Dynamism of food security and agricultural sustainability to face the climate scenario in the 21st century

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Received: 28.11.15
Accepted: 10.01.16

ABSTRACT

Agriculture is occupying about 38% of the Earth's terrestrial surface, the world's largest use of land (Foley, J.A. *et al.* 2011). The agricultural community has had tremendous successes in massively increasing world food production over the past six decades and making food more affordable for the majority of the world's population, despite a doubling in population. Global food demand will continue to increase for at least another 50 years – against a backdrop of growing competition for land, water, labor and energy and under threat from climate change. FAO projected that feeding a world population of about 9 billion people in 2050 would require raising overall food production by at least 70 % (FAO, 2009).

India with a land area of merely 2.4 per cent of the world's area is a home to 15 per cent of the global population (1.1 billion out of 7.3 billion). India is also rapidly urbanizing with 7.3 million people moving into urban centers every year. In India per capita arable land availability has declined from 0.29 ha in 1965-66 to 0.14 ha in 2011-12 (Fertilizers Statistics 2013-14) and will shrink to less than 0.08 ha in 2025. Currently almost 46 percent of India's geographical area is under agriculture. A large percentage of this land falls in rain-fed regions generating 55 percent of the country's agricultural output, providing food to 40 percent of the nation's population (Ahmad et al., 2011; Planning Commission, 2012). More than 80 percent of the farmers are smallholder producers, with very poor capacity and resources to deal with the vagaries of weather and changes in climate. This necessitates that India needs a strategy to increase food production at one side and also keeping pace to equalize the negative effects of change in climate.

Food Security

Food Security means that all people at all times have physical & economic access to adequate amounts of nutritious, safe, and culturally appropriate foods, which are produced in an environmentally sustainable and socially just manner, and that people are able to make informed decisions about their food choices. At the core of food security is access to healthy food and optimal nutrition for all. Food access is closely linked to food supply, so food security is dependent on a healthy and sustainable food system.

A total of 842 million people in 2011–13, or around one in eight people in the world, were estimated to be suffering from chronic hunger, regularly not getting enough food to conduct an active life. This figure is lower than the 868 million reported with reference to 2010–12. The total number of undernourished has fallen by 17 percent since 1990–92. Developing regions as a whole have registered significant progress towards the Millennium Development Goals 1 hunger target.

Sustainable Food Systems

A sustainable community food system is a collaborative network that integrates sustainable food production, processing, distribution, consumption and waste management in order to enhance the environmental, economic and social health of a particular place.

Understanding Agricultural Sustainability

Despite the potential benefits of farming practices and systems that improve sustainability, their adoption are far less widespread than society might want. Sustainability in agriculture is a complex and dynamic concept that includes a wide range of environmental, resource-based, economic, and social issues. The sustainability of a farming practice or system could be evaluated on the basis of how well it meets various societal goals or objectives. Shift to sustainable agriculture is often seen as a compromise on food security. This is mainly because food is understood as only wheat and rice, few pulses, oilseeds and vegetables. The food basket can be increased if we can expand the scope to include millets, coarse cereals, dryland fruits, uncultivated greens etc which can also bring in nutrition security.

Emphasis on sustainable agriculture is the result of growing understanding of the harm done to the basic life support systems of soil, water, biodiversity, forest, and the atmosphere by ecologically insensitive technologies and public policies. It is only synergy between technology and public policy that can lead

to the spread of sustainable farm practices. The problem before us is how to feed billions of new mouths over the next several decades and save the rest of life at the same time, without being tapped in a Faustian bargain that threatens freedom from security (M.S. Swaminathan, 2006). The most fundamental way in nutritional security is by making food more available and affordable through agricultural productivity growth. This strategy is particularly appropriate in settings where under nutrition and micronutrient deficiencies are the primary malnutrition concern (FAO, 2012c).

Sustainable Agricultural Systems in the 21st Century

Modern agriculture has had an impressive history of productivity that has resulted in relatively affordable food, feed, and fiber for domestic purposes, accompanied by substantial growth in agricultural exports. With global populations rising rapidly, Indian agriculture faces the challenge of producing enough food, feed, and fiber to meet increasing demand in conditions of changing climate and scarce natural resources. Innovative policies and new farming approaches based on a strong scientific foundation are needed to tackle the challenge of increasing production while also meeting environmental, economic, and social goals.

Sustainability not as any particular end state, but rather as progress towards four goals: (1) producing enough to satisfy human needs; (2) enhancing environmental quality and protecting the natural resource base; (3) being profitable; and (4) increasing the quality of life for farmers, farm workers, and society as a whole.

Current Situation of Food Production and Fertilizer Consumption

Globally, India is the third largest producer of cereals, with only China and the USA ahead of it. Between 1950-51 and 2006-2007, production of food grains in the country increased at an average annual rate of 2.5 per cent compared to the growth of population, which averaged 2.1 per cent during this period (MSSRF, 2008). Warding off doomsday predictions of hunger and famine, India came to be in a situation following the Green Revolution in the late sixties, where we hardly had to resort to foodgrain imports between 1976-1977 and 2013-14, except occasionally.

Fertilizers played a key role in raising food production. Consumption of fertilizer nutrients ($N+P_2O_5+K_2O$) increased from 0.78 MT in 1965-66 (baseline for green revolution) to 24.48 MT in 2013-14 against rise in food production from 124.0 MT to 264.7 MT in corresponding period (Fertilizer Statistics 2013-14). In spite of the increased fertilizer consumption, use efficiencies of the applied nutrients have remained abysmally low. Utilization of fertilizer nitrogen by crop seldom exceeds 35 per cent under low land and 50 per cent under upland conditions. Declining partial factor productivity of NPK for food grain production (dropped from 81 kg grain per kg of NPK in 1966-67 to 16 kg grain per kg of NPK in 2003-04 as reported by Benbi et. al. 2006) and diminishing response ratios (13.4 kg grain per kg NPK in 1970 to 3.4 kg grain per kg NPK in 2005, Biswas and Sharma, 2008); and real or imaginary environmental scares have exuberated the degradation of soil environment, soil quality and soil health etc. Thus, soil quality (physical, chemical, biological and ecological) must be optimal to sustain principle rhizosphere processes in relation to crop growth. Soil organic carbon (SOC) contribution, at an optimal level of 1.5 per cent in the root zone, is an essential parameter affecting soil quality, rhizospheric process, and ecosystem services essential to human well being and environmental quality. Besides, improvement in soil organic carbon, other important benefits are improving soil quality, increasing agronomic productivity and ensuring food security for growing and affluent population.

The economic pathways through which productivity growth in agriculture makes food more available and affordable are through income growth, broader economic growth and poverty reduction, and lower real food prices. Plagued with endemic food shortages, India adopted mechanized agricultural intensification model with exclusive aim of maximization of the yield per unit cultivated area with application of synthetic agro chemicals including fertilizers and pesticides to the nutrient responsive high yielding crop varieties grown on the intensively cultivated lands having assured irrigation. Despite impressive achievements in agricultural production since 1950s, total food grain production has increased many folds and it can be easily doubled from 257 million tonnes to 550 million tones. Further, agronomic yields of major crops in India are much lower than the attainable yield and those obtained in other countries (Table 2.0).

Agronomic Interventions to Improve Nutrition

Although food production employs a number of inputs, such as labor, capital, machinery, water, innovation, fertilizers, pesticides, and improved crop types, fertilizers are the key input to support ecologically sustainable production; it is estimated that around half of the current crop yield is attributable to commercial fertilizer use (Stewart et al., 2005). Since 1960, fertilizer use has risen by around 3.2% per year (Heffer and Prud'homme, 2011), whereas world grain production has risen by 2.4% per year during the same period. So nutrients

are important inputs underpinning global food security, and in the medium term there are adequate supplies of these fertilizer raw materials.

Agronomic interventions along with proper attention to soil health, access to water, quality seeds and other inputs and package of practices suited to the crop and the agro-ecological region, supplying of the needed micronutrients in the soil to address the hidden hunger has the greatest impact on increasing yield. Factor productivity of fertilizer application also has declined tremendously thereby cost of production has increased manifold without the desired impact on yields. Low fertilizer use efficiency means that nutrients otherwise intended for crop uptake are moved from one part of the environment to another. The efficient use of nutrients has two significant dimensions, one to enable more food to be produced with the same or lower nutrient input and the other to reduce nutrient outflows into the environment (Smil, 2000b).

Developing and implementing strategies to increase nutrient-use efficiency will be successful only if the nutrient in question is the limiting or colimiting factor to improved productivity. Selection of crop cultivars with high yield potential will also raise the response to applied nutrients even without specific selection for improved nutrient-use efficiency. Good agronomic practices must be in place before the various interventions in rate, time, place, and product can improve nutrient efficiencies, and indeed water-use efficiency and nutrient-use efficiency interact and have been shown to give trade-offs in semiarid farming systems (Sadras and Rodriguez, 2010).

Improving the fertility of soils through the use of organic or inorganic fertilizers sources can enhance crop yields and improve the nutrient concentrations in crops. Adding specific micronutrients to fertilizers or irrigation water can further enhance yields and micronutrient concentrations. Adding micronutrients to soils enhanced the yields by 20–80 percent and a further 70–120 percent when micronutrients were added in conjunction with nitrogen and phosphorous (Dar, 2004). These results were found for a number of crops, including maize, sorghum, greengram, pigeonpea, castor, chickpea, soybean and wheat. Yield increases achieved through balanced crop fertilization can reduce the land area needed to grow staple crops and thus add to the sustainability of the farming system.

Strategies to Increase Food Production and Productivity

It is clear that India will remain a predominantly agricultural country during most of the 21st century, particularly with reference to livelihood opportunities. Therefore, there is a need for both vision and appropriate action in the area of shaping our agricultural destiny. Our major agricultural strengths are our large population of hard working farm women and men, our varied climatic and soil resources, abundant sunshine throughout the year, reasonable rainfall and water resources, a long coast line and rich agro-biodiversity. Converting these into jobs and income is the challenge. There are however, several available areas of improvement for increasing the levels of production and productivity and improving the lives of the people dependent on agriculture and allied activities.

In the 21st century the world faces a stark contrast between the availability of natural resources and the demands of billions of humans who require those resources for their survival. Agricultural productivity growth makes food more sustainable by reducing the resources required for production. The traditional roles of agricultural production and productivity growth in generating incomes and reducing food prices will continue to be of crucial importance in the coming decades. At the same time, the sector can and must do more to improve the sustainability, diversity and nutritional quality of food.

Threat of Climate Change

Climate change poses a serious threat to food security for many of the world's poorest countries and millions of its poorest households, although the threat is certainly not limited to poor countries. Rich and poor countries alike will feel the impact of changing rainfall patterns, extreme weather events and rising sea levels (UNDP, 2006). The impacts of a changed climate are likely to be alterations to thermal regimes, which will affect water supply and the rates of plant growth and development. To meet future food supplies against a scenario of declining energy and resource availability, climate change, and a static world land area, continual improvements in efficiency will be needed (Eickhout et al., 2006).

Biogenic emissions of CO_2, CH_4 and N_2O are emitted as part of the natural biogeochemical cycling of C and N (e.g., decomposition of burning of plant material). Anthropogenic emissions of CO_2, CH_4, and N_2O are emitted due to human decisions, activity, and influence of our abiotic and biotic environment (Bruinsma, 2003). Since the industrial revolution in 1750, CO_2 concentrations have increased from 280 to 379 ppm, CH_4 concentrations have increased from 715 to 1732 ppb, and N_2O concentrations have increased from 270 to 319 ppb (IPCC, 1997). Since 1970, atmosphere concentration of CO_2, CH_4 and N_2O has increased by approximately 31, 151, and 17%, respectively in the United States (USDA, 2004).

Currently, over half of the total global CH_4 emissions and one third of N_2O emissions are from anthropogenic sources including agriculture, land

fills, biomass burning, industrial activities, and natural gas (IPCC, 1997). The Inter Governmental Panel on Climate Change (IPCC) estimated that the agricultural sector contributes between 10 and 12 % of the global anthropogenic CO_2 emissions (i.e., fossil fual burning), 40% of global anthropogenic CH_4 emissions (i.e., enteric fermentation, wetland rice cultivation, decomposition of animal waste)), and 65% of global anthropogenic N_2O emissions (i.e., agricultural soils, use of synthetic and manure fertilizers, manure deposition, biomass burning) (De Gryze *et al*., 2008; IPCC, 1997). Therefore, agriculture is considered the largest source of anthropogenic CH_4 and N_2O at the global, national, and state level (CEC, 2005; De Gryze *et al*., 2008; EPA e*t al*., 2009), while transportation is considered the largest anthropogenic source of CO_2 production (EPA *et al*., 2009).

Climate change will affect all four dimensions of food security: food availability, access to food, stability of food supplies, and food utilizations- with overall impact differing across regions. Climate change will increase the dependency of developing countries on imports and accentuate the existing concentration of food insecurity in Sub-Saharan Africa. It will also affect South Asia. Based on quantitative assessment, the second half of the 21st century is expected to bring more severe biophysical impacts but also a greater ability to cope with impacts of climate change (Schmidhuber and Tubiello, 2007).

Increase in food grain production during last three decades made India self sufficient and contributed tremendously to their food security. The later, however, is now at risk due to increased demand of continuously increasing population. Also the situation is grim as decline in soil fertility, decline in groundwater level, rising salinity, resistance to many pesticides, degradation of irrigation water quality and genetic diversity of the popular varieties in the farmers field has been rapidly decreasing. It is however of paramount importance to sustain the natural resource. In recent years, the prospect of climate changes has stimulated considerable research interest in attempting to predict how production of crops will be effected. The purpose of this review was to provide overview of the likely effect of the climate change on food production in India. Although, the effect of climate change on crop productivity could be biased depending upon the uncertainties in crop models used for impact assessment, climate change scenarios, region of study, technological changes and the agronomic management, the integrated assessment of climate change impact on different sectors of Indian economy is very important to determine future strategies for sustainable development, adaptation and other policy decisions.

In addition to the impact of increasing population, urbanization, biofuel competition and natural resource stresses caused by direct effects of climate change, its impact also will be especially felt in terms of reduced productivity in tropical low latitude regions where many poor countries are located and where production growth is most needed. Potential agricultural output up to 2080-2100 may be reduced by up to 30 per cent in Africa and up to 21 per cent in developing countries as a whole (FAO, 2009d). Although the problems we face today to promote sustainable nutrition security are staggering, we should be prepared to face the challenges in relation to probable food demand and sustained use of natural resources.

At this juncture, based on the different reports it can be concluded that the agricultural impacts of climate change in India are uncertain. The total average impact may be positive or negative depending on the climate scenarios (temperature rising in 2^0C, 3^0C, 4^0C, increase in CO_2 and interaction of increase in temperature and CO_2). Impacts also vary both quantitatively and qualitatively by crop, level of agronomic management, region and season. As to the seasonal impacts, the '*rabi'* agriculture (winter season) in central and southern India will be more risky. But most scenarios show that climate change will have an overall positive impact or not affect significantly on India's agriculture until 2050. By the year 2080 when temperature increase are very large, the Indian agriculture will suffer the most. In other word it can be say that food production is not threatened up to 2050 and does not need to import food, but by the year 2080 food production is threatened.

Impacts of Climate Change on Agriculture

Climate change is manifesting itself in many ways across the country. Among the indicators, while long term rainfall data analysis shows no clear trend of change, regional variations as well as increased rainfall during summer and reduced number of rainy days can be noticed. In the case of temperature, there is a 0.6^o C rise in the last 100 years and it is projected to rise by 3.5-5^o C by 2100. The carbon dioxide concentration is increasing by 1.9 ppm each year and is expected to reach 550 ppm by 2050 and 700 ppm by 2100. Extreme events like frequency of heat and cold waves, droughts and floods have been observed in the last decade. The sea level has risen by 2.5mm every year since 1950 while the Himalayan glaciers are retreating. These are all symptomatic of climate change.

Climate-Smart Adaptive Sustainable Agriculture

- Stabilization and management of the natural resource base (land, water, and biodiversity) is important for all, particularly the semi-arid and rain-fed, regions. An ecosystems-based approach to Participatory Watershed Management as a central point of activity is essential for building the adaptive capacities to climate change.
- Assessing vulnerability of a cluster of villages/sub-region to climate change is essential for developing a road map for building locale-specific resilience of the people and their land to varying weather extremes.
- It is imperative that we integrate a package of climate-smart agriculture practices into ongoing programmes which includes weather-based locale specific agro-advisories, contingent crop planning, promotion of low-external input technology, water budgeting, livelihood diversification, and promotion of local agro-biodiversity. These, together, would build the resilience of the farming community, while simultaneously improving the quality of the resource base.

Future Developmental Goals

Indeed we have now crossed the first decade of 21st Century and going through the era of most modern technological agricultural production system which needs urgent post-2015 goals for sustainable resource use without sacrificing agricultural production and food security. Some of the important goals to be achieved are:(water, energy, fertilizer, etc.).

i. Stopping of the expansion of agricultural activities into ***Food & nutritional security goals***

- Increase the world's real food supply by 70-100% by 2050 through increasing agricultural productivity on existing land, minimizing the use of food crops for bio energy, and reducing food waste.
- Enhancing distribution and access of the food to all
- Eradicate hunger and malnutrition by 2030 (caloric & nutrient insufficiency).
- Make food production systems more resilient.
- ***Socio-economic development goals***
- Food for the poor at affordable prices.
- Increase in the sources of income of rural livelihoods.
- Making agriculture more remunerative and attractive for people living in rural areas.
- ***Sustainable environmental development goals***
- Increase in the use efficiency of natural resources sensitive natural ecosystem areas for the protection of wildlife, biodiversity and other ecosystem services in agricultural landscapes.
- Improvement in the water resources, soil degradation, and soil nutrient status.

Achieving these goals will require changing in the behaviour of all sectors involved in the agriculture and food sector, from the consumer to the farmer. Many interventions are needed, but not all can be done at once. On the supply side, the most critical issue is to increase production on existing crop land by closing yield gaps and, where possible, diversifying and increasing the number of crops grown per year, as well as for reducing post-harvest losses. That is a prerequisite for being able to stop agricultural expansion into natural environments.

SUMMARY

Indian economy is very much linked to the advancement of agriculture and that too of resource poor marginal and small farmers who constitute 80 per cent of >115 million far, families cultivating only 29 per cent of the consolidated and scattered arable land. Sustaining house hold food security has been an issue of prime importance to majority of the farmers (Gill et al., 2009). In developing countries, poor farmers work hard to feed themselves and try to make a living from their limited land, with same livestock and crops, which is very much revealed from Integrated Farming System Approach besides increase in system productivity, profitability, sustainability, balanced food, clean environment, recycling of resources adoption of improved technology, regulate the farm income, create employment opportunities, high input-output ratio, solving feed, fodder, fuel crises, encourage afforestation, promoting agricultural oriented industry and ultimately standard of living of farming community. Productivity growth in agriculture is the key strategy to meet food security. The increase in production during the Green Revolution—into the Evergreen Revolution—is a case study in ecological intensification, which has delivered increased food supply as well as preserved land for wildlife and non-agricultural pursuits. Improved nutrient-use efficiency, especially for N and P, will be a cornerstone of future farming systems and will require judicious use of fertilizers. There has been significant progress in improving efficiency measured in food produced per unit of fertilizer used or as the recovery of nutrient in produce.

The impact of modern agriculture on natural resources has become a major global concern. Population growth and expanding demand for agricultural products constantly increase the pressure on land and water resources. A major point of concern for many intensively managed agricultural systems with high external inputs is the low resource-use efficiency, especially for nitrogen. A high input combined with a low efficiency ultimately results in environmental problems such as soil degradation, eutrophication, pollution of groundwater, and emission of ammonia and

greenhouse gases. Evidently, there is a need for a transition of current agricultural systems into highly resource-use efficient systems that are profitable, but at the same time ecologically safe and socially acceptable.

Agriculture is facing daunting challenges. Not only farmers are expected to produce adequate agricultural products at affordable prices to meet the food, fiber, feed, and biofuel needs of a rising global population, but also they are expected to do so under conditions of rising production costs and increasingly scarce natural resources and climate change. Agricultural R&D priorities must continue to include the sustainable intensification of staple food production, but must also be made more nutrition-sensitive, with a stronger focus on nutrient dense foods such as legumes, fruits, vegetables and animal-source foods. Greater efforts must be directed towards interventions that diversify smallholder production, such as integrated farming systems.

Table 1: Trends in grain yields in India over last four decades and comparison with world's highest yields

Crop	Grain Yield (kg/ha)				World High Yield	
	1970-71	1990-91	2010-11	2012-13	kg/ha	Country
Rice	1123	1740	2240	2461	10800	Australia
Wheat	1307	2281	2938	3117	8900	Holland
Pulses	524	578	689	789	2800	China
Oilseeds	579	771	1325	1168	-	-
Sugarcane	48322	65395	68596	68254	125000	Peru
Tea	1182	1652	1669	2143	-	-
Cotton	106	225	510	486	4600	Israel

Source: (http://en.wikipedia.org/wiki/Agriculture in India)

Table 2: Trends of food grain production in India and world over last more than 60 years

Year	NPK consumption (MT) in India	Foodgrain production (MT) in India	NPK consumption (MT) in World	Foodgrain production (MT) in World
1950-51	0.07	50.8	14.0	631.0
1960-61	0.29	82.0	27.0	824.0
1970-71	2.25	108.4	68.0	1079.0
1980-81	5.51	129.6	116.0	1429.0
1990-91	12.54	176.4	137.0	1769.0
2000-01	16.70	196.8	137.0	1846.0
2010-11	28.12	244.4	172.0	2199.0
2011-12	27.79	259.3	176.0	2314.0
2012-13	25.53	257.3	176.0	2258.0
2013-14	24.48	264.7	181.0	2438.0
Potential		550.0	-	-

Source: Das, 2012; Ahmed and Haseen, 2012; FAO, 2011; IFA, 2013 and FAI Statistics, 2013-14

Table 3: Global Fertilizer Consumption in Megatons and Trends

Nutrient	2007/08 to 2009/10	2014/15	Annual Percentage Change
N	101.0	112.1	+1.8
P_2O_5	36.6	44.0	+3.1
K_2O	25.0	32.2	+4.3
Total	162.7	188.3	+2.5

Source: Heffer, P., and M. Prud'homme. *Fertilizer Outlook* 2011–2015, International Fertilizer Industry Association, 2011.

Table 4: Food grain requirement of different region of the world in 2025

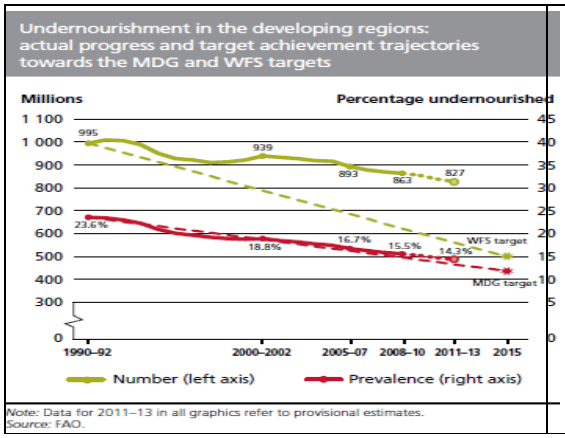
Regions	Population (billions)	Average per capita consumption (kg)	Food grains requirement (MT)
Africa	1.62	257	416
South America	0.78	296	231
Asia	0.54	300	1362
North America	0.35	885	310
Europe	0.52	700	364
USSR	0.37	983	364
Oceania	0.04	578	23
World	**8.22**	**373**	**3070**

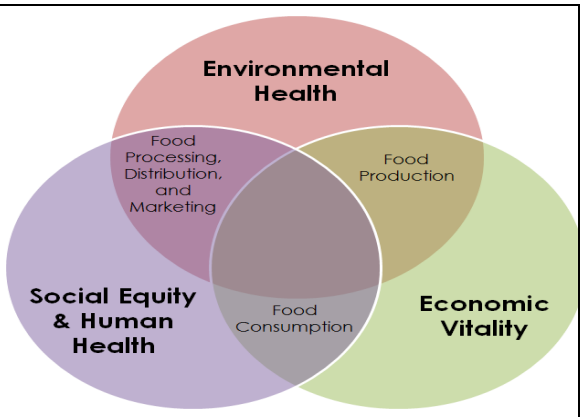
Source: Sanderson, F.H. (1984)

Table 5: Additional land requirement to meet cereal demand in 2025

Region	Potential arable land (mha)	Cultivated land (mha) 1986	Cultivated land for cereals (mha) 1986	To be Cultivated land for cereals (mha) 2025	Additional land for cereals (mha)
Africa	734	158	74	277	203
Asia	627	519	307	340	33
Australia & New Zealand	153	32	16	16	-
Europe	174	154	71	78	7
North America	465	239	103	103	-
South America	681	77	39	93	54
USSR	356	227	111	146	35
World	3190	1406	721	1053	332

Source: WECD, 2000





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Reproductive biology and breeding system of pomegranate: A Review

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Received: 11.01.16
Accepted: 19.03.16

ABSTRACT

Punica is the sole genus in family Punicaceae and there are only two species in the genus Punica viz: *Punica granatum* and *Punica protopunica.* Pomegranate is considered as a monoecious species developing male and perfect flowers (hermaphrodite) and being self and cross pollinated. As the cytological understanding of a species is useful in planning breeding programmes. Success of tree improvement generally depends upon the combination and expression of characters in the new genotypes which holds the key for boosting the productivity and yield of the economic product. In this context, regulation of variation through reproductive system forms the basic approach which is dependent upon the information pertaining to reproductive biology as the biological process. Therefore, the studies on reproductive biology and breeding system are pre-requisite for developing appropriate strategies for tree breeding.

Key words: Wilt, pomegranate, pollination, flowers, etc.

Pomegranate belongs to the order Myrtales and most likely originated from Saxifragales. The Lythraceae family is likely to be an initial form, which initiated the Sonneratiaceae and Punicaceae families (APG II, 2003). However, the genus Punica, described for the first time in 1753 by Linnaeus, had tropical ancestors close to Lythraceae and Sonneratiaceae. Punica is the sole genus in family Punicaceae and there are only two species in the genus Punica viz: *Punica granatum* and *Punica protopunica*. As the cytological understanding of a species is useful in planning breeding programs, so wild pomegranate is reported to contain 2n = 2x = 16, 18 chromosomes (Smith, 1976). Wild Pomegranate (*Punica granatum* L.) is one of the oldest known edible wild fruits and is capable of growing in different agro-climatic conditions ranging from the tropical to sub-tropical land (Levin, 2006 and Jalikop, 2007). It has also been one of the well known Mediterranean fruits since ancient times (Ercisli, 2007).

Wild pomegranate with narrow petals, friable seeds, fruits resistant to cracking is found naturally in Northern India which is locally known as "Daru". Daru is very common and gregarious in gravels and boulder deposits of dry ravines, well drained mid hill pasture lands and cultivated fields. Fruit with best quality are produced in the area with cold winters and hot dry summers.

Pomegranate is considered as a monoecious species developing male and perfect flowers (hermaphrodite) and being self and cross pollinated. The development of stamens is normal and pollen is fertile in both hermaphrodite and male flowers but in hermaphrodite flowers, pollen are more fertile than male flowers (Evreinoff, 1957). A positive correlation exists between the fruit bearing capacity and percentage of perfect flowers (Chaudhari and Desai 1993). Regarding the type of flowers in pomegranate; usually three types viz., pin, thrum and homostylous flowers are found (Singh *et al*. 2006).

However, there is now a rapidly increasing knowledge about the usefulness of wild pomegranates for mankind; such as its importance to treat obesity (Rahimi *et al*. 2012). The wild pomegranate generally cultivated through seeds which tends to create heterozygosity and variations, which makes the fruit selection a significant tool in pomegranate breeding programs (Jalikop and Kumar, 1998). The wild pomegranate breeding program also used to increase high productivity, dwarfing habit, frost resistant and good fruit quality (Levin, 1990).

Success of tree improvement generally depends upon the combination and expression of characters in the new genotypes which holds the key for boosting the productivity and yield of the economic product. In this context, regulation of variation through reproductive system forms the basic approach which is dependent upon the information pertaining to reproductive biology as the biological process. Therefore, the studies on reproductive biology and breeding system are pre-requisite for developing appropriate strategies for tree breeding.

Floral biology of Pomegranate

Pomegranate produces two types of flowers i.e. hermaphrodite flowers (vase shape) and male flowers (bell shape). Both types of flowers have several hundred stamens. The bell shaped flower had a poorly developed or no pistil and atrophied ovaries

contained few ovules and is infertile. Bell shaped flower is referred as male flower and to droped without fruit set. The vase shape flower was fertile with a normal ovary capable to developed fruit. The stigma of the hermaphrodite is at anthers height or emerging above them, this position allows for self pollination as well as pollination by insects. The factors that determine the fruit set capacity was the number of base shaped flowers. Tree with higher vase shaped to bell shaped flower ratio resulted in a higher fruit yield potential. The percentage of vase shape in India varied from 53-80 % (Nalawadi *et al.* 1973).

Pomegranate bears cymose inflorescence which develops from mixed buds situated terminally on previous season growth as well as on one or two years old spurs (Singh *et al.* 1978). Bavale (1978) reported three types of flowers in pomegranate viz. male, hermaphrodite and intermediate, while studying the floral biology of certain Pomegranate cultivars. Shulman *et al*. (1984) observed in pomegranate that the fertile flowers are vase shaped, whereas, bell shaped flowers with few egg cells are sterile and does not produce fruits. Pomegranate flowers were protogynous and stigma becomes receptive at least twenty four hours prior to dehiscence of anthers. Bal (1997b) observed anthesis in pomegranate at 8.00 am and was complete by 4.00 pm with a peak at 2.00 pm. The stigma receptivity initiated one day before anthesis and remained receptive up to 5 days. Nalwadi *et al.* (1973) observed that in pomegranate, anther dehiscence occurred immediately after the maximum opening of flower at 2.00 pm, except in the local variety where it occurred prior to the opening of flowers.

Morphological characteristics of Pomegranate

Pomegranate is a shrub that naturally tends to develop multiple trunks and have a bushy appearance. When domesticated, it is grown as a small tree that grows up to 5m. Under natural conditions, it can sometimes grow up to more than 7m at other extremes, in severe natural environment, one can find creeping bush varieties (Levin 2006). Goor and Liberman (1956) observed in pomegranate that young branches of recent year were numerous and thin, pink-brown in colour upon maturation the pink colour of branches started to disappear and in the second year, the bark became light grey that darkened as tree mature.

Fahan (1976) studied in tree morphology of pomegranate and examined young branches have thorns at their tips that are visible already in the axils in the young bloom. The branches are polygonal (quadrangular). As the branches mature, they became round. Young leaves tend to have a reddish colour that turns green when leaf matures. Leaves have an lanceolate shape with an acute apex and acuminate base. Mature leaves were green, entire, smooth and hairless with short petioles. Morneo (2005) reported in pomegranate that leaves were exstipulate, opposed and pairs alternately crossed at right angles. Some varieties have 3 leaves per node arranged at 120 degree and even 4 leaves per node on same tree (2 opposed leaves per node). Flowers occured about 1 month after bud break on newly developed branches of same year, mostly on spurs or short branches. Flowers appeared as solitary, pairs or clusters. In most cases, the solitary flowers will appeared on spurs along the branches while the clusters were terminal.

Nalawadi *et al.* (1973) examined in wild pomegranate almost all the flowers, mostly solitary and rarely in clusters, some terminal flowers were also observed. These were hermaphrodite, male and intermediate. Singh *et al.* (1978) recorded the Percentage of hermaphrodite flowers varied from 19.70 to 49.0% and reported that the fertile flowers were vase shaped, whereas bell shaped flowers with few egg cells were sterile and does not produce fruits .

Breeding system of Pomegranate

Josan *et al*. (1979a) reported that stigma receptivity in pomegranate were determined through visual observations (colour, shininess and oozing of stigmatic surface). Stigma became receptive one day prior to anthesis with peak receptivity on the day of anthesis and remains receptive up to two days after anthesis. Nath and Randhawa (1959b) reported that in pomegranate stigma remained most receptive only on day of opening of flower and stigma attained maturity one day before anthesis thereafter it gradually decrease till the third day and after that it abruptly sank into non receptivity.

Nalawadi *et al.* (1973) observed that in pomegranate stigma was receptive even one day before opening of flower and the receptivity remained for two days after anthesis. Josan *et al.* (1973) observed that stigma in pomegranate became receptive one day before anthesis with a maximum receptivity on the day of anthesis and remained receptive till the third day after anthesis.

Nath and Randhawa (1959b) studied four modes of pollination in seven varieties of pomegranate viz., self, hand pollination, open and natural cross pollination. Fruit setting under all the 4 types of pollination was observed after 15 days. The maximum fruit set (67.92%) resulted from hand cross pollination which was followed by open pollination (66.92%), self pollianation (46%) and natural cross-pollination (26.19%). The results indicated that both self and cross pollination were

effective in pomegranate and the percentage of fruit set was also high.

Randhawa and Dass (1962) examined the pollination mechanism of phalsa and reported some amount of self pollination. Insects were found main agents of cross pollination and fruits took 41 days to mature after full bloom.

Pollination mechanism of Pomegranate

Nath and Randhawa (1959a) revealed that in pomegranate 78 per cent pollen germination took place in 5 per cent sucrose solution and pollen viability ranged from 67.70 to 91.54 per cent. Nalawadi *et al.* (1973) obtained 69 per cent germination in cutivar 'Dholka" in 5 per cent sucrose solution after 48 hours of incubation and reported 92 to 96 per cent pollen viability during peak period of anthesis in 2 per cent acetocarmine solutions. Morton (1987) reported that pollination in pomegranates appeared to be ambiguous. Pomegranate can be self-pollinated or cross-pollinated by insects. According to Malgarejo et al. (2000), pollination in pomegranate is primarily affected by insects or hummingbirds. Beetles belonging to the genera Cetonia and Trichodes were reported to affect both cross-pollination as well as self-pollination in pomegranate.

Morton (1987) studied that pomegranate both self pollinated and cross pollinated by insects, mainly bees. Wind pollination was reported to occur but very infrequently. He also studied that in hermaphrodite flowers, 6 to 20% of pollen may be infertile; in male flowers 14-28% was infertile. Karale *et al*. (1993) obtain higher fruit set (66.20%) in artificial self pollination than through natural self pollination (43.30%). Fruit set through pollination was 79.00%. So, it was inferred that pomegranate was capable of both self and cross pollination. Josan *et al*. (1979a) reported that fruit set by open pollination ranged from 26.61% in kandhari to 63.81 % in dokhla and by self pollination fruit set varied from 20.05% in kandhari to 53.33% in Bedana, Sunni bedana and Achikdana fruit set through controlled cross pollination was higher than self and open pollination.

Pollen studies of Pomegranate

Nath and Randhawa (1959a) reported that pollen fertility in acetocarmine (2%) was as high as 84 per cent in cultivar Kandhari and in 12.5 per cent sugar and 12.50 per cent sugar plus 0.50 per cent agar media the pollen grains germinated satisfactorily with 78 per cent.

Kar and Singh (1983) studied some exotic pomegranate cultivars. Maximum pollen germination (78%) was recorded in the medium containing 12.50 per cent sucrose solution followed by 75.0 per cent germination in 12.50 per cent solution plus 0.50 per cent agar solution. No pollen germination was recorded with media like 5 per cent and 25 per cent sucrose solution containing 25 ml of water plus 0.5 g gelatin. Pollen fertility varied from 64.50 per cent (Shirin Anar) to 88 per cent (Kazkai).

Chadha (1983) reported 73.50 per cent pollen germination in 12.5 per cent sucrose solution in cultivar Kazkai. No pollen germination increased when agar-agar was added to the sucrose solution. Derin and Eti (2001) carried out the research to determine the pollen quality (pollen viability and germination), quantity (pollen production) and the role of cross pollination on the fruit set in Hicaz and 33 N 26 pomegranate cultivars. Pollen viability levels with TTC and FDA, pollen germination level with agar plate method in both male (A type-unfertile) and bisexual (B type-fertile) flowers by using 1 per cent agar and different concentrations (0, 5, 15, 20 and 25%) of sucrose media. The highest pollen viability was observed 75.24 per cent in TTC, 82.45 per cent in FDA and highest germination (68.50%) in 1 per cent agar plus 10 per cent sucrose medium and lowest (2.05%) with 1 per cent agar and 0 per cent in bisexual flowers of Hicaz, in agar plate method. The rates of fruit set in self and open pollination were found to be lower than those of cross pollination. Pollen viability and pollen germination rates in male flowers of 33 N 26 was recorded, 72.36 per cent in TTC, 76.75 per cent in FDA and highest pollen germination 61.50 per cent with 1 per cent agar plus 15 per cent sucrose was observed and lowest (2.10%) with 1 per cent agar plus 0 per cent sucrose.

Sharma and Bist (2003) studied pollen characters and pollination behaviour in eight year old trees of eight pomegranate cultivars (Anar Shirin Mohammad Ali, Chawla, Jodhpur Red, Kandhari Hansi, Mridula, Ganesh, G-137 and PS-75-K-5). Pollen morphology, viability and fertility and fruit set using various pollination methods (selfing by bagging, open or natural pollination, and artificial cross pollination) were evaluated. Pollen viability was tested in 2 per cent acetocarmine and 1 per cent tetrazolium salt solution, whereas pollen germination was studied by hanging drop method using sucrose solution at various concentrations (5, 10, 12.50, 15 and 20%) with or without boric acid (10 ppm). Pollen viability in acetocarmine solution ranged from 91.15 (Mridula) to 97.91 per cent (G-137). In tetrazolium salt solution, pollen viability varied from 87.60 (Mridula) to 96.70 per cent (Jodhpur Red). The highest pollen germination (72.05%) was observed in G-137 with 12.50 per cent sucrose plus 10 ppm boric acid solution.

Engin and Hepaksoy (2003) determined the pollen germination of type A fowers of cultivars

Izmir 1, Izmir 2, Izmir 10, Izmir 12, Izmir 1261, Izmir 1265, Izmir 1267, Izmir 1479, Izmir 1499 and Izmir 1513. Pollen germination was tested in 10, 15 and 20 per cent sucrose solution plus 1 per cent agar in petri plate method. The media containing 15 and 20 per cent sucrose gave 48.53 per cent (Izmir1267) and 48.73 per cent (Izmir 10) pollen germination, respectively.

Prakash *et al.* (2010) carried out *in vitro* pollen germination and pollen fertility tests in *Punica granatum* L. Pollen viability as tested by Alexander's stain, FCR test and 1 per cent TTC, showed that in first phase of flowering the pollen grains recorded 87.42 per cent viability compared to 81.01 per cent during the second phase of flowering as tested by Alexander's stain. The pollen viability was 65.21 per cent during the first phase of flowering and 62.24 per cent during the second phase of flowering with TTC stain solution and 84.24 per cent as tested by FCR during first phase of flowering. However, during the second phase of flowering it was 82.01 per cent. The pollen viability was reduced during second phase of flowering when, temperature was 37.0 °C to 25.10 °C. *In vitro* pollen germination as tested by Brewbaker and Kwacks medium showed 25 per cent pollen germination while different concentrations of sugar solutions (10, 15 and 20 %) showed 20, 45.83 and 14.26 per cent pollen germination during first phase of flowering. Maximum percentage of germination 45.83 and 42.25 per cent was recorded at 15 per cent sucrose solution during first and second phase of flowering.

Gadze *et al.* (2011) investigated *in vitro* pollen viability, germination capacity and tube growth of pollen grains of five pomegranate cultivars *viz.* Sladun, Barski, Ciparski, Glowas and Konjsbi Zub. Pollen viability varied from 36.73 per cent (cultivar Konjski Zub) to 51.80 per cent (cultivar Barski) in fluorescent diacetate (FDA) test. The average pollen germination percentages were found to be lowest (6.83%) in cultivar Konjski Zub and the highest (42.51%) in cultivar Glavas with a media containing 10 per cent sucrose plus 5 ppm H_3BO_3 plus 0.2 per cent agar.

Wetzstein *et al.* (2011) collected the pomegranate flowers from eight year old tree of cultivar Wonderful and conducted an assay to show the effect of temperature on pollen germination. The pollen germination medium consisted of 0.062 per cent $CaNO_3$ (w/v), 0.024 per cent boric acid (w/v) and 12 per cent sucrose (w/v). Cultured pollen grains were maintained at one of the four temperature's (5, 15, 25, or 35 °C) and per cent germination assessed at 1, 3 and 5 hours incubation times using an inverted microscope (DIAPHOT; Nokon, Garden City, NY). A pollen grain was considered germinated if, tube length was longer than the diameter of the pollen grain. The conducted assay at different temperatures showed that pollen germination markedly influenced by temperature. At 25 and 35 °C, per cent pollen germination was similar and reached 74 to 79 per cent respectively, at 5 h incubation. Germination was rapid with a T_{50} (time of 50% germination in the population of germinating pollen grains) of nearly about 45 minutes. In contrast, germination was significantly reduced at 1 hour with only 6.6 per cent and 0.5 per cent at 15 and 5 °C temperatures respectively, compared with nearly about 50 per cent at two higher temperatures. The T_{50} at 15 °C was nearly about 2 hours. Maximum per cent germination at 15 °C was 73 per cent of that obtained at 25 °C. Germination was reduced by over 90 per cent when pollen assay were conducted at 5°C.

Dinesh *et al.* (2011a) examined the pollen viability with acetocarmine stain (1%) and reported 93.20 per cent pollen viability in Ganesh cultivar of pomegranate, 91 per cent in Bhagwa, 92.80 per cent in Mridula and 88 per cent in Arakta in Solapur conditions of Maharashtra.

Kumar (2012) attempted crosses between six soft seeded cultivars namely Ganesh, G-137, Dholka, Nabha, Jodhpur Red, Mridula and three hard seeded cultivars namely Kandhari Hansi, China Seedling and Bush Large. Pollen studies revealed that pollen viability in Acetocarmine ranged from 90.79 to 97.86 per cent whereas in Tetrazolium and Erythrosin B, pollen viability varied from 88.94 to 97.13 per cent and 80.76 to 94.65 per cent respectively. Maximum pollen germination was obtained in 10 per cent sucrose solution after 72 hours with 52.32 per cent germination and minimum was recorded in 20 per cent sucrose solution, having no germination after 24, 48 and 72 hours in some varieties.

Hybridization studies of Pomegranate

Nath and Randhawa (1959b) conducted studies to ascertain the precise nature of pollination in cultivar Muscat White and reported that wind does not play any role in pomegranate flower pollination. Pomegranate flower possesses dichogamy (protandry) and heterostyly. In fruit set experiment, greater percentage was obtained by hand pollination and open pollination as compared to self pollination. But since 46 per cent fruit set was obtained through self-pollination, so it was inferred that it is capable of both self and cross-pollination. Cross-pollination by hand, however improved the fruit set to 67.92 per cent.

Krestnikov (1974) reported that cultivar Desertyni (Dessert), obtained by crossing Wonderful with high yielding Soviet cultivars and back crossing to Wonderful, gave fruits which had equal standard and with soft seeds.

Josan *et al.* (1979) observed that fruit set by open pollination ranged from 26.61 per cent (Kandhari) to 63.81 per cent (Dholka) and by self pollination, fruit set varied from 20 per cent (Kandhari) to 53.33 per cent (Bedana, Sunni Bedana, Anar Malas and Kazkai). Fruit set through controlled cross-pollination was higher than self and open-pollination. Minimum fruit set (60%) was obtained in Bedana x Kazkai and maximum (76%) in Dholka x Kazkai when artificial cross-pollination was performed. So, it was inferred that fruit set was improved by open-pollination and cross-pollination and hence reported pomegranate to be an often cross-pollinated crop.

Kale (1986) made an attempt to incorporate blood red colour of Russian type cultivars into Ganesh. Several crosses were made at MPAU, Rahuri in 1976 and out of 122 F_1 hybrids, seven had deep red aril colour but hard seeds and inferior taste than Ganesh. Purohit (1987) observed that pollination by soft seeded cultivars slightly decreased seed hardness in hard seeded cultivars while pollination either by a hard or soft seeded cultivar increased seed hardness in soft seeded cultivars. Keskar *et al.* (1989) reported that in a hybridization programme initiated at MPAU, Rahuri, back crossing with resultant F_1's of Ganesh and Russian types Ganesh did not give good results, however some desirable recombinants in F_2 progeny raised from open pollinated fruits of these hybrids have been observed as Mridula.

Karale *et al.* (1993) obtained higher fruit set (66.20%) in artificial self-pollination than through natural self-pollination (43.30%). Fruit set through open-pollination was 79 per cent. So, it was concluded that pomegranate is capable of both self and cross-pollination. Pareek (1996) reported about a Hybrid No. 15-9-94 with dark red, non sticky arils and soft seeds with high sweetness and low tannin and further named it Ruby. Kumar (1998) evaluated more than 2900 hybrids of single, double, three way and other complex crosses including F_2's in a breeding programme carried out at Indian Institute of Horticulture Research, Bangalore to develop vigorous growing plants having attractive fruits, deep red, bold arils, soft, small seeds and sweet juice.

Nageswari *et al.* (2000) carried out a hybridization programme involving five hybrid combinations, Ganesh x Jyoti, Ganesh x Kabul, Ganesh x YCD-1, Jyothi x Ganesh and Ganesh x Bedana Bosco at Horticultural Research Station, Yercaud. The aril colour was dark pink in the cross Ganesh x Jyothi, light pink in Ganesh x Kabul and Ganesh x YCD-1 and pink in Jyothi x Ganesh and Ganesh x Bedana Bosco. The texture of seed was medium in all the crosses except the cross Jyothi x Ganesh, which produced fruits with soft seeds.

Jalikop *et al.* (2000) reported that a F_1 pomegranate hybrid known as "Amlidana" was developed at Indian Institute of Horticultural Research, Bangalore by hybridizing Ganesh, a popular table cultivar and a dwarf ornamental miniature pomegranate Nana.

Jalikop and Kumar (2000) reported about Ruby, a multiple pomegranate hybrid, bred mainly for red arils and soft seeds. The hybrid develops dark red arils in winter and dark pink or red in summer with soft seeds. Ruby derives certain fruit quality attributes from Ganesh, while incorporating genes for red colour from a Russian cultivar, Gulsha Rose Pink. Ruby–complex hybrid between Ganesh, Kabul and Yercaud developed at Indian Institute of Horticultural Research, Bangalore.

Derin and Eti (2001) studied the percentage of fruit set through self, open pollination and cross pollination in Hicaz and 33 N 26 pomegranate cultivars under Adana conditions, Turkey in 1997. They reported that rates of fruit set in self and open pollination were lower than cross-pollination. The lowest fruit set was obtained from open pollination in 33 N 26 with 46.02 per cent and highest fruit set (78.92%) was observed in Hicaz pollinated with pollen taken from 33 N 26 male flowers. The fruit set level was found to be 70.50 per cent in Hicaz x 33 N 26 bisexual flower combinations, 68.50 per cent in 33 N 26 x Hicaz male flower combinations and 61.75 per cent in 33 N 26 x Hicaz bisexual flower combinations. In both Hicaz and 33 N 26 cultivars fruit set was increased considerably when pollinated with pollen taken from male flowers.

Jalikop (2003) investigated the rosseted siblings in F_2 of a cross in pomegranate using Ganesh, Kabul Yellow rosette mutant clone (RMC) and Kabul Yellow wild type clone (WTC) and studied the seed germination of different cross combinations *viz.* G x RMC-F_2 (N), G x RMC-F_2 (33 D), (G x RMC) x G-BC_1, (G x RMC) x WTC-BC_1, (G x RMC) x 33 G, (G x RMC) x 33 G. He recorded high seed germination percentage (38.82%) in (G x RMC) x 33 G and minimum (0.12%) in cross combination (G x RMC) x 33 G.

Sharma and Bist (2003) examined the per cent fruit set and reported that through open pollination it ranged from 9.26 to 23.32 per cent and fruit set upon selfing by bagging varied from 5.91 to 13.72 per cent. Fruit set varied from 50 per cent (G-137 x Anar Shirin Mohammad Ali) to 90 per cent (Mridula x Kandhari Hansi) through artificial cross pollination.

Jayesh and Kumar (2004) performed hybridization among seven pomegranate cultivars namely Ganesh, Kabul Yellow, Nana, Ruby, Double flower, Amlidana and hybrids from August 2001 to Feburary 2002 and recorded the fruit set in different cross combinations. Maximum fruit set was observed

in crosses involving Ganesh, Ruby, Daru and very low in Kabul Yellow upon selfing and same trend was observed in crosses involving Kabul Yellow, possibly due to poor cross and self-compatibility with other genotypes. The highest numbers of single crosses were done in Ganesh x Ruby followed by Daru x Ganesh and Ruby x Ganesh. Cross involving (Ganesh x Nana) resulted in higher fruit set (66.67%) when compared to F_1's in the three way crosses. Though, maximum numbers of crosses were made in three way crosses but highest percentage fruit set was observed in selfing. In winter months, maximum numbers of fruits were produced in all crosses due to the low temperature and high humidity conditions, thereby resulting in higher percentage viable pollens.

Jalikop *et al*. (2005) employed the pomegranate cultivar Daru in breeding tropical anardana cultivar and disease resistance as it exhibited high level of acidity and field tolerance. Daru was crossed with cultivar Ganesh as well as the F_1's of the Ganesh x Nana and Ganesh x Kabul yellow. Very high fruit acidity was recorded in all the crosses. High acidity was always dominant to low acidity, pink aril colour to white and hard seeded nature to soft. Jalikop *et al*. (2006) reported that the resistance for bacterial blight was governed by recessive alleles in 'Daru' while that of 'Nana' an ornamental pomegranate was controlled by dominant alleles. The overall segregation pattern revealed a polygenic control of fruit attributes. Generally, greater segregation with more recombinants was recorded in F_2 than in F_1. YanLi *et al.* (2006) reported that cultivar Yushiliu-4 was derived from the cross between Yushiliu 1 and Yushiliu 3, attempted in 1986 and proved to be a very promising cultivar having large sized fruit upto 366.70 grams on average but reached 757 grams, had a deep glossy red rind and high adaptability. Fruit matures at the end of September.

Sheikh (2006) reported that Bhagwa – commercially known by different names *i.e*. Shendari, Asthagandha, Mastani, Jai Maharashtra, and Red Daina in various districts of Maharashtra, is the selection from progeny raised from cross between Ganesh and Gul Shah Red. This cultivar had attractive glossy red thick skin with blood red arils *vis-a-vis* soft seeds, high TSS and thin skin. He also reported that, cultivar Arakta, a selection from open pollinated population of a cross Ganesh and a Russian cultivar. The fruit of cultivar was dark red, soft seeded, dark red colored aril and high TSS.

Isk and Celik (2009) carried out an experiment to study similarities between pomegranate parents and crosses regarding some fruit characteristics. After self-pollination and crossing, 9 combinations were compared with their parents regarding taste, rind colour, aril colour and seed hardness properties. The fruits of 87.63 per cent of Fellahyemez x Ernar and 93.58 per cent of Ernar x Fellahyemez combinations were observed to be sweet. The higher percentage (37.11%) of the types in Fellahyemez x Ernar combination were soft seeded whereas the higher percentage (44.92%) of the types in the Ernar x Fellahyemez combination were hard seeded. The fruits of 39.70 per cent and 40.66 per cent of Hicaznar x Ernar and Ernar x Hicaznar were hard seeded respectively. While 38.50 per cent of the types obtained from the Hicaznar x Fellahyemez combination were soft seeded, 44.64 per cent of Fellahyemez x Hicaznar combination were found to be hard seeded. Jalikop *et al.* (2010) hybridized varieties Ganesh, Kabul Yellow, 'Nana' and their hybrids with 'Daru' in order to introgress bacterial blight resistance. When wild non-cultivated types are involved in the breeding work, one has to go for repeated backcrosses by making selection in each generation in order to eliminate several undesirable traits of the wild type.

Dinesh *et al.* (2011a) conducted an investigation at National Research Centre on Pomegranate, Solapur, Maharashtra during 2008-09 and studied the extent of fruit set and fruit retention upon selfing as well as crossing of cultivar Ganesh. They observed 31.57 per cent fruit set out of which 16.66 per cent fruits were retained at one month after selfing whereas when Ganesh was crossed with the pollen of hermaphrodite (h), intermediate (i) and staminate flowers (s) of Bhagwa, 56.66, 53.33 and 36.66 per cent fruit set were observed in all the cross combinations, respectively. All the hybrid fruits were retained in two crosses (hermaphrodite and staminate flowers) at one month after crossing, whereas one cross combination (intermediate flowers) showed 50 per cent fruit retention.

Dinesh *et al.* (2011b) in another investigation conducted at National Research Centre on Pomegranate, Solapur, Maharashtra during 2008-09, studied the extent of fruit set and fruit retention upon selfing as well as crossing in cultivar Bhagwa. They observed 20 per cent fruit set and out of which 16 per cent fruits were retained at one month after selfing whereas when Bhagwa was crossed with the pollen of hermaphrodite (h), intermediate (i) and staminate flowers (s) of Ganesh, 33.33, 33.33 and 36.66 per cent fruit set were observed in all the cross combinations, respectively. All of the hybrid fruits showed retention at one month after crossing.

Singh *et al*. (2012) attempted some inter-varietal crosses with a view of infusing blood red aril colour and soft seededness in the hard seeded commercial varieties. Maximum fruit set (80.95%) was recorded in Dholka x Kandhari Hansi whereas minimum fruit set was (37.6%) was observed in Dholka x Bush Large.

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Direct seeded rice is a reduce input of rice production in India- A Review

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Received: 10.12.15
Accepted: 16.03.16

ABSTRACT

Rice (*Oryza sativaL.*))is one of the most important stable food crops in the world. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. Total geographical area under rice in India is 43.73 million hectares with annual production of 106.19 million tones with productivity 2.46 tons per ha in 2013-2014 crop year (Annual report 2014). As this crop requires standing water from transplanting to harvesting, thus cultivation of this crop is facing problems due to water shortages, particularly in Asia. Aerobic rice technique involves by direct seeding of rice in the field by skipping the practice of nursery raising as in conventional flooded rice cultivation system, is gaining ground with passage of time. The technique of direct seeded rice not only saves water but labor as well. The yield of direct seeded rice can be increased to many folds by optimizing plating pattern which is the most important agronomic practice.

Key words: Direct seeded rice, sowing method, aerobic

Rice (*Oryza sativaL.*) appears to have originated in the area of the foothills of the Himalayas, *Oryza sativa*var. *indica*on the Indian side and *Oryza sativa*var. *japonica* on the Chinese and Japanese side. It belongs to the genus *Oryza* of the sub tribe *oryzineae*in the family Gramineae. Rice genus *Oryza* consists of 24 conventional species, of which 2; *Oryza glaberrima*and *Oryza sativa*are cultivated and 22 are wild. All rice varieties of Europe, Asia and America belongs to the species *Oryza sativa*, whereas some of others rice cultivated varieties of West Africa belongs to the species *Oryza glaberrima*. It was considered that universal wild rice, *Oryza rufipogon*, was the wild ancestor of Asian rice [1, 2]. Rice is being grown in many regions of the world, mostly by conventional flooded rice cultivation system which provides 75% of the world rice supply [3].Imminent water crisis, water-demanding nature of traditionally cultivated rice and climbing labour costs ramble the search for alternative management methods to increase water productivity, system sustainability and profitability. Direct seeded rice (DSR) technique is becoming popular nowadays because of its low-input demanding nature. It offers a very exciting opportunity to improve water and environmental sustainability [4]. The reduced emission of these gases helps in climate change adaptation and mitigation, enhanced nutrient relations, organic matter turnovers, carbon sequestration and also provides the opportunity of crop intensification [5].Weeds are the greatest yield-limiting constraint to rice (WARDA, 1996)[6]. Rice farming is practiced in several regions and under a wide range of agro-climatic conditions. Over the centuries, naturally occurring selection pressure like submergence, drought and biotic stresses has widely diversified the rice ecosystem (FAO, 2004b)[7]. Traditionally, rice has been cultivated in flooded conditions mostly for irrigation and effective weed control (Bouman, 2003 [8]. But due to shortage of farm labor along with physical and economic scarcity of water, flood irrigated rice has been replaced by different less labor dependent and water saving production systems. Khush GA, (1997)[9].So with this background the available literature on "Direct seeded rice is a reduce input of rice production in India" has been reviewed and presented under the following heads.

Role of direct seeding

Direct-seeding methods have several advantages over transplanting (Singh *et al*., 2005) [10].In addition to higher economic returns, DSR crops are faster and easier to plant, less labour intensive and consume less water (Bhushan *et al.,* 2007), are conducive to mechanization (Khade *et al.,* 1993), generally flower earlier leading to shorter crop duration (Farooq*et al*., 2008)[11].Typically, DSR is established earlier than TPR without growth delays from transplant injury; which hastens physiological maturity and reduces vulnerability to late-season drought (Tuong L., 2008)[12]. Dry-seeding on flat land or raised beds with successive saturated soil conditions reduces the amount of water needed for land preparation and thus overall water demand (Bouman and Tuong, 2001 [13]. Direct seeding also offers the option to resolveedaphic conflicts (between rice and the subsequent non-rice crop) and enhance sustainability of both the rice–wheat cropping system and succeeding winter crops, particularly early sown wheat (Farooq*et al*.,

2008)[14]. Yield in DSR is often lower than TPR principally owing to poor crop stand and high weed infestation (Singh *et al.*, 2005) [15].Moreover, cost for weed control is usually higher than TPR. High weed infestation is a major constraint for broader adoption of DSR (Rao *et al*., 2013) [16].

Growth

Kumar *et al.* (2006) are revealed that, both the years average tillers was recorded in seedling of sprouted seed (426.08 tillers/m^2) as compared to as compared to conventional transplanted (358.75 tillers/m^2)[17]. Roy et al. (2009) reported that, the highest number of effective tillers per hill (18.02) was recorded from direct seeding with wider spacing 25 cm x 20 cm. They found that, plant height was higher under direct seeded rice as compared to puddled transplanted rice at 50 DAS but at time of harvest plant height did not differ among different methods of establishment[18]. Ghasal *et al.* (2014)found that, number of effective tiller were 21.2 percent and 13.8 percent higher under upland direct seeded rice and zero tillage direct seeded rice respectively over the puddled transplanted rice and they found dry matter accumulation was recorded higher under direct seeded rice as compared to puddled transplanted rice at 50 DAS and 100 DAS[19].Gill et al. (2014) recorded that, maximum dry matter of direct seeded is highest (145.2 q/ha) as compared to manual transplanting (135.6 q/ha) and maximum leaf area index (LAI) of direct seeded is highest (5.2) as compared to manual transplanting (4.2)[20].

Yield attributes and yield

Drum seeding recorded numerically higher grain yield and net returns (5.63 q/ha and Rs. 17,836 /ha) than transplanting methods (5.52 q per ha and Rs.16,165 /ha)Santhi *et al*. (1998) [21].Budhar and Tamilselven (2002).reported that, manual broadcasting method recorded higher grain yield of 57.22 q/ha followed by wet seeding with drum seeder (56.57 q/ha) and traditional transplanting method (55.7q/ha) [22]. Singh et al. (2008)noted that, under drilling method significantly increased panicle length of rice was as compared to transplanted rice.Parameswari *et al.* (2014)recorded that, rice yields under aerobic conditions 2.4–4.4 tonnes per hectare which, were 14–40 percent lower than under flooded conditions[23]. Lal*et al.* (2013)resulted in significantly higher grain yield (3.98 t/ha) followed by drum seeding (3.37 t/ha), broadcast seeding (3.27 t/ha) of sprouted seeds and row seeding (2.95 t/ha) [24].

Nutrient uptake

Singh et al. (2006) observed that, the total uptake of NPK by rice was significantly higher under transplanted rice (84.4, 15.6 and 110.8 kg/ha than direct seeded rice (78.2, 14.7 and 105.5 kg/ha) [25]. Gobi *et al*. (2008)revealed that, line planting with 50 hills per meter square registered significantly higher N uptake at tillering stage where as broadcasting with 40 hills per meter square recorded higher N uptake during flowering and at harvest stages. Seeding by broadcasting with 40 hills per meter square registered significantly higher P and K uptake. Revealed that, the highest uptake of NPK in transplanting method in 2003 was (96.22, 19.68 and 33.18 kg/ ha) and in 2004 was (96.53, 19.38 and 33.18 kg/ha) as compared to drum seedingYadav *et al.* (2010) [26].Brar and Bhullar (2013) revealed that, the rice grains utilized significantly lower amount of N, P and K in all direct seeding treatment as compared to transplanted [27].Islam *et al*. (2013 recorded that, total uptake of NPK at harvest with system of rice intensification (SRI), (69.63, 14.73 and 14.32 kg per ha respectively) followed by integrated crop management method (67.70, 14.32 and 14.18 kg/ha respectively) [28]. Parameswari et al. (2014)resulted in significantly observed that, NPK (112.8, 17.0 and 172.3 kg/ha respectively) up take by rice were significantly higher under transplanting than direct seeded rice [29].

Economics

Santhi et al. (1998) concluded that, drum seeding recorded numerically higher grain yield and net returns (5.63 q/ha and Rs. 17,836/ha) than manual establishment (5.46 q/ha and Rs. 16,561/ha) and transplanting (5.52 q/ha and Rs. 16,165/ha). Singh et al. (2008) establishment of rice by drilling and drum seeding were equally good and gave higher net returns and enhanced, B:C ratio than transplanted rice *viz.* drilling and drum seeding recorded higher net income (Rs. 39950 and 35060.5/ha) and B: C ratio (3.99 and 3.07 respectively), against the manual transplanting practice (Rs. 25172.5/ha and 2.00).Ghasal *et al*. (2014)reported that, both season net returns (Rs. 23466 /ha) and B: C ratio (1.74) was higher with TNAU drum seeder compared to conventional transplanting (Rs. 6474 /ha and 1.15).Rao *et al*. (2013)reported that, total cost of cultivation was higher under puddled transplanted rice over upland direct seeded rice and zero tillage direct seeded rice. Gill *et al.* (2014)revealed that, cost of cultivation (Rs/ha) was 8.87 per cent low in direct seeded rice but cost: benefit ratio was 3.96 per cent higher in direct seeded rice than transplanted rice.establishment transplanted method of paddy resulted stated that, line transplanting recorded significantly higher gross income (Rs.31158/ha) as compared to drum seeding (Rs. 30,829/ha) and broad cast seeding (Rs. 22,032/ha)Parameswari et al. (2014).

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Rapid and highly efficient In vitro regeneration protocol for cowpea (*Vigna unguiculata* (L.) Walp.)

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Received: 08.01.16
Accepted: 18.03.16

ABSTRACT

The cotyledons node explants of *Vigna unguiculata* variety GC-4 were cultured on Murashige & Skoog (MS) medium supplemented with 0-5mg/liter BAP. All treatments produced shoot. Most rapid growth and number of shoots were achieved through 1mg BAP/ liter. Rhizogenesis was recorded in MS medium with IBA (0.5 – 5 mg/liter). The highest rooting (89.56%) was observed on medium supplemented with 5 mg/liter of IBA under continuous light conditions. Higher plantlet regeneration was obtained using cotyledonary node explants in Cow pea than any other explants.

***Key words*:** Cowpea, In-vitro Regeneration, Ex-plants, MS medium, Kinetin and Auxin.

Cowpea (*Vigna unguiculata* (L.) Walp.) is cultivated around the world primarily as a pulse but it also used as a vegetable, as a cover crop and as fodder for animals(Li *et al*., 2011). Cowpea is having abundant amount of nutritious value such as its grains contain about 25% protein, especially rich in folate, potassium, iron, magnesium and the essential amino acids lysine and tryptophan (Smatt, 1976). However, cowpea is one of the greatest plant victims of pathogens attack due to its succulent nature. More than 20 viruses, 31 insect species (insects, aphids, flower thrips, cowpea pod borer, pod sucking bugs, the cowpea weevil, and the leaf beetle) and also some fungal disease (anthracnose, brown blotch, leaf spots, web blight) have been reported on cowpea from different cowpea production areas (Diallo et al., 2008; Latunde-Dada, 1990; Ehlers and Hall, 1997; Li et al., 2011). The production of transgenic cowpea plants harboring genes of interest has been mostly unsuccessful due to the nonexistence of a compatible and efficient method of plant regeneration (Le et al., 2002; Diallo et al., 2008).

A biotechnological approach could help breeders to overcome these losses, by genetically engineering cowpeas at the cellular and molecular level. However, effective plant genetic manipulations require a reliable method of plant regeneration. Various cells, tissues and organs from numerous plant species have been cultured successfully to regenerate whole plants (Raut et al., 2015). Plant regeneration of cowpea via organogenesis has been achieved from epicotyls, hypocotyls, primary leaves, cotyledons, cotyledonary nodes, shoot tips, plumular apices and shoot meristem. Of these, cotyledonary node explants seemed the most responsive for the induction of multiple shoots, which was appropriate to agrobacterium-mediated transformation (Chaudhury et al., 2007; Raji et al., 2008; Solleti et al., 2008a, 2008b; Adesoye et al., 2010). The paper deals with rapid and easy protocol for regeneration of cow pea plantlet.

MATERIALS AND METHODS

Plant material

Healthy seeds of Cowpea variety GC-4 (obtained from Center of Excellence for Research on Pulses, Sardarkrushinagar Dantiwada Agriculture University (SDAU) Sardarkrushinagar, Gujarat, India) was used to establish and optimize the regeneration.

Explant preparation

The seeds were first washed thoroughly with tap water for 5 to 10 min. Subsequently, rinsed in 70% (v/v) ethanol for 1 minute and surface-sterilized with 0.1% (w/v) mercuric chloride solution for 7 min followed by several rinses in sterile distilled water to remove all traces of mercury. External seed coats were aseptically removed using sterile forceps.

Germination

Seeds were aseptically germinated in glass culture tubes which containing MS medium (1962) consisting 3% sucrose and B5 vitamins (Gamborg *et al*. 1968) supplemented with TDZ (40 µmol/L).

Shoot induction and elongation

The cotyledons node explant excised from 6-day-old seedling were cultured in MSB5 medium supplemented with 6-BAP with of various concentrations (0.5, 1, 2, 3 and 4 mg.l-1 6-BAP), respectively. The pH of all media was adjusted to 5.6-5.8 using 0.1 N KOH or 0.1 N HCl after adding 3.0% sucrose. All cultures were incubated in growth chamber at 24±2^{o}C with 16 h light photoperiod. After 12 days of culture, the multiple shoots were removed from the explants and transferred to fresh

medium with the same concentration of 6-BA for subculture for another 18 days.

Rooting and acclimatization

Regenerated shoots with appropriate size were removed and placed on MS supplemented with 0.0, 0.5, 1.0, 2.0 and 5.0 mg.l-1 IBA in culture tubes for 18 days with 16 h light photoperiod.

After 18 days of culture on rooting media, In vitro plantlets were subjected to a hardening procedure. The plantlets were removed from MS medium and washed to remove the residual agar completely from the roots. The plantlets were transferred to plastic cups containing clay, sand and organic matter (2:1:2). The pots were covered with low density transparent polythene bags to maintain the internal humidity and placed in growth room at room temperature. A hole was made in the cover and filled with plastic foam to gradually reduce the relative humidity. The cups were in the growth room for a week (26°C, approximately 12 h day length). The established plants from cups were then transferred to pots in sterile soil in the net house where the plants were grown to maturity.

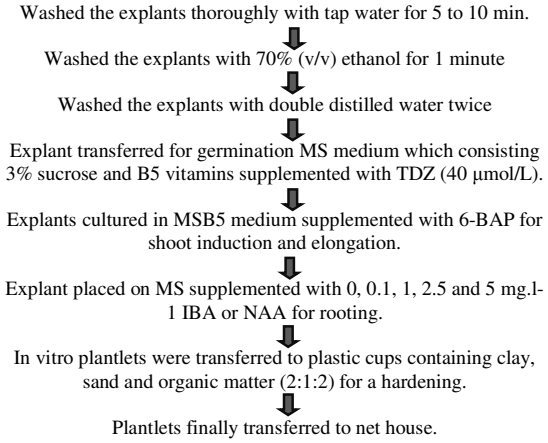

Fig.1 Experimental Procedure Design

RESULTS AND DISCUSSION

Shoot regeneration started within a week from explants, MSB5 medium was more efficient for multiple shoots formation from cotyledonary node explants. Shoot proliferation was favored in presence of BAP (1 mg.l-1) producing a 5.57 average number of shoots per explant when cultivated on MSB5. Length of regenerated shoot range from 7.83 to 24.55 mm, respectively. The minimum shoot length 7.83mm was observed on MS medium containing 2 mg/l BAP whereas, maximum shoot length (24.55mm) was recorded in MS medium with 0.5mg/l BAP. Increasing BAP concentration explants reduced shoot proliferation and their subsequent elongation (Table 1).

The results clearly showed the effects of the concentration of BAP on the frequency (%) of shoot regeneration, mean number of shoots per explant and shoot length. Direct organogenesis from cotyledonary nodes cultured on MSB5 containing BAP responded well in plant regeneration (Ravindra et al., 2009 and Aasim et al., 2013).

On control medium (MS half strength without hormone), the rooting rate was 38.75% after 1 week. Our study is akin to Ravindra et al., 2009 showed that MSB5 bereft of hormone could give rise roots. Induction medium (MS half strength) added with IBA (0.5-5 mgl-1), cultures produced highest percentage of rooting (89.56%) and vigorous roots. IBA was found more effective for rooting (Sani et al.,2015). However shoots and roots did not elongate significantly comparatively at lower concentration (Table 2).

CONCLUSION

In the present investigation, we tried to break the adage of legumes are recalcitrant to in vitro regeneration. 1 mg.l-1 BAP mg/L respond well for proliferation and elongation of shoots from cotyledonary node explants and IBA was found more effective for rooting because shoots were more vigorous and roots longer, 5.0 mg.l-1 IBA cultures produced highest percentage of rooting (89.56%) and vigorous roots.

Table 1: Effect of different concentrations of BAP on average proliferation and elongation of shoots from cotyledonary node explants of *Vigna unguiculata*

BAP (mg.l-1)	Average no of shoot per explants	Average Shoot length (mm)
0	1.87	12.78
0.5	3.20	24.55
1	5.57	11.25
2	3.45	7.83
4	2.56	8.47

Table 2: Effect of different concentration of auxin on inductive media on roots development after 7 days culture in expression basal medium (without hormone).

IBA (mg.l-1)	% Rooting
0.0	38.42
0.5	60.47
1	61.75
2	65.83
5	89.56

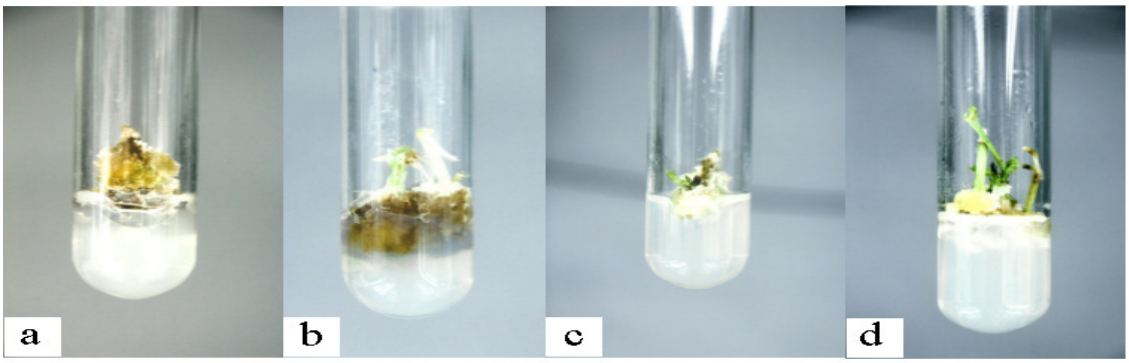

Fig. 2 Callus initiation from explant and shooting, plant regeneration from callus of genotype of Cowpea (*Vigna unguiculata* (L.) Walp.)(a) In Callus formation from apical meristem explants, (c) Shoot initiation from callus on MS medium supplemented with BAP (1 mgl-1), (d) Shoot elongation from callusing on MS basal medium supplemented with BAP (1 mgL−1)

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Knowledge of improved sugarcane (*saccharum officinarum* l.) production technology by the farmers of Chittorgarh district of Rajasthan

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Received: 07.09.15
Accepted: 12.03.16

ABSTRACT

Sugarcane is an important commercial crop playing a key role in social and economic status of the country. The present study was conducted in Chittorgarh district of Rajasthan. There are total ten tehsils in Chittorgarh district, out of which two tehsils namely, Chittorgarh and Gangrar were selected on the basis of maximum area under sugarcane cultivation. Four villages from each identified tehsil were selected on the basis of maximum area under sugarcane cultivation. For selection of respondents, 120 sugarcane growers (40 marginal, 40 small, and 40 large farmers) were randomly selected from identified villages for data collection.

The study revealed that 36.67 per cent of the total respondents possessed in medium level of knowledge while, 35.83 and 27.50 per cent sugarcane growers had low and high level of knowledge about improved sugarcane production technology. In overall farmers had more knowledge about soil and field preparation and time of sowing, whereas, less knowledge regarding soil treatment and plant protection measure.

Key words :- Knowledge, Technology, Sugarcane, molasses, bagasses and treatment.

Sugarcane is cultivated in about seventy five countries; the leading countries are being India, Brazil, Cuba, Mexico, Thailand, etc. Sugarcane is an important commercial crop playing a key role in social and economic status of the country. Now a day, sugarcane cultivation and sugar industry helps in increasing the economy of India. Sugar industry supports the alcohol and paper industries with its byproducts like molasses and bagasses. Molasses based feed is important for animal husbandry in India.

Sugarcane is becoming an important cash crop for farmers because there is a great potential for sugar production and by products of sugarcane in domestic market. Therefore the expansion of sugarcane industry in india would greatly benefit the economy by foreign exchange saving, generation of employment and income, development of rural area and living standard of rural people. India is considered as homeland of sugarcane, In India 35 million farmers are engaged in sugarcane cultivation on 4.09 million hectares of land. Though sugarcane occupies only two per cent of the total cultivated area, it contributes to seven percent of the total value of agricultural output.

Geographically, Rajasthan is well suited for growing sugarcane. In Rajasthan sugarcane is mainly growing in Shriganganagar, Chittorgarh, Bundi, Rajasmand, Udaipur, Bharatpur, Tonk, Dholpur, and Banswara districts. In the Southern Rajasthan, Chittorgarh district ranked first in highest area in sugarcane crop under MPUAT service area. It is generally assumed that if an individual has more knowledge about different aspects of technologies, he is likely to adopt the innovations with higher speeds. Keeping this in mind the present study was carried out with the specific objective "To assess the knowledge level of sugarcane about improved sugarcane production technology".

METERIAL AND METHODS

The present investigation was conducted in Chittorgarh district of Rajasthan because of the selected district has the highest area and great potential of increasing production and productivity under sugarcane crop. The selected district consist of ten tehsils, out of which two tehsil namely Chittorgarh and Gangrar with maximum area under sugarcane crop were selected for the study purpose. Four villages from each tehsil were identified on the basis of maximum area under sugarcane crop. Thus, in all eight villages were selected for the present investigation. To select the respondents, a comprehensive list of all sugarcane growers was prepared separately for all selected villages of identified tehsils. Then after the farmers were categorized in to three categories i.e. large, small and marginal farmers. The respondents were selected randomly from each category of the farmers. Following the procedure laid down above a sample of total 15 respondents from each category of sugarcane grower from each selected village was

taken. Thus the study sample for the present investigation was comprised of 120 respondents. (*i.e.* 40 marginal, 40 small, and 40 large farmers). Data were collected by personnel interview technique through suitable structured schedule. Thereafter, data were tabulated, analysed and inferences were drawn in light of the objective.

RESULTS AND DISCUSSION

Knowledge of farmers about improved sugarcane production technology:

It was tried to find out the level of knowledge of farmers about improved sugarcane production technology. Knowledge as a body of understood information possessed by an individual is one of the important components of behavior and plays an important role in adoption of an innovation. Keeping this view in mind, the level of knowledge of farmers about improved sugarcane production technology was assessed. The results are presented in subsequent tables.

Distribution of respondents according to their knowledge about improved sugarcane production technology

To get an overview of the knowledge level, the respondents were grouped into (i) low (< 60.28), (ii) medium (60.28 to 67.18) and (iii) high (> 67.18) knowledge level on the basis of calculated mean and standard deviation of the obtained knowledge scores. The distribution of respondents in each category is given in table 1.

The data in table 1 reveal that out of 120 respondents, majority of respondents 36.67 per cent fell in medium level knowledge group whereas, 35.83 per cent sugarcane growers were observed in the low level knowledge group and remaining 27.50 per cent respondents possessed high level of knowledge about improved sugarcane cultivation technology.

Further analysis of data in table indicates that 60.00 per cent marginal farmers, 35.00 per cent small farmers and 12.50 per cent large farmers had low level of knowledge about improved sugarcane cultivation technology. Whereas, 30.00, 40.00 and 40.0 per cent marginal, small and large farmers possessed medium level of knowledge about improved sugarcane cultivation technology respectively. On the other hand, 10.00 per cent marginal farmers, 25.00 per cent small farmers and 47.50 per cent large farmers were kept in the high level of knowledge group about improved sugarcane cultivation technology.

On the basis of above data, it could be inferred that fair majority of the large farmers possessed high level of knowledge about improved practices of sugarcane cultivation. With the results at hand it can be safely concluded that the existing knowledge of large farmers is comparatively higher than the marginal and small farmers in the study area. The higher knowledge of large farmers can be attributed to their high degree of economic motivation, high S.E.S. and higher cosmopolitan outlook.

Aspect-wise knowledge of respondents about improved sugarcane production technology

To get a clear picture of knowledge possessed by sugarcane growers, aspect-wise knowledge of sugarcane growers was worked out. For this mean per cent scores for each practice was calculated and ranks were accorded. The results of the same have been presented in table 2.

The data presented in table 2 shows that large farmers of the study area possessed 81.79 per cent of knowledge about use of high yielding varieties aspect of sugarcane production technology whereas, knowledge of marginal and small farmers about this practice was comparatively less with 63.57 per cent and 69.29 per cent. It was observed that majority of the farmers had knowledge about the name of varieties of sugarcane namely CO-419, CO-449, CO-997, CO-1007and CO-527 and they were fully acquainted with duration and average yield of these recommended varieties of sugarcane in the study area.

The knowledge about soil and field preparation it was noted that marginal, small and large had knowledge 89.0, 98.0 and 97.0 per cent respectively. Further, analysis of table shows the marginal, small and large farmers had extent of knowledge about soil treatment was 55.83, 35.00 and 39.17 MPS respectively. Majority of the respondents were not aware of chemicals used for the soil treatment for killing termites in their fields in small group of farmers.

Further, analysis of table shows the marginal, small and large farmers had extent of knowledge about seed treatment was 48.33, 60.83 and 69.17 MPS respectively The knowledge about time of sowing, it was found that 77.92, 95.42 and 96.67 per cent knowledge was recorded in large, small and marginal farmers and ranked second by small and large farmers respectively.

Regarding knowledge about seed rate and recommended method of sowing, it was noted that marginal, small and large farmers had 70.83, 85.00 and 89.17 per cent extent of knowledge respectively. Majority of the respondents from all categories of farmers had fully knowledge about recommended seed rate 40000 – 45000 setts/ha and plant to plant distance 25 cm and row to row distance 90 cm is the most appropriate spacing for sugarcane. In case of fertilizers application, marginal, small and large farmers had 83.00, 82.00 and 84.67 per cent knowledge and ranked fourth by small, large and second by marginal farmers respectively. Whereas,

in case of irrigation management, marginal, small and large farmers had 65.00, 69.58 and 74.17 per cent knowledge and ranked seventh by small and marginal farmers and eighth by large farmers respectively.

Regarding knowledge about weed management practice was placed at fourth rank by marginal farmers, fifth by large farmers, and sixth rank by small farmers with 74.88, 84.58 and 75.21 MPS respectively.

Regarding knowledge about plant protection measures, it was found that marginal, small and large farmers had knowledge 61.62, 63.97 and 65.59 per cent respectively. Table clearly shows that all the category of farmers had high knowledge about plant protection measures and this aspect ranked ninth by marginal and small farmers, tenth by large farmers. It means that sugarcane growers were acquainted with plant protection measures; they have fair knowledge about insect-pest of sugarcane in comparison with chemicals quantity used to control them. At last the knowledge about harvesting, it was found that 67.50, 76.67 and 75.00 per cent was recorded in marginal, small and large farmers respectively. The knowledge about this aspect at sixth ranked by the marginal, fifth by small farmers, seventh rank by large farmers respectively.

In overall, it has found that first rank is given to soil and field preparation with MPS 94.67, followed by time of sowing with MPS 90.00, fertilizer application with MPS 83.22, seed rate and recommended method of sowing with MPS 81.67 and were ranked second, third and fourth respectively. It indicate that sugarcane growers knew very well about soil and field preparation, time of sowing fertilizer application and seed rate and recommended method of sowing. Whereas less knowledge regarding soil treatment with MPS 43.33, seed treatment with MPS 59.44 and plant protection measure with MPS 63.73.It was observed that most of the respondents were not aware about chemical used for seed treatment and soil treatment.

Comparison of knowledge among marginal, small and large farmers about improved sugarcane production technology

To find out the significance of difference among the marginal, small and large farmers with respect to knowledge about improved sugarcane production technology, analysis of variance test (f test) was applied. The results are presented in table 3.

Hypothesis

H_{01} There is no difference among marginal, small and large farmers with respect to knowledge about improved sugarcane production technology.

RH_1 There is a difference among marginal, small and large farmers with respect to knowledge about improved sugarcane production technology.

The data recorded in table 3 shows that calculated 'f' value 28.39 is higher than tabulated value at 1 per cent level of significance. Thus, the hypothesis (H_{01}) is rejected and alternative hypothesis which stated that "there is a difference among marginal, small and large farmers with respect to knowledge about improved sugarcane production technology" was accepted. It infers that there was a significant difference in knowledge among marginal, small and large farmers about sugarcane production technology.

By comparing the mean value with critical difference (C.D.) value, it was found that there was a difference between large and small, and marginal, large and marginal farmers about knowledge of improved sugarcane production technology. This reveals that large farmers possessed more knowledge than marginal and small farmers about sugarcane production technology. Higher knowledge of large farmers about improved practices of sugarcane cultivation was not unexpected. The large farmers of the study area had contacts with scientists of Krishi Vigyan Kendra located in the district. Furthermore they have better extension contacts and cosmopolitan outlook due to higher socio-economic status which might have contributed in increasing the knowledge of this category in comparison to others.

CONCLUSION

It was concluded from the study that 36.67 per cent of the total respondents possessed in medium level of knowledge while, 35.83 and 27.50 per cent sugarcane growers had low and high level of knowledge about improved sugarcane production technology. In overall farmers had more knowledge about soil and field preparation and time of sowing, whereas, less knowledge regarding soil treatment and plant protection measure.

Table 1: Distribution of respondents on the basis of level of knowledge about improved sugarcane production technology

n =120

Knowledge level	Marginal farmers		Small farmers		Large farmers		Total	
	F	**%**	**F**	**%**	**f**	**%**	**f**	**%**
Low (<60.28)	24	60.00	14	35.00	5	12.50	43	35.83
Medium (60.28 to 67.18)	12	30.00	16	40.00	16	40.00	44	36.67
High (>67.18)	4	10.00	10	25.00	19	47.50	33	27.50
Total	**40**	**100.00**	**40**	**100.0**	**40**	**100.0**	**120**	**100.0**

f = Frequency, % = per cent

Table 2: Extent of knowledge of farmers about improved sugarcane cultivation practices

n=120

Aspect/ Practices	Marginal farmers		Small farmers		Large farmers		Total	
	MPS	Rank	MPS	Rank	MPS	Rank	MPS	Rank
Use of high yielding varieties	63.57	8	69.29	8	81.79	6	71.55	7
Soil and field preparation	89.00	1	98.00	1	97.00	1	94.67	1
Soil treatment	55.83	10	35.00	11	39.17	11	43.33	11
Seed treatment	48.33	11	60.83	10	69.17	9	59.44	10
Time of sowing	77.92	3	95.42	2	96.67	2	90.00	2
Seed rate & recommended method of sowing	70.83	5	85.00	3	89.17	3	81.67	4
Fertilizer application	83.00	2	82.00	4	84.67	4	83.22	3
Irrigation management	65.00	7	69.58	7	74.17	8	69.58	8
Weed management	74.88	4	75.21	6	84.58	5	78.06	5
Plant protection measures	61.62	9	63.97	9	65.59	10	63.73	9
Harvesting	67.50	6	76.67	5	75.00	7	73.06	6

MPS = Mean per cent score,

Table 3: Comparison of knowledge among marginal, small and large farmers about sugarcane production practices

n=120

Source of variation	d.f.	SS	MSS	'f' Value
Between the categories of farmers	2	1355.617	677.808	28.39**
Error	117	2793.05	23.872	
Total	119	4148.667		

**Significant at 1 per cent level of significance.

Mean value Table

Categories of farmers	Mean value	SEm±	CD
Marginal farmers	63.18		
Small farmers	66.98	0.12	0.45
Large farmers	71.40		

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Impact of front line demonstrations on scientific temperament of wheat growers

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Received: 20.08.15
Accepted: 14.03.16

ABSTRACT

Available agricultural technology does not serve its purpose till it reaches and adopted by its ultimate users, the farmers. FLDs educate farmers through results obtained in terms of higher yields and also provide an effective learning situation as farmers see the crops and participate in the discussion for getting maximum production. While a large number of studies have been made to discuss the yield potentialities and procedures for conducting these demonstrations, limited studies have been conducted to assess the impact of FLD on scientific temperament of farmers. The present study was therefore conducted to find the impact of front line demonstrations on scientific temperament of wheat growers. The study was conducted in Tikamgarh district of Madhya Pradesh state, where Frontline Demonstrations were conducted by KVK, Tikamgarh and total 42 wheat growers from eight villages were benefitted by this programme. All 42 beneficiary farmers, and same number of non-beneficiary farmers, were selected randomly from same villages of Tikamgarh district. Thus total 84 respondents were selected for the study purpose. The finding of the study shows that majority of the respondents (beneficiaries of FLD programme and non-beneficiaries) possessed medium level of scientific temperament. The findings also indicates that correlation coefficients in respect of land holding, house type, farm power, occupation, annual income, mass media exposure, and adoption were found significant at 1 per cent level of probability except age, education, family size, family type and material possession. Regarding problems faced by the beneficiaries in adoption of new technology while conducting FLDs, majority of the beneficiaries reported untimely supply of agricultural inputs. Therefore, for improving FID majority of the respondents suggested timely supply of quality input in adequate quantity.

Key words: Scientific temperament, frontline demonstration, wheat growers.

The population is increasing in a geometric progression leading to an increased demand of wheat but there is no possibility of further increase in area due to growing urbanization, diversification, dwindling water resources, micro-nutrient deficiencies and soil health deterioration. Therefore, the need to produce more wheat has to be met out with fewer resources in a sustainable and cost effective manner. Front Line Demonstration (FLD) was started in wheat to generate production data and feedback information to various development agencies, which are engaged in dissemination of technological advances through researchers to the farmer's fields. For increasing the productivity and improving the economic condition of the farmers, depend upon the level of knowledge and skills of the farmers. The FLD aimed at achieving this twin objective by bringing about the change in knowledge and adoption behavior of farmers. The frontline demonstration is the important mandate of Krishi Vigyan Kendra. It aims to demonstrate the production potentialities of newly developed crop production technologies of pulses and oilseeds on farmers' field. FLDs educate farmers through results obtained in terms of higher yields and also provide an effective learning situation as farmers see the crops and participate in the discussion for getting maximum production. The main emphasis is to maximize production per unit area by using high yielding varieties of wheat in conjunction with the package and practices. While a large number of studies have been made to discuss the yield potentialities and procedures for conducting these demonstrations, limited studies have been conducted to assess the impact of FLD on scientific temperament of farmers. Considering the points, an effort was made to see the impact of FLD with regard to scientific temperament and adoption level of wheat growers. Therefore, the present study was conducted to find out the impact of front line demonstrations on scientific temperament of wheat growers.

MATERIAL AND METHODS

The study was carried out in Tikamgarh district of Madhya Pradesh, where Frontline Demonstrations were conducted by Krishi Vigyan Kendra (KVK) of Tikamgarh. The KVK, Tikamgarh was purposively selected as no impact studies were conducted and particularly relating to the effect of Frontline Demonstrations on scientific temperament of wheat growing farmers. The farmers from villages where

FLDs of wheat production technology were conducted by KVK, Tikamgarh were selected as FLD beneficiaries. Further, farmers who were not benefited by FLD were selected as non-beneficiaries. Accordingly two types of respondents were selected i.e. FLD Farmers/ Beneficiaries and Non FLD Farmers/ Non-Benificiaries. A total 42 wheat growers were benefitted by this programme. All the beneficiary farmers and same number of non-beneficiary farmers, as control were selected randomly from same villages of Tikamgarh district. Thetotal sample therefore, consisted of 84 respondent farmers from both the groups as shown in Table 1.

RESULTS AND DISCUSSION

Scientific temperament of respondents

The scientific temperament of the beneficiaries of FLD programme and non-beneficiaries was measured with the help of scientific temperament scale comprises of four components viz., scientific knowledge, scientific attitude, scientific habit and utilization of scientific method.

Scientific knowledge

Table 2 presents the percentage distribution of respondents on the basis of the scientific knowledge and shows that out of total respondents, 45.24 per cent had medium level of knowledge, 32.14 per cent had low and 22.62 per cent had high level of knowledge. In case of beneficiaries of FLD programme, 61.90 per cent had medium level of knowledge, 21.43 per cent had high and 16.67 per cent low level of knowledge. Similarly, in case of non-beneficiaries,47.62 per cent had low level of knowledge followed by 28.57 per cent had medium, and 23.81 per cent had high level of knowledge.The mean scores for FLD and non-FLD respondents were 13.19and11.12 with standard deviation of 3.68and 4.63, respectively.The t-test of such datawas found to be non-significant. The null hypothesis is therefore accepted, thereby indicating that there was no significant difference in level of knowledge of FLD and non-FLD respondents.

Scientific attitude

The data presented in Table 2 shows that out of the total respondents, 46.42 per cent had medium level of scientific attitude, while 28.57 per cent had high and 25 per cent had low level of scientific attitude. Regarding beneficiaries of FLD programme, 47.61 per cent of the respondents had medium level of scientific attitude, while 33.33 per cent had high and 19.04 per cent had low level of scientific attitude. Similarly, as regard to the non-beneficiaries of FLD programme, 45.23 per cent had medium level of scientific attitude, while 30.95 per cent had low and 23.80 per cent had high level of scientific attitude. The mean scores for FLD and non-FLD respondents were 155.2 and 144.31 with standard deviation of 49.52and 54.28, respectively.The t-test of such datawas found to be non-significant. The null hypothesis is therefore accepted, thereby indicating that there was no significant difference in level of scientific attitude of FLD and non-FLD respondents.

Scientific habit

Table 2 shows the percentage distribution of the respondents according to their scientific habit. It is clear from the table that out of total respondents, 38.10 per cent had medium level of scientific habit, followed by 32.14 per cent high and 29.76 per cent had low level of scientific habit. In case of beneficiary farmers of FLD programme, 40.47 per cent had high level of scientific habit, while 38.09 per cent had medium and 21.43 per cent had low level of scientific habit. Similarly, in case of non-beneficiary farmers, equal percentage of respondents i.e. 38.09 per cent had low and medium level of scientific habit and 23.81 per cent had high level of scientific habit. The mean score for FLD and non-FLD respondents was 94.48 and 81.14 with standard deviation of 35.94and 26.89, respectively. The t-test of such data was found to be non-significant. The null hypothesis is therefore accepted, thereby indicating that there was no significant difference in the level of scientific habit of FLD and non-FLD respondents.

Utilization of scientific method

Table 2 highlighted the percentage distribution of respondents according to their utilization of scientific method. It is obvious from the table that out of total respondents, 45.24 per cent had medium level of utilization of scientific method, while 32.14 per cent had high and 22.62 per cent had low level of utilization of scientific method. In case of beneficiary farmers,4 7.62 per cent respondents had medium level of utilization of scientific method, while 38.09 per cent had high and 14.29 per cent had low level of utilization of scientific method. Similarly, in case of non-beneficiary farmers, 42.86 per cent had medium level of utilization of scientific method, while 30.95 per cent had low and 26.19 per cent had high level of utilization of scientific method. The mean scores for FLD and non-FLD respondents were 5.67 and 4.52 with standard deviation of 2.13and 2.06, respectively. The t-test of such data was found to be non-significant. The null hypothesis is therefore accepted, thereby indicating that there was no significant difference in level of utilization of scientific method of FLD and non-FLD respondents.

Extent of Scientific temperament

The percentage distribution of the respondents according to their extent of scientific temperament is shown in Table 3. The perusal of the data in the table

reveals that 45.24 per cent respondents possessed medium level of scientific temperament, while equal i.e. 27.38 per cent of the respondents possessed low and high level of scientific temperament.

In case of FLD respondents, 45.24 per cent had medium level of scientific temperament, while 35.71 per cent had high and 19.05 per cent had low level of scientific temperament. In case of non-FLD respondents, 45.24 per cent had medium level of scientific temperament, while 35.71 per cent had low and 19.05 per cent had high level of scientific temperament. The data given in the Table 3 also presents mean value of scientific temperament of the farmers. The data indicated that mean value of scientific temperament of beneficiary farmers of FLD and non-beneficiaries was 266.14 and 235.09with standard deviation of 87.58 and 94.95, respectively. The t-test of such data was found to be non-significant. The null hypothesis is therefore accepted, thereby indicating that there was no significant difference in level of utilization of scientific method of FLD and non-FLD respondents.

Relationship between profile of wheat growers and their scientific temperament

The data presented in Table 4 indicated the correlation of all the attributes of the FLD and non-FLD respondents with scientific temperament towards wheat production technology. The data indicates the correlation coefficient between age (x_1), education (x_2), land holding (x_3), family type (x_4), family size (x_5), house type (x_6), material possession (x_7), farm power (x_8), occupation (x_9), mass media exposure (x_{10}), annual income (x_{11}) and adoption (x_{12}) with Y dependent variable i.e. 'scientific temperament'.

Relationship between different characteristics and scientific temperament of FLD Respondents

Table 4 shows that out of twelve independent variables, seven variables i.e. land holding, house type, farm power, occupation, annual income, mass media exposure and adoption were found to be significantly related with scientific temperament of wheat growers whereas age, education, family type, family size and material possession were non-significantly related with scientific temperament. Singh et al (2014) in their study reported that the adoption of well proven technology is constrained due to small size of holding and poor farm resources

The variable age had not shown any significant relationship with scientific temperament and the finding is in conformity with the findings of Subshini, Thyagarajan (2002) and Dayaram et al (2010).The variable family type had not shown any significant relationship with scientific temperament. This finding supports the finding of Mahoviya (2006), Nagle (2011).

Further, family size was not having significant relationship with scientific temperament. This finding supports the finding of Mahoviya (2006). The variable farm power was found to be positively and significantly related with scientific temperament at 1 per cent level of probability. This finding is in line with the finding of Mahoviya (2006) and Nagle (2011).

The data shows that the variables house type, landholding, occupation, income, mass media exposure and adoption were found to be positively and significantly related with scientific temperament at 1 per cent level of probability. Sharma et al (2011) in their study revealed that level of adoption was higher among beneficiary farmers who were provided seed material and training on improved package of pearl millet cultivation.

Scientific temperament of Non-FLD Respondents:

The correlation coefficient "r" between 12 different independent variables and their scientific temperament revealed that the correlation coefficient between age, education, land holding, family type, family size, house type, material possession, farm power, occupation, mass media exposure, annual income and adoption was non- significant. Thus, it can be concluded that there is no relation between various independent variables and scientific temperament of non-FLD beneficiaries.

Problems faced by the beneficiaries conducting FLDs

Table 5show the problems reported by the beneficiaries in adoption of new technology. It is evident from the data that the major problems reported were Untimely supply of agricultural inputs (83.33%), Lack of power supply (76.19%), Unavailability of fertile land (69.05%), Disbelief on govt. officials for distribution of agricultural inputs (61.90%), Lack of perceiveness regarding scientific management (57.14%), Rocky land caused problem in using agriculture implements (52.38%), Monopoly of business sector people (45.24%), Lack of frequent monitoring by scientific staff (38.10%), Change in weather (28.57%), Lack of irrigation facilities (21.43%) and Rising market prices of all commodities (14.29%).

Suggestions for improvement

Table 6shows the suggestions made by FLD beneficiaries. Among suggestions made by the FLD beneficiaries timely supply of quality input in adequate quantity was ranked first followed by loan facilities should be provided in time, technical knowledge should be given more regularly by the experienced local persons, irrigation facilities should be provided and pre-training of farmers before organizing FLD as second, third, fourth and fifth, respectively.

CONCLUSION

The finding of the study shows that majority of the respondents (beneficiaries of FLD programme and non-beneficiaries) possessed medium level of scientific temperament. The mean value of scientific temperament of beneficiary farmers of FLD was higher than the mean score of scientific temperament of non-beneficiaries. The t-test of such data was found to be non-significant indicating that there was no significant difference between scientific temperament of FLD and non-FLD respondents. Regarding relationship between different characteristics and scientific temperament, it was found that land holding, house type, farm power, occupation, mass media exposure, annual income, and adoption affect the scientific temperament. Hence, these factors may be considered for increasing the scientific temperament of the farmers.

Table 1. Number of selected FLD and non-FLD farmers from different villages

Village	No. of Beneficiary Respondents	No. of Non-beneficiary Respondents
KateraKhera	7	7
Kanti	17	17
Bhopalpura	6	6
Surajpura	3	3
Charpuan	2	2
Juravan	2	2
Vidha	3	3
Madhuvan	2	2
Total	**42**	**42**

Table 2. Distribution of respondents according to different components of scientific temperament

Categories	FLD respondents F (%)	Non-FLD respondents F (%)	Total F (%)
A. Scientific knowledge			
Low (up to 8 scores)	07 (16.67)	20 (47.62)	27 (32.14)
Medium (9 to 16 scores)	26 (61.90)	12 (28.57)	38 (45.24)
High (17 and above scores)	09 (21.43)	10 (23.81)	19 (22.62)
Total	42	42	
$\overline{X}$	13.19	11.12	
S.D.	3.68	4.63	
Calculate t value		0.0261^{NS}	
B. Scientific attitude			
Low (35 to 105 scores)	08 (19.04)	13 (30.95)	21 (25.00)
Medium (106 to 175 scores)	20 (47.61)	19 (45.23)	39 (46.42)
High (176 to 245 scores)	14 (33.33)	10 (23.80)	24 (28.57)
Total	42	42	
$\overline{X}$	155.2	144.31	
S.D.	49.52	54.28	
Calculated t value		0.34^{NS}	
C. Scientific habit			
Low (21 to 63 scores)	09 (21.43)	16 (38.09)	25 (29.76)
Medium (64 to 105 scores)	16 (38.09)	16 (38.09)	32 (38.10)
High (106 to 147 scores)	17 (40.47)	10 (23.81)	27 (32.14)
Total	42	42	
$\overline{X}$	94.48	81.14	
S.D.	35.94	26.89	
Calculated t value		0.058^{NS}	

D. Utilization of scientific method			
Low (1 to 3 scores)	06 (14.29)	13 (30.95)	19 (22.62)
Medium (4 to 6 scores)	20 (47.62)	18 (42.86)	38 (45.24)
High (7 to 9 scores)	16 (38.09)	11 (26.19)	27 (32.14)
Total	42	42	84
$\overline{X}$	5.67	4.52	
S.D.	2.13	2.06	
Calculated t value		0.0144^{NS}	

NS = Non-significant

Table 3. Distribution of respondents according to their scientific temperament

Categories	FLD respondents F (%)	Non-FLD respondents F (%)	Total F (%)
Low (up to 179 scores)	08 (19.05)	15 (35.71)	23 (27.38)
Medium (180 to 300 scores)	19 (45.24)	19 (45.24)	38 (45.24)
High (above300 scores)	15 (35.71)	08 (19.05)	23 (27.38)
Total	42	42	82
$\overline{X}$	266.14	235.09	
S.D.	87.58	94.95	
Calculated t value	0.123^{NS}		

NS = Non-significant

Table 4. Relationship of all independent variables with their scientific temperament

Variable	'r' value FLD	Non-FLD
Age	-0.248^{NS}	0.191^{NS}
Education	0.065^{NS}	-0.201^{NS}
Land holding	0.627**	0.027^{NS}
Family type	0.011^{NS}	-0.141^{NS}
Family size	-0.125^{NS}	0.287^{NS}
House type	0.516**	-0.143^{NS}
Material possession	0.297^{NS}	0.004^{NS}
Farm power	0.795**	-0.069^{NS}
Occupation	0.746**	-0.049^{NS}
Annual income	0.793**	-0.053^{NS}
Mass media exposure	0.810**	-0.053^{NS}
Adoption	0.847**	-0.061^{NS}

**Significant at 0.05 probability level;*
***Significant at 0.01 probability level;*
NS = Non-significant.

Table 5. Problems faced by FLD beneficiaries (N=42)

Problems	No. of respondents	Percentage	Rank
Unavailability of fertile land	29	69.05	III
Lack of power supply	32	76.19	II
Rising market prices of all commodities	06	14.29	XI
Disbelief on govt. officials for distribution of agricultural inputs	26	61.90	IV
Lack of perceiveness regarding scientific management	24	57.14	V
Untimely supply of agricultural inputs	35	83.33	I
Change in weather	12	28.57	IX
Rocky land caused problem in using agriculture implements	22	52.38	VI
Lack of frequent monitoring by scientific staff	16	38.10	VIII
Lack of irrigation facilities	09	21.43	X
Monopoly of business sector people	19	45.24	VII

Table 6. Suggestions made by FLD beneficiaries (N=42)

Suggestion	No. of respondents	Percentage	Rank
Timely supply of quality input in adequate quantity	33	78.57	I
Loan facilities should be provided in time	27	64.29	II
Technical knowledge should be given more regularly by the experienced	21	50.00	III
Irrigation facilities should be provided	07	16.67	IV
Pre-training of farmers before organizing FLD	03	7.14	V

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Factors affecting adoption of improved technologies of wheat cultivation

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Received: 21.09.15
Accepted: 07.12.15

ABSTRACT

Wheat is one of the most important staple food grains of human race. India produces about 86.9 million tons of wheat per year which is about 12.34 per cent of world production. It is now the second largest producer of wheat in the world. Being the second largest in population, it is also the second largest in wheat consumption after China, with a huge and growing wheat demand. Rajasthan accounts for 9% of the total wheat production in India. The yield per ha of wheat is 2800 kg in Rajasthan which is low than states like Haryana (4000) and Punjab (4300). Wheat production in Rajasthan has been assumed to growth at 1% pa over the next 25 years. The existing yield gap is about 30 per cent of total production and is caused by a number of abiotic, biotic and socio-economic constraints. The existing yield gap can be bridged by adopting improved production practices, increasing supply of location-specific quality seeds, adoption of optimum input dosages and through active institutional support. Hence the Government of Rajasthan has rightly modified T&V system since January 1, 1993 and renamed it as Kisan Mandals and Kisan Seva Kendra. In this System unlike the T&V system the Village Extension Worker has to approach a group of 20 progressive farmers collectively rather than contacting 10 individual contact farmers. This group of 20 progressive farmers namely Kisan Mandal assembles once a fortnight on a fixed place and used to have discussion with Village Extension Worker on latest agricultural technologies. Besides this, a Kisan Seva Kendra is established at every Village Extension Worker's headquarter to solve the urgent problems of farmers regarding input arrangements, insect and pest control etc. In this Kisan Seva Kendra, every Thursday farmers are apprised with know-how about latest scientific cultivation practices, soil and water conservation techniques and farmer's problems regarding such matters are solved immediately by the respective extension functionaries. Realizing the importance of this new system of Kisan Mandals and Kisan Seva Kendra in transfer of technology, an effort was made to know the extent of adoption of improved practices of wheat cultivation and identify the factors associated with the adoption of improved practices of wheat cultivation and the selected independent variables such as knowledge, attitude, participation in extension activities, social participation, education, size of land holding and socio-economic status was studied in this investigation. The study was conducted in Jaipur district of Rajasthan. A sample of 180 farmers belonging to two categories viz. mandal and non-mandal was randomly selected for study purpose. Study revealed that majority of the total respondents was medium adopters of improved technology of wheat cultivation. It was also observed that knowledge, attitude, participation in extension activities, social participation, education, size of land holding and socio-economic status were significantly associated with adoption of improved technology of wheat cultivation.

***Key words*: –** Kisan Mandal; Kisan Seva Kendra; Agro-clinic; Training and Visit System; Village Extension Worker.

Wheat (*Triticum* spp.) is the second most important winter cereal in India after rice. Wheat crop contributes substantially to the national food security by providing more than 50 per cent of the calories to the people who mainly depend on it. India is 2nd largest producer (86.9 mt) in the world next to China (117.4mt). India's per capita wheat production is 67 kg against per-capita consumption of 73 kg, which is also on upswing. It is estimated that India will require 109 million tons of wheat to feed the population of about 1.25 billion by the year 2020 A.D. Area and productivity of wheat crop in Jaipur district is 139226 ha. and 3214.5 kg per ha, respectively. The productivity of wheat is comparatively low in Rajasthan (2800 kg per ha.) than other wheat cultivated states such as Punjab (4307 kg per ha) and Haryana (4000 kg per ha). The low productivity of this crop is due to poor adoption of improved technologies of wheat by the farmers. T & V system has been successful up to some extent to minimize the gap between technology available at lab and its real adoption up to the field level. Taking a step ahead Rajasthan Government modified this T&V system in to Kisan Mandals and Kisan Seva Kendras. This modified system has an edge over the T&V system by overcoming the limitation of

individual contact approach in T&V system and advocated for group approach by suggesting fortnightly meeting of Village Extension Worker with Kisan Mandal which consisted of a group of 20 progressive farmers. The another aspect of this system was to provide technical consultancy on every Thursday to farmers by Village Extension Worker on a well equipped centre known as Kisan Seva Kendra/ Agro Clinic.

There are many factors which might influence the adoption of improved practices of wheat cultivation. The study about such factors will provide a way for improving the adoption of improved practices of wheat cultivation. Keeping this fact in mind the present study has been undertaken to know the extent of adoption of improved practices of wheat cultivation and find out the association between adoption of improved practices of wheat cultivation and the selected independent variables such as knowledge, attitude, participation in extension activities, social participation, education, size of land holding and socio-economic status.

METERIAL AND METHODS

Jaipur district which comprises of three sub-districts namely Shahpura, Sanganer and Jhotwara, was selected for the study purpose: Three Village Extension Worker circles were selected from the each *panchayat samiti* (one from each sub clusters) by random sampling technique. Two Kisan Mandals were selected from each of the Village Extension Worker circles. Finally from each selected Kisan Mandals, 5 mandal and 5 non-mandal farmers were selected randomly. Thus, the total sample comprised of 180 farmers (90 mandal + 90 non- mandal) was selected for study.

The extent of adoption of recommended improved technology of wheat was measured through an adoption index, developed in the lines of adoption index used by Sharma (1989).

$$\text{Adoption index of improved practices of wheat cultivation} = \frac{\text{Total score}}{\text{Total weightage}} \times 100$$

The relationship between the selected independent variables viz; knowledge, attitude, participation in-extension activities, social participation, level of education, size of land holding, socio-economic status and dependent variable and the extent of adoption of improved practices of wheat cultivation was measured by computing 'Zero order correlation".

RESULTS AND DISCUSSION

Categorization of respondents based on level of adoption

To get an overview of the respondents with respect to level of adoption, the farmers were categorized into low, medium and high adoption groups. This categorization was based on the basis of mean score and standard deviation of the adoption scores obtained by the respondents.

It is revealed that majority of the total respondents (60.50 per cent) were medium adopters. While 22.22 per cent and 17.22 per cent of the total respondents were categorized as high and low adopters of improved technologies of wheat cultivation, respectively. Finding also revealed that 41.11 per cent of the mandal farmers and only 3.33 percent non-mandal farmers were high adopters. This indicated that Kisan Mandals and Kisan Seva Kendra helped in rapid transfer of technology and at the same time in acceptable manner to the mandal farmers which resulted in increasing the adoption level of these farmers. However the adoption of the improved technologies of wheat cultivation by non-mandal farmers was not encouraging.

Theoretically, the mandal farmers were supposed to communicate the innovations to the non-mandal farmers. Looking to the present results, it appeared that practically it did not happen. In other words the mandal farmers did not communicate the technology in an effective manner to non-mandal farmers. Similar findings have also been reported by Jat (1991) who concluded that majority of contact farmers (66.66 per cent) were medium adopters and 30 per cent contact farmers were high adopters. While 62.45 per cent non-contact farmers were medium adopters and only 2.08 per cent non-contact farmers were high adopters of improved practices of wheat.

Extent of adoption of individual improved practices of wheat cultivation by the respondents.

An examination of the data in Table 1 explains the extent of adoption of individual improved practices of wheat cultivation by the respondents. It was observed that both the categories of respondents i.e. mandal and non-mandal farmers rated all the practices in similar manner except the use of HYV seeds. It was interesting to note that there was over adoption in case of seed rate of wheat cultivation. The reason explained for over adoption of the seed rate by the respondents at the time of interview that in order to maintain optimum plant population the adoption of the seed rate was generally higher. As the farmers were of the view that there may be low germination of seed, plant- mortality at the time of germination so the farmers used high seed rate than recommended seed rate. They said in local language "Lann mai hi pann hota hai" that is more population will certainly achieve the higher yield.

It may also be seen from the Table 1 that none of the farmers had adopted application of potash in wheat crop. This might be due to the fact that mostly the potash availability in the study area was

sufficient for crop requirement. It was also observed that application of weedicide in wheat crop was adopted by only a little percentage of farmers. The high cost of weedicides compelled the farmers not to use weedicide and simultaneously the laboures were available comparatively at cheaper rate. The low adoption of seed treatment practice might be attributed to high cost of fungicide and lack of knowledge about proper method of seed treatment. It was also observed that application of phosphorus, application of nitrogen and use of high yielding variety seed was adopted by nearly 50 per cent of the mandal farmes. Likewise Sharma (1989) and Jat (1991) reported in his study that seed rate was most widely adopted practice followed by application of nitrogen under T&V system and minimum adoption was about the use of potash and use of weedicide.

It was also observed that there was a significant difference in the extent of adoption of use of high yielding variety seed, application of nitrogen, application of Phosphorus, plant protection measures, seed treatment and application of weedicide in wheat crop between mandal and non-mandal farmers. The results arrived so because of the fact that the mandal farmers attended the kisan mandal meetings frequently and they did not disseminate the innovations to other farmers. This might have created the gap in the adoption level between mandal and non-mandal farmers. The similar results have also been reported by Kumawat (2008) that there was significant difference in the use of high yielding variety seeds, seed treatment, use of balanced fertilizers in wheat crop between demonstrator and non-demonstrator farmers under FLD system of Agricultural extension.

Association between selected independent variables and the adoption of improved technologies of wheat cultivation by the farmers.

The relationship between the selected independent variables viz; knowledge, attitude, participation in-extension activities, social participation, level of education, size of land holding, socio-economic status and dependent variable i.e. the extent of adoption of improved practices of wheat cultivation was measured by computing 'Zero order correlation. The results have been presented in Table-2.

Table 2 explained that knowledge, attitude, participation in extension activities, social participation, level of education, size of land holding and socioeconomic status were positively and significantly associated with the level of adoption of improved technologies of wheat cultivation at 1 per cent level of probability.

A critical examination of the data presented in Table 2 revealed that knowledge level of farmers was significantly and positively associated with the extent of adoption of improved practices of wheat cultivation. This might be due to the fact that the adoption of improved agricultural practice depends upon accurate and up to date knowledge of a person about it. A farmer cannot be motivated for adoption of any improved practices unless he has sufficient knowledge of the subject. Hence, it was quite obvious that knowledge about Kisan Mandal and Kisan Mandals has exercised a conspicuous role in the adoption behaviour of farmers. The importance of knowledge in augmenting adoption level was also supported by Sharma (1989), Jat (1991), Thakar *et. al.* (2007), Rajpoot *et. al.* (2011) and Ghimire *et. al.* (2015) indicating that level of knowledge of farmers regarding improved practices was a significant factor affecting the adoption of improved practices.

Corollary to the assumption, attitude was significantly and positively associated with the adoption of improved technologies of wheat cultivation by the farmers. Many scientists reported that the attitude which an individual farmer• possessed towards an innovation exercised significant influence on his accepting or rejecting the innovation. So the results appeared to be quite justifiable that attitude has emerged out as one of the predictors of adoption of innovations. The findings was supported by Sharma (1989), Jat (1991) and Rajpoot *et. al.* (2011) who found that the farmers' attitude towards improved practices influencing significantly their level of adoption of package of practices.

Farmer's degree of participation in extension activities was found significantly and positively associated with the adoption of improved technologies of wheat crop. This might be due to the positive involvement of farmers in various activities like farmers fair, field days, Kisan gosthies, result demonstrations etc. It is also a fact that people learn more if all of their senses are involved in learning process like in demonstrations. It had been found that due to Kisan Mandal meetings farmers got more opportunities to mix together and discuss about the innovations and their problems. The findings were in line with the findings of Sharma (1989), Jat (1991), Thakar *et. al.* (2007), Goudappa et al (2008), Rajpoot *et. al.* (2011) ,Singh *et. al.* (2011) and Ghimire *et. al.* (2015) who revealed that participation in extension activities was positively related with the adoption.

The data presented in Table 2 revealed that farmers' participation in social organization was found significantly associated with the extent of adoption of improved practices of wheat crops by the farmers. It leads to the conclusion that social participation was one of the factors which inspired the farmers for adoption of newer technologies. This might be due to the fact that people's social

participation gave an opportunity to them to widen their scope for interaction. This interaction might sometimes helped the farmers in understanding new innovations and strengthen the already established opinion about technologies. The findings were in• line with the findings of Sharma (1989), Jat (1991), Thakar et al (2007), Goudappa et al (2008), Rajpoot et al (2011) and Singh et al (2011), who stated that social participation was positively and significantly associated with adoption.

The data presented in Table 2 revealed that education was significantly and positively associated with the extent of adoption of wheat crop by the farmers. This may be true because education gives shape and direction to the thinking process of the individuals, hence significant influence of education on the adoption behaviour of the farmers may be justified. The finding was supported by Sharma (1989) and Jat (1991)) who stated that education was one of the important factors of increasing adoption level. Similarly Singh and Sharma (1990), Goudappa *et al* (2008), Rajpoot *et al* (2011) and Singh *et al* (2011) found that education was positively and significantly related for both the contact and non-contact farmers with adoption behaviour. While Thakar *et al* (2007) expressed that education did not influence any way in acquisition and acceptance of improved technology.

The size of land holding of the farmer was an independent factor and it was not in purview of the system to increase the size of land holding but the farmers who were inspired through Kisan Mandals and Kisan Seva Kendras seemed to have tried to acquire more land and got higher income. Results of the study indicated that the farmers having larger size of land holding and resources showed higher impact of Kisan Mandals and Kisan Seva Kendras as compared to those who had small size of land holding and less resources. Such findings may be acceptable as per the concept of Kisan Mandals and Kisan Seva Kendras because it was expected that all the categories of farmers must be equally benefited by Kisan Mandals and Kisan Seva Kendras. However, this degree of variation needed to be minimized through more intensive efforts by the extension agencies. The finding was supported by Sharma (1989), Thakar et al (2007), Goudappa et al (2008), Rajpoot et al (2011), Singh et al (2011) who stated that size of land holding was significantly associated with adoption of improved practices.

Table 2 also depicted that socio-economic status was significantly and positively associated with the adoption of improved technologies of *bajra* and wheat cultivation by the farmers. It means that higher the socio-economic status, higher will be the adoption of improved practices by both the categories of farmers. The result portrayed the fact that the economically sound farmers could take more risk as compared to the poor farmers. They could adopt the newer technologies without fearing about the consequences. The findings were in line with the findings of Jat (1991) and Singh *et al* (2011) who revealed that socio-economic status was positively related with adoption.

Multiple Regression Equation with selected independent variables associated to adoption of improved technologies of wheat cultivation

In order to find out the relative degree of influence of each of the seven independent variables on the adoption of improved technologies of wheat cultivation, a test known as "multiple regression" was applied. The value of each of the independent variables was put in the multiple regression equation and analysis was made. The results have been presented in Table 3.

Table 3 revealed that all the seven independent variables had significant contribution (60.1 per cent) on the adoption of improved technologies of wheat cultivation. The respective 'F' values at 7 and 172 degrees of freedom were 36.984 which were significant at 1 per cent level of probability. Thus, the results implied that all the seven independent variables would account for a highly significant amount of variation for the adoption of improved technologies of wheat cultivation by the farmers.

Further, test of significance ('t' values) indicated that the coefficient of regression (b-value) was found positively and significantly for the level of knowledge (X_1) at one per cent level of significance, while 't' values of participation in extension activities (X_3) was found positively and significantly at 5 per cent level of significance. The table also depicted that regression coefficient was non-significant for attitude (X_2), social participation (X_4), education (X_5), sized of land holding (X_6) and socio-economic status (X_7).

The depth analysis of the relationship between dependent and independent variables portrayed that level of knowledge and participation in extension activities by the farmers were the most important variables among all the seven variables in the study whose contribution was maximum in adoption of improved technologies of wheat cultivation by the farmers.

CONCLUSION

On the basis of findings, it can be concluded that majority of the respondents had adopted the improved technology of wheat cultivation from medium to high extent. The technology about which farmers were found very conscious was seed rate followed by application of phosphorous and nitrogen among all the eight recommended improved

technologies of wheat cultivation. It was also concluded that knowledge, attitude, participation in extension activities, social participation, education, size of land holding and socio-economic status were significantly associated with adoption of improved technology of wheat cultivation. All the selected independent variables had exerted 60 per cent (R^2= 0.601) contribution on adoption of improved technology of wheat cultivation. Further it was also revealed that level of knowledge and participation in extension activities were the most important influencing factors on adoption of improved technology of wheat cultivation.

Table 1: Extent of adoption of improved technologies of wheat crop by mandal and non-mandal farmers.

N=180

Improved Practices	Mandal farmers (N=90)		Non-mandal farmers (N=90)	
	Adoption index	Rank	Adoption index	Rank of adoption
Use of HYV seed	53.88	III	32.10	II
Seed rate	111.03	I	116.04	I
Seed treatment	41.11	V	23.14	V
Application of N	53.72	IV	28.62	IV
Application of P	62.38	II	31.07	III
Application of K	0.00	VIII	0.00	VIII
Application of weedicide	11.11	VII	4.44	VII
Plant protection	27.55	VI	12.16	VI

Table 2: Association between selected independent variables and the adoption of improved technologies of wheat cultivation by the farmers.

Independent variables	Zero order correlation 'r' values
Knowledge	0.764**
Attitude	0.650**
Participation in extension activities	0.719**
Social participation	0.401**
Education	0.530**
Size of land holding	0.308**
Socio-economic status	0.279**

** Significant at 1% level of probability.

Table 3: Multiple regression values showing influence of independent variables on the extent of adoption of improved technologies of wheat crop under Kisan Mandals and Kisan Seva Kendras.

N = 180

Independent variables	b-value (R. cof.)	S-error of b	t-value for b
Knowledge	0.771	0.179	4.304**
Attitude	0.018	0.023	0.757
Participation in extension activities	0.345	0.167	2.059*
Social participation	0.220	0.312	0.704
Education	–0.048	0.178	–0.270
Size of land holding	0.509	0.390	1.306
Socio-economic status	0.040	0.028	–1.444

** Significant at 1% level of probability, * Significant at 5% level of probability, R2 = 0.601, Calculated value of 'F' = 36.984 ** (with 7 and 172 d.f.s.)

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Growth, yield and yield attributes of rice in rainfed uplands of Western Central Table Land Zone

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Received: 27.08.15
Accepted: 29.12.15

ABSTRACT

Growth and yield attributes of rice were increased in association with okra but were decreased when grown with cluster bean. Ground nut as an intercrop also reduced the yield attributes of rice. Intercropping with ground nut, cluster bean, pigeon pea, okra and green gram decreased grain yield of rice by 29.3%, 24.8%, 22.7%, 17.9% and 15.7 % respectively as compared to sole crop yield of 2763 kg/ha. Rice + okra was the most productive and remunerative rice based intercropping system with root volume 237.2 cc/m, dry matter content 626.2 g/m^2 ,leaf area index 4.53, net return of Rs 23, 763/ ha and B:C 2.4 .

***Key words*:** Intercropping, dry matter Plant height, yield, economics, B: C

About 43.7% of total cultivable land in Odisha is upland where we mainly grow rice maturing within 100 days. Rain fed upland rice constitutes about 17% of the total rice area in our country. The average yield of rice in these upland is 0.5 to 0.6 t/ha which is much less than those in other ecosystems. Major constraints of growing rice in rain fed upland includes moisture deficit causing drought, severe weed competition, nutrient loss due to light textured soil , poor growth due to low input use and problem of pest and disease. Therefore cultivation of direct seeded upland rice is rather risky and uneconomical. As rice is vulnerable to moisture deficit stability of crop yield in these handicapped ecology can be achieved with crop substitution and intercropping (Kar and Verma 2008).

Intercropping involves growing two or more crops or varieties simultaneously on the same piece of land with definite row ratio. Crop intefication is in both time and space dimensions. There is intercrop competition during all part of crop growth(Sanchez, 1976; palaniappan, 1985; Pal et al 1985). Intercropping provides insurance against drought, modifies soil environment, improves moisture and radiation use, ensure better weed control, reduces disease and pest incidence and in whole increases and stabilizes the productivity. Intercropping has been identified as a kind of biological insurance against risks under aberrant rainfall behaviour. Crop diversification is also necessary to get higher yield and return to maintain soil health, conserve natural resources, preserve environment, meet daily food requirement of human and animals, withstand price fluctuation and ensure constant flow of income.(Siddique *et al*, 2012).

MATERIAL AND METHODS

A field experiment was conducted at Bolangir district of Odisha to assess the production potential of different cropping system in rain fed uplands during 2011-12.The experiment with 7 different cropping systems was conducted in a randomised block design with three replications. The cropping systems were:

T_1 : Rice-horse gram
T_2 : Rice(Drought Management)-horse gram
T_3 : Rice+ green gram (3:1)- horse gram
T_4 : Rice +ground nut(3:1)-horse gram
T_5 : Rice +okra(4:2)-horse
T_6 : Rice +cluster bean (4:2)-horse gram
T_7 : Rice + pigeon pea (5:2)

DM: drought management practices include line sowing of 4% KCl treated hardened seeds and application of SSP(equivalent to P dose of rice) enriched FYM.

The salient characteristics of variety used:

Crop	Variety	Duration
Rice(Oryza sativa L.)	ZHU XI-26	80
Pigeonpea(Cajanus cajan L.)	Asha(ICPL-87119)	180
Greengram(Vigna radiate L.)	PDM-54	70
Groundnut(Arachis hypogeal L.)	Smruti	100
Horsegram(Macrotyloma uniflorum)	Urmi	95
Okra(Abelmoschus esculantus Moench.)	Arka anamika	60-65
Clusterbean(Cyamopsis tetragonoloba Taub.)	Pusa Sadabahar	70-75

RESULTS AND DISCUSSION

Various intercrops including pulses like greengram and pigeonpea, oilseeds like groundnut and vegetables like okra and clusterbean might have modified the environmental conditions of rice because of their differential growth habit, nutrient need and resource use efficiency. All these resulted in variation of growth, yield and yield attributes of rice in different intercropping systems. Okra as an intercrop favoured the growth of associated rice

crops from the initial period i.e., 30 DAS onwards. This has resulted in maximum plant height at harvest (66.95 cm), number of shoots/m row length(96), total dry matter production(626.2 g/m2) and LAI(4.53) at 60 DAS. Most of the yield attributes of rice (Table 4.7) were also higher due to intercropping with okra. Application of higher fertilizer dose i.e., 80-40-40 kg NPK to the associated crop that too N in split doses might have favourably influenced the growth of rice crop. All these favourable effects culminated in production of 2269 kg grains/ha even with only 57% of its normal population, which would have been 3982 kg/ha had it been grown as a sole crop giving yield advantage of 44%. Inclusion of groundnut to some extent favoured the dry matter accumulation (Table 4.3 to 4.5) and root characteristics(Table 4.6) of rice at vegetative stages. But because of its longer association most of the yield attributes of rice were decreased(Table 4.7) resulting in lowest grain yield of 1954 kg/ha even with 75% plant population in intercropping system. This system has also created problem in harvesting of rice because of overlapping groundnut canopy on rice plant. Being a legume crop cluster bean failed to favourably influence rather depressed the dry matter accumulation, crop growth rate and yield attributes of rice because of lodging of the crop on standing rice crop. Even some of rice plants beneath the lodge canopy of cluster bean perished. rice was not benefited much in association with pigeon pea or green gram both in respect of growth and yield attributes except the number of ear bearing tillers. Many worker have reported reduction in yield and yield attributes of rice under intercropping system. Sarkar and Pal(2009) have reported reduction and yield attributing characters of rice intercropped with groundnut or pigeon pea in 2:1 ratio due to depression effect of intercrop. But yield attributes were improved in 6:1 ratio due to more population of rice. In a season with well distribution of rainfall, favourable effects of different drought management practices were not reflected on the growth and yield attributes of upland rice variety ZHU XI-26. Ray (2008) has also reported similar findings.

SUMMARY

Drought management practices like seed hardening with 4% KCl and FYM enrichment with P dose of rice did not favourably influenced the growth and yield of rice in a season receiving 33% excess rainfall. Most of the growth parameter and yield attributes of upland rice variety ZHU XI-26 were increased due to intercropping with okra in 4:2 ratio. Intercropping with cluster bean decreased most of these parameter and with groundnut yield attributes. Ear bearing tillers were increased due to intercropping with green gram and pigeon pea. Intercropping rice with groundnut in 3:1 , cluster bean 4:2, pigeon pea 5:2, okra 4:2 and green gram 3:1 decreased grain yield of rice by 29.3, 24.8, 22.7, 17.9 and 15.7% respectively as compared to the sole crop yield of 2763 kg/ha. The corresponding decrease in straw yield of rice(3802kg/ha)was18.1, 16.9, 12.7, 19.3 and 15.7%.

Table no 1. Effect of intercropping system on plant height (cm) of rice at successive growth stages

Particulars	Days after sowing				Harvest
	15	30	45	60	
T_1	10.80	13.23	30.40	44.07	61.50
T_2	10.30	13.43	31.00	44.48	62.90
T_3	11.30	13.40	31.87	44.03	61.20
T_4	10.73	13.80	32.13	46.78	63.75
T_5	11.47	18.57	33.50	48.15	66.95
T_6	10.73	11.97	26.73	42.93	59.33
T_7	10.77	14.30	30.33	45.44	62.90
SEm(±)	0.28	0.45	0.62	0.98	1.43
CD(P=0.05)	NS	1.40	1.90	3.04	4.39

DM: with drought management practice involving seed hardening in 4% KCl and FYM enrichment with single super phosphate.

Table no 2. Effect of intercropping systems on number of shoots per meter row length of rice at successive growth stages

Particulars	Days after sowing			
	15	30	45	60
T_1	29	66	81	82
T_2	29	67	82	82
T_3	30	64	84	84
T_4	30	66	82	84
T_5	29	73	99	96
T_6	30	62	82	81
T_7	30	66	82	84
SEm(±)	1.03	1.77	3.69	2.56
CD(P=0.05)	NS	5.45	11.4	7.90

Table no 3. Effect of intercropping systems on leaf area index (LAI) of rice at successive growth stages

Particulars	Days after sowing			
	15	30	45	60
T_1	0.62	2.66	3.35	3.55
T_2	0.62	2.73	3.52	3.63
T_3	0.56	2.65	3.52	3.21
T_4	0.68	3.23	4.17	4.44
T_5	0.71	3.28	4.66	4.53
T_6	0.60	2.86	3.49	3.17
T_7	0.67	2.77	3.83	3.44
SEm(±)	0.038	0.124	0.150	0.114
CD(P=0.05)	NS	0.383	0.46	0.352

Table no 4. Effect of intercropping systems on dry matter accumulation (g/m^2) of rice at successive growth stages.

Particular	Days after sowing											
	15			30			45			60		
	Shoot	Leaf	total	Shoot	Leaf	total	Shoot	Leaf	total	Shoot	Leaf	Total
T_1	26.9	20.5	47.4	50.7	92.5	143.2	178.2	135.2	313.4	323.4	169.0	492.5
T_2	27.8	20.7	48.5	54.3	94.8	149.1	183.1	142.0	325.1	339.1	172.9	512.0
T_3	24.0	18.7	42.7	51.0	91.9	142.8	173.5	141.8	315.4	335.9	152.8	488.6
T_4	31.1	22.8	53.9	56.7	112.2	168.9	199.4	168.2	367.6	381.1	211.3	592.4
T_5	32.6	23.6	56.2	57.9	113.9	171.8	216.0	187.8	403.8	410.7	215.6	626.2
T_6	25.8	20.0	45.7	51.6	99.4	151.0	176.0	140.7	316.8	332.2	151.0	483.3
T_7	25.8	22.3	48.1	55.6	96.2	151.8	176.6	154.5	331.3	336.7	163.6	500.3
SEm(±)	1.85	1.28	3.07	1.26	4.31	4.60	7.64	6.03	9.2	11.39	5.44	11.59
CD(P=0.05)	NS	NS	NS	3.9	13.3	17.2	23.5	18.6	28.3	35.1	17.8	35.7

Table no. 5 Effect of intercropping system on CGR, RGR and NAR of rice at successive growth stages

Particular	CGR(g/d/m^2) Days after sowing			RGR(g/g/d) Days after sowing			NAR(g/m^2 leaf area/d) Days after sowing		
	15-30	30-45	45-60	15-30	30-45	45-60	15-30	30-45	45-60
T_1	6.39	11.34	11.94	0.074	0.052	0.030	4.57	3.79	3.27
T_2	6.71	11.73	12.16	0.075	0.052	0.030	4.71	3.77	3.67
T_3	6.68	11.50	11.55	0.081	0.053	0.029	4.97	3.76	3.45
T_4	7.66	13.25	14.99	0.076	0.052	0.032	4.69	3.61	3.48
T_5	7.71	15.47	14.83	0.075	0.057	0.029	4.60	3.96	3.26
T_6	7.02	11.05	11.10	0.080	0.049	0.028	4.88	3.50	3.33
T_7	6.91	11.95	11.28	0.077	0.052	0.027	4.67	3.66	3.10
SEm(±)	0.37	0.60	0.96	0.004	0.002	0.002	0.198	0.13	0.235
CD(P=0.05)	NS	1.85	2.96	NS	NS	NS	NS	NS	NS

CGR-crop growth rate, RGR-relative growth rate, NAR-net assimilation rate

Table no 6 Effect of intercropping systems on root characteristics of rice at successive growth stages

Particulars	Root weight(g/meter row length)				Root volume(cc/meter row length)			
	15 DAS	30	45	60	15 DAS	30	45	60
T_1	25.6	46.5	64.5	64.1	27.6	50.7	121.2	117.9
T_2	25.2	48.9	65.6	66.9	27.0	53.3	125.3	123.0
T_3	24.9	53.0	85.6	89.7	26.6	57.7	160.9	163.5
T_4	25.7	57.6	121.9	124.5	28.0	62.2	229.2	232.1
T_5	26.6	58.2	123.0	125.5	29.0	63.4	231.2	237.2
T_6	24.4	51.0	68.9	65.8	26.3	56.3	129.8	121.2
T_7	24.1	51.2	81.3	76.7	26.1	55.8	152.7	142.3
SEm (±)	1.574	3.89	4.65	3.06	1.69	3.15	8.74	5.63
CD(P=0.05)	NS	NS	14.3	9.4	NS	NS	26.9	17.3

Table no 7 Effect of intercropping systems on yield and yield attributes of rice

Particular	Ear bearing tillers/m2	Ineffective tillers/m	Length of the panicle(cm)	Panicle weight(g)	Filled spikelets/panicle	Sterility(%)	1000 grain weight(g)	Grain yield(kg/ha)	Straw yield(kg/ha)	Harvest index(%)
T_1	57.3	23.7	19.00	1.80	64.7	9.8	26.38	2763	3802	42.11
T_2	56.0	25.0	19.67	1.80	64.0	9.1	26.62	2778	3869	41.80
T_3	69.7	22.7	19.00	1.84	67.7	9.6	26.03	2329	3204	42.08
T_4	63.2	21.7	18.33	1.76	66.3	10.8	24.03	1954	3113	38.48
T_5	71.6	20.0	22.00	2.22	76.3	5.8	26.08	2269	3259	41.07
T_6	62.7	18.3	18.00	1.66	60.0	11.8	25.05	2077	3160	39.61
T_7	68.7	19.0	19.33	1.84	65.7	9.1	25.17	2136	3321	39.13
SEm(±)	2.10	2.26	0.61	0.10	2.51	0.80	1.06	90.3	110.3	0.61
CD(P=0.05)	6.5	NS	1.88	0.30	7.7	2.5	NS	278	340	1.87

Table no 8 Economics of various intercropping and cropping systems

Particular	Gross return(Rs/ha)		Net return(Rs/ha)		B: C	
	Intercropping system	Horsegram	Intercropping system	Cropping system	Intercropping system	Cropping system
T_1	18,134	7,911	3,114	4,850	1.21	1.23
T_2	18,625	7,955	3,145	4,925	1.21	1.23
T_3	19,485	8,330	5,923	7,448	1.37	1.37
T_4	22,495	6,895	3,985	4,955	1.21	1.20
T_5	41,503	6,679	23,763	24,517	2.34	2.04
T_6	20,459	6,109	2,695	2,879	1.15	1.12
T_7	35,337	-	17,477	-	1.98	-

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Impact study on climate resilient technology demonstrated in NICRA village- Choma kot in Vertisol of Rajasthan

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Received: 26.08.15
Accepted: 27.12.15

ABSTRACT

Chaumakot in Kota district of Rajasthan is a water scarcity village. The annual rainfall is 780 mm. The soil of the village is clay loam heavy textured with pH 8.20 - 8.53, low in available nitrogen (145-160 kg/ha), organic carbon (0.48-0.50 %), medium in available phosphorus (23-34 kg/ha) and high in available potassium (345-365 kg/ ha). Climate-resilient technologies i.e. raised bed planting in soybean and wheat , short duration varieties of soybean (JS 95-60 and JS 93-05) , in-situ moisture conservation by field bunding, Broad bed furrow, deep ploughing and inter cropping on soybean + maize (5:2 rows) were demonstrated at farmer fields along with existing practices during kharif and rabi seasons of 2011-2013 under NICRA . Results revealed that raised bed planting in soybean and wheat gave the highest seed yield (18.25 and 61.92 q / ha) and B:C ratio (3.44 and 4.65), respectively in comparison to conventional sowing. Drought resistant variety JS 95-60 took minimum number of days for attaining maturity and gave higher seed yield(17.60 q / ha) and B;C ratio(3.18) over check variety JS 335.Cultivation of soybean and mustard after adaptation of moisture conservation technologies proved better with 43.42,16.12 and 12.77% increased in seed yield of bunding-soybean, deep ploughing – soybean and BBF- mustard plots over the respective check. Inter cropping of Soybean + Maize (5:2 rows) system produced higher profit (Rs 60,360/ha) and B: C ratio (3.48) over sole soybean and maize and the system was found more efficient, profitable and suitable for rainfed situations. These climate-resilient technologies will help the farmers to cope with such extremes situations.

Key words: Bed-planting, Demonstration, Inter-cropping, moisture conservation, maize, soybean and wheat.

The major climatic vulnerability of Kota district is water scarcity/ erratic rainfall and heat stress. Due to changing climatic conditions, number of rainy days is decreased, drastically reduced total rainfall period from June to Sept. The factor responsible for low productivity of *kharif* crops in rainfed area are use of long duration variety, unaware of in situ water harvesting technology and scattering rainfall and early withdrawn of monsoon. Farmers of the area are facing the problem of failure of sown crop in that situation. Long duration varieties are not performing well in that situation. At the same time, there is a scope to improve the resilience of agriculture by application of exiting knowledge and technology on farmer's field as a holistic package. This study are to be conducted to enhance the resilience of crops to climatic variability and climate change through development and using improved production and risk management technologies under rainfed condition of south-east Rajasthan.

The major cropping systems are soybean-wheat under irrigated and fallow-mustard under rainfed condition. Soybean is also grown under rainfed conditions but its productivity is affected due to less number of rainy days coupled with dry spells and sometimes early withdrawn of monsoon. The major necessity to go for conserving the moisture in soil in situ as well as harvesting of rain water to save the crops by minimizing water stress or providing life saving irrigation during dry spells in *kharif* in tackling the major climatic constraint of the area. To improve the overall productivity and sustainability, feasibility, farmers often grow soybean in association with maize, in some part of Rajasthan. Among them, soybean + maize, soybean-coriander /mustard are the most important cropping systems for the region. Raised bed planting of soybean and wheat, field bunding and broad bed furrow practices had also been found suitable to reduce the incidences of moisture stress at critical growth stage. The work was therefore, initiated with the following objectives:

- To enhance the resilience of Indian agriculture covering crops to climatic variability and climate change through development and application of improved production and risk management technologies.
- To demonstrates site specific technology packages on farmers' field for adapting to current climate risks.

MATERIALS AND METHODS

The study area of Chauma kot village, Sultanpur block, Kota district, comes under agro climatic Zone V of the Rajasthan and is situated in the South eastern part of the district. The major climatic constraints in study area are water scarcity, erratic rainfall and heat stress. The annual rainfall is 780 mm; hence this village was selected to implement the National Initiative on Climate Resilient Agriculture (NICRA) project during the year 2010-13. Soil of the village is clay loam heavy textured with pH 8.20 - 8.53, low in available nitrogen (145-160 kg/ha) and organic carbon (0.48-0.50 %), medium in available phosphorus (23-34 kg/ha) and high in available potassium (345-365 kg/ ha). Total cultivated area of the village is 400 ha out of which more than 65 % area is under rainfed and remaining comes in irrigated area. Bore well is the source of irrigation. The major field crops of the village are soybean, mustard, wheat, coriander and chickpea. Fluctuation in area of these crops subjected to rainfall pattern and market price. A set of demonstrations on improved technologies i.e. raised bed planting in soybean and wheat , short duration varieties of soybean (JS 95-60 and JS 93-05) , in-situ moisture conservation by field bunding, BBF, deep ploughing and inter cropping on soybean + maize (5:2 rows) were conducted under NICRA Project to develop improved technologies through short term research and also demonstrated the existing technologies for enhancing the resilience at farmer fields during kharif and rabi seasons of 2011-2013.Technology was demonstrated on 0.4 ha area at each farmer field. The existing varieties viz. JS 335, PEHM-2, Lok-1 and Bio-902 were used for soybean, maize and wheat and mustard respectively. Planting of three rows of soybean and wheat on each bed was done by FIRB machine which forms 2 broad beds with a furrow at a time. Broad bed width with 15 cm height in wheat and soybean were kept 50 and 60 cm, respectively maintaining 30 cm furrow between two broad beds. The cost of field earthing bund, BBF and deep ploughing were Rs 10000, 200 and 3000 / ha, respectively. In demonstration plots BB furrows across the slope were formed at a distance 3 m by single plough, while deep ploughing was done by MB plough. Soybean, mustard and soybean crops were grown after followed field bunding, deep ploughing and BBF, respectively. Crops were sown in first week of July and second week of November and harvested manually in first week of October and first week of April, respectively seasons. All the recommended cultural operations to raise the crop were followed as and when required. A net plot area of 25 m^2 from each demonstration was harvested for seed yield as measurable indicators of output and economics were workout and compared with farmers, practices

RESULTS AND DISCUSSION

Bed planting Technique is a potential solution for enhancing yield under scares water condition

The major cropping system is soybean-wheat under irrigated situation and fallow- mustard under rain-fed situation in practice. The production of soybean in *kharif* is drastically decreasing due to reduction in rainy days during monsoon as well as erratic temporal early, mid and late dry spells or even an early withdrawn of monsoon. The introduction of short duration draught resistance variety of soybean (JS 95-60) and bed planting has become most essential to overcome from the existing erratic rainfall pattern. The another major necessity to go for conserving the moisture in soil in situ as well as harvesting of rain water to save the crops by minimizing water stress or providing life saving irrigation during dry spells in *kharif* is tackling the major climatic constraint of the area. Soybean in *kharif* and fallow- mustard in *rabi* are the major cropping sequence whereas wheat is generally grown where irrigation water is available in their under ground water sources. Due to change in climate it has become very difficult to grow wheat, therefore, the farmers were diverted to grow less water requirement crops by providing life saving irrigation. Under such circumstances the farmers were purchasing wheat grain and straw from nearby areas for eating themselves and cattle's feed, respectively. Looking to the availability of irrigation water and need of wheat grain & straw, the farmers under NICRA suggested growing wheat in the some part of their land holding with adoption of raised bed planting method alongwith adoption of ridge sowing practice with intercropping of berseem and fenugreek in between the furrows to cope up with limited irrigation water. Farmers are going to cultivate soybean and wheat with the FIRB machine which has already been kept in Custom hiring centre in the project.

The data present in Table 1 clearly indicated that bed planting of soybean gave higher grain yield (18.25q/ha) with more return (Rs 58,400/ha) and B: C ratio (3.44) in comparison to conventional sowing. The increase in seed yield in soybean over check was 2.5 percent. Higher soybean yield was due to cope up / mitigate moisture stress at pod filling stage.The furrow irrigated raised bed system (FIRBS) machine was developed under NICRA project which was found feasible for bed planting for wheat in Vertisols. The raised bed planting technique of wheat gave higher grain yield (61.92q/ha) with more net returns (Rs 67334/ ha) & B: C ratio (4.65)

than conventional sowing method. The increase in seed yield in wheat over check was 10 percent. The success & benefits of the system in wheat are time saving i.e. takes less time 2.43/hrs/ha/irrigation for complete one irrigation in one ha area, requires 20-25% lower seed rate, and saves water up to 25-30% , better water management & better weed management resulted increase water use efficiency, reduces crop lodging and less compaction for light & nutrients. Similar finding was reported by Idnani and Ashok Kumar (2012).

Soybean variety JS-95-60 suitable for moisture stress situation

More than 80% area of total soybean acreage is under rainfed condition. Use of long duration variety, erratic rainfall and early withdrawn of monsoon are important factors for low yield in rainfed situation. The most common variety of soybean i.e. JS-335 which is grown by majority of the farmers not only in Kota district but all over the Hadoti region, The production of soybean in previous 5-7 years is reducing due to climate change in terms of early withdrawl or drought spell or late onset of mansoon. Under such conditions farmers grow long duration variety of soybean JS-335 are facing moisture stress problem due to early withdrawl of monsoon during grain filling stage, which ultimately reduced the productivity of those farmers fields who are unable to manage life saving irrigation (at grain filling stage). Thus soybean yield of this area is falling at an alarming rate. Under this adverse situation, demonstrations on short duration variety of JS-95-60 and JS 93-05 were conducted during 2011 to 2013. The results in table 2 revealed that JS 95-60 variety produced higher seed yield (17.60 q/ha), returns (Rs 56,320/ha) and B: C ratio 3.18 as compared to JS 93-05 and JS 335 varieties and was found most suitable to cope up with adverse climatic conditions and become enable to produce better yield as compared to the existing long duration variety (JS 335). Increase in grain yield to the tune of 17.33 percent over check. Alli monsefi *et al.* (2013) reported similar results in soybean. In the feedback process, early maturing soybean variety (JS-95-60) was appreciated by the soybean growers in a situation of early withdrawl of monsoon. This Short duration variety offers certain advantages i.e. faster growing habit, early crop maturity by 15-19 days, less water requirement, mitigate early withdrawl monsoon effect, often higher yield, low production cost and more profit on an average 15-20% percent higher seed yield in demonstration was recorded over check (JS-335).

The adoption of the short duration variety JS 95-60 from 2011 to onward has spread over 3 lakh ha in Hadoti area. Likewise 80% farmers from NICRA village have gone for cultivation of JS 95-60 variety of soybean in 2012 and 2013 who will be enable to cultivate mustard crop after harvesting Soybean hence will produce more income from per unit area of land.

Resource conservation and enhanced crop productivity through Mechanization

Nature of climate variability actually observed in the district during reporting years are medium erratic rainfall and poor soil health. Soil moisture, nutrient availability and residue management are major factors for low crop production in rainfed areas. Improper use of implements & intensive agriculture has led to dramatic losses of organic matter and organic carbon from cultivated soil of the village. Before initiation of NICRA project, farmers of the village were often followed the conventional practice of ploughing and digging of land due to non-availability of suitable implements and lack of awareness about their uses. Most of the farmers were cleaned their field by burning the crop residues thus reduced organic carbon status of soil (0.20 to 0.58%). A Custom Hiring Centre was established in Choumakot village in June, 2011 under NICRA project, with the main objective of equipments service to the farmers. Need based equipments were introduced and cost of operation was reduced from 15 to 25 % besides saving time, energy and drudgery even on small holdings .These equipments became useful in rainwater harvesting *in-situ* relevant to moisture stress, to cope up with the problem of moisture stress in the major crops, field bunding, broad bed furrow, deep ploughing, breaking hard clay layer of soil and planting of technology demonstration at farmers' field. Among the various management options to conserve and sequester carbon in agricultural soils; modern equipment of custom hiring centre played key role in reduced tillage and residue management. In NICRA village, soybean-wheat/mustard based cropping systems are prevalent and they generate ample residue which recycled to soil by suitable tillage practices. Now soil organic carbon is showing positive trend at various farmers field ranging from 0.22 to 0.59%. Farmers, who have adopted rainwater management strategies *in-situ* moisture conservation by adopting M. B. Plough, chisel plough and tractor drawn blade-harrow in view of after each rain shower in that field minimized the risk of crop failure and increased moisture retention capacity (10-15%). Mechanized weed control in wide row spacing crop i.e. soybean and maize was found more beneficial in view of moisture conservation (breaking crust formation) and labour saving in weeding. Thus the productivity of demonstrated technology i.e. soybean, wheat and mustard was substantially enhanced (15-20%) in comparison to conventional practices. Farmers of the service area are getting benefit that are poor and

unable to held all type of farm machinery equipments themselves in addition to capable farmers. Small and marginal farmers are getting more benefited by the centre equipments. Presently the earning income from this hiring centre is Rs. 80,500.

In supporting of this study results of selected moisture conservation technologies (Table 2) revealed that field bunding- soybean, deep ploughing- soybean and broad bed –mustard gave higher seed yield (21.80, 17.65 and 20.30 q/ha) with more returns (Rs 69,760, 56480 and 64,960/ha), respectively grown after adaptation of these moisture conservation technologies than check. The increase in seed yield of crops was 43.42, 16.12 and 12.77 percent respectively over check. Almost similar results have been reported by Sudha and George (2011) and Ratanlal (2013). The table 2 revealed that Inter-cropping of Soybean + Maize (5:2 rows) system resulted in higher profit (Rs 60,360/ha) with B: C ratio (3.48) over farmer practices i.e. sole soybean and maize. Similar results were also reported by Choudhary and Dilip Singh (2010) and Dwivedi and Shrivastava(2011). The system was found more efficient, profitable and suitable for rainfed situation as it gave the highest additional net return of soybean and maize Rs. 3080 and 9360 per ha as compared to sole soybean and maize, respectively. Planting of both crops i.e. Soybean and Maize at same row distance at 30 cm were done simultaneously by seed-cum fertilizer-drill maintaining 5:2 rows ratio of Soybean and Maize. This new inter-cropping machine designed with the help of local manufacturer for feasible sowing of both crops as inter-crop at same time and place.

CONCLUSION

Innovative Farming Technologies (IFTs) disseminated successfully in NICRA village Chauma kot during 2011 to 2013, which have been enabled the farmers to increase productivity and their Cost Benefit Ratio. Soybean variety JS-95-60 was found suitable to cope up with moisture stress situation. It gave 15-20% higher yield. Inter-cropping Soybean + Maize; (5:2 rows)system was found more efficient, profitable and suitable for rainfed situation as it gave the highest additional net return of soybean and maize Rs. 3,080 and 9,360per ha as compared to sole soybean and maize, respectively.

FIRBS machine was found feasible for bed planting for soybean and wheat in Vertisols and gave higher grain yield with more returns & B: C ratio than conventional sowing method. Farm Machinery Custom Hiring Centre is highly appreciated by villagers as it reduced the cost of cultivation per ha and time saving with the earning of Rs. 80,500 in very short period.

Table 1: Impact of mechanizing Custom Hiring Centre

Particulars	Impacts
Enhancement of major crop productivity	15-2 0%
Timely field operation	Saving in time
Reduced cost of cultivation	15-25%
Dependence on landlords	Reduced
Dependency of farmers on banking for implement loan	Decrease
Earning income from the centre (Rs.)	80,500/-
Custom Hiring Centre Service	**Satisfactory**

Table 2: Impact of production and management technology followed at farmers' fields (Mean data of 2 years)

Technology demonstrate	No. of demos.	Average yield (q / ha)	Cost (Rs/ ha)	Return (Rs/ ha)	BC ratio	Increase in seed yield over check (%)
A. Bed planting in soybean						
Raised bed planting	10	18.25	16,968	58,400	3.44	2.5
Conventional sowing	10	17.80	17,560	56,960	3.24	-
B. Bed planting in wheat						
Raised bed planting Conventional sowing	10	61.92	18,425	67,334	4.65	10.0
	10	56.25	18,850	59,056	4.13	-
C. Drought resistant soybean varieties						
JS 93-05						
JS 95-60	31	17.50	17,668	56,000	3.16	16.66
JS 335(Check)	29	17.60	17,668	56,320	3.18	17.33
	30	15.00	17,188	48,000	2.79	-
D. In-situ moisture conservation by field bunding/ BBF/ Deep ploughing						
Bunding-Soybean	20	21.80	27,668	69,760	2.52	43.42
Deep ploughing- Soybean	25	17.65	19,668	56,480	2.87	16.12
BBF- Mustard	10	20.30	17,170	64,960	3.78	12.77

Technology demonstrate	No. of demos.	Average yield (q / ha)	Cost (Rs/ ha)	Return (Rs/ ha)	BC ratio	Increase in seed yield over check (%)
Soybean(check)	25	15.20	17,188	48,640	2.83	-
Mustard(check)	10	18.00	17,020	57,600	3.38	-
E. Inter-cropping system						
Soybean + Maize (5:2 raw)	10	13.80 +13.50	17,325	60,360	3.48	5.36
Soybean sole	10	17.90	17,668	57,280	3.25	
Maize sole	10	42.50	17,400	51,000	2.93	

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Awareness of Tribal Sub–Plan for Livelihood Security of Tribal's in Dungarpur district of Southern Rajasthan

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Received: 16.11.15
Accepted: 05.04.16

ABSTRACT

The tribal development efforts had been subjected to close scrutiny from Plan to Plan and had undergone continuous modifications, finer tuning and reorientation. It was during the Fifth Plan period that the concept of Tribal Sub-Plan (TSP) was implemented. The Eleventh Five Year Plan (EFYP) seeks to strengthen the TSP. One of the major objectives of the Eleventh Plan is "to reform TSP and restore its dynamic character to make it an effective instrument for tribal development". The study was conducted with the objective to determine the awareness of tribal regarding livelihood programmes in TSP area. Total 84 male and female respondents from five villages of Dungarpur tehsil/district of Rajasthan were interviewed for data collection.structured interview schedule was used for the purpose. The findings revealed that Majority of male and female respondents were possessed medium level of awareness followed by low and high level of awareness groups. They possessed least awareness regarding do you know about Supervision & controlling of the activities regularly done by the staff members and Evaluation of the activities done by the project staff members.

Key words: Awareness, livelihoods, empowerment, self help groups, tribal, tribal sub-plan, Badi Vikas Yojna and Swarojgar Yojana

Tribal Sub-Plan (TSP), a strategic policy initiative to secure overall development of the STs, was first introduced in the Fifth Five Year Plan. The focus of TSP is on "securing budgetary allocations for tribal development at least proportionate to their population, in order to bring them at par with other sections of society and to protect them from exploitation." With the fast developing world, tribal's required specific attention not only with monetary allocation but along with special interventions for their rapid socio-economic development. It required an integrated approach of all departments in a united manner and not works in isolation. The Tribal Sub-Plan envisages reducing gaps between the tribals and non-tribals in health, education, communication and other areas of basic amenities of life by providing legal and administrative support. The Sub-Plan also implements income generating schemes to boost the income of the tribals on a sustainable basis by taking into account their aptitude and skill.

MATERIALS AND METHODS

The study was conducted in dungarpur district of southern region of Rajasthan. Tehsil Dungarpur appears to be at first in total population in dungarpur district. First five villages based on highest tribal population were selected. From each village, equal numbers of male and female respondents were selected randomly. Thus, sample size comprised 84 male and female respondents, interviewed with specially designed interview schedule. The data were analyzed using statistical tools viz., frequencies, percentage, mean, mean per cent score and rank correlation co-efficient.

RESULTS AND DISCUSSION

Distribution of respondents according to their level of Awareness

The awareness of respondents about livelihood programmes was assessed. For this, the respondents were divided into three awareness level groups on the basis of Mean Score obtained by them and Standard Deviation. The data related to the awareness of both the category of respondents i.e., male and female indicate that the respondents awareness for livelihood programmes had a wide dispersion. In order to place the respondents into their appropriate categories, awareness score were categorized and reported in table 1.

The ranges of awareness score obtained by total respondents were divided into three groups and frequencies (f) as well as percentage of the respondents falling in each group were worked out.

The data presented in table 1 in case of Dungarpur as a whole male and female reveals that 58.33 per cent respondents fall in the medium level of awareness group followed by low and high awareness group with 21.43 and 20.24 per cent respondents, respectively.

In case of male respondents, fall under the high 11(26.19%) level of awareness group, and only 6

(14.29%) female respondents possessed high level of awareness regarding livelihood programmes.

Tribal's Awareness about livelihood Programmes in TSP area

The awareness of male and female respondents with regard livelihood programmes were measured in terms of Mean Percent Score (MPS). As many as 20 statements of livelihood programmes were included to assess the awareness regarding livelihood programmes.

If we look to the table 2 irrespective of male and female respondents of Dungarpur data shows that respondents had very good amount of awareness (above 75%) regarding practices like are you informed that BPL families were eligible for livelihood programmes, have you heard about breed improvement activities run under TSP Programme, can you say that TSP generates employment opportunities, have you heard about women SHGs yojna running in TSP area, TSP activities can increase family income, do you know women SHGs yojna provide women's empowerment in TSP area, did you observe that breed improvement programmes significantly increased the milk production in TSP area and have you observed that A.I. centers are successfully improving the local breed with 90.47, 86.90, 85.71, 85.95, 84.52, 80.95,79.76 and 78.57 MPS, respectively.

Respondent's possessed good amount of awareness (above 50%) in the practices like are you aware about Tribal area development department, do you have any information about the activities initiated by the TADA for villagers in TSP area, have you heard about the different schemes of livelihood security run in your area, do you have any information about Badi Vikas Yojna, have you heard that trainings were given to the tribal's for their upliftment, Have you heard about Swarojgar Yojana, have you heard about distribution of agriculture implements at 100 per cent subsidies and have you felt that livelihood programmes are changing your living standard in TSP area assigned 9th, 10th, 11th, 12th, 13th, 14th, 15th and 16th ranks, respectively. They possessed least awareness regarding do you know about Supervision and controlling of the activities regularly done by the staff members and Evaluation of the activities done by the project staff members.

The table 2 further shows that male respondents possessed very good awareness (above 75%) regarding are you informed that BPL families were eligible for livelihood programmes, have you heard about breed improvement activities run under TSP Programme, whereas, female respondents possessed very good awareness (above 75%) regarding have you heard about women SHGs yojna running in TSP area, do you know women SHGs yojna provide women's empowerment in TSP area with 95.25, 90.47, 92.85 and 90.47 MPS respectively.

CONCLUSION

Majority of male and female respondents were possessed medium level of awareness followed by low and high level of awareness groups.

Respondents had very good amount of awareness regarding, are you informed that BPL families were eligible for livelihood programmes. This was followed by have you heard about breed improvement activities run under TSP Programme. While relatively less awareness perceived by them were, are you aware about Tribal area development department, do you have any information about the activities initiated by the TADA for villagers in TSP area. They possessed least awareness regarding do you know about Supervision & controlling of the activities regularly done by the staff members and Evaluation of the activities done by the project staff members.

Table 1 Distribution of respondents according to their level of Awareness

Level of awareness	Dungarpur					
	Male(n = 42)		Female (n = 42)		Total (n = 84)	
	F	%	F	%	F	%
Low (below 11 score)	8	19.05	10	21.43	18	21.43
Medium (11-16)	23	54.76	26	58.33	49	58.33
High (above 16 score)	11	26.19	6	20.24	17	20.24
Overall	**42**	**100**	**42**	**100**	**84**	**100**

f = frequency, % = percentage

Table 2. Level of Awareness about livelihood Programmes in TSP area

Aspect	Dungarpur					
	Male (n = 42)		Female (n = 42)		Total (n = 84)	
	MPS	Rank	MPS	Rank	MPS	Rank
Awareness about Tribal Area Development Department	79.19	7	73.80	8	76.50	9
Activities initiated by the TADA for villagers	69.05	10	69.05	10	69.05	10
Schemes of livelihood security run in area	66.67	11	66.67	11	66.67	11
Trainings were given to the tribals for upliftment	54.76	15	64.28	12	59.52	13
BPL families were eligible for livelihood programmes	95.25	1	85.71	4	90.48	1
TSP generates employment opportunities	83.33	5	88.09	3	85.71	4
TSP activities can increase family income	88.09	3	80.95	6	84.52	5
TSP provides subsidy in livelihoods activities	48.24	17	50.00	17	49.12	17
Swarojgar Yojana	64.28	12	52.38	16	58.33	14
Swarojgar yojana is best for youth employment	47.61	18	47.61	18	47.61	18
Badi Vikas Yojana	61.90	13	61.90	13	61.90	12
Distribution of agriculture implements at 100 per cent subsidies	57.14	14	54.76	15	55.95	15
Breed improvement activities run under TSP Programme	90.47	2	83.33	5	86.90	2
A.I. centers are successfully improving the local breed	85.71	4	71.43	9	78.57	8
Breed improvement programmes significantly increased the milk production	80.95	6	78.57	7	79.76	7
Women SHGs running in TSP area	78.57	8	92.85	1	85.71	3
Women SHGs provide women's empowerment	71.43	9	90.47	2	80.95	6
Livelihood programmes are changing living standard	50.00	16	59.52	14	54.76	16
Supervision and controlling of the activities regularly done by the staff members	40.47	19	35.71	19	38.09	19
Evaluation of the activities done by the project staff members	38.09	20	30.95	20	34.52	20

MPS= mean percent score

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Knowledge level of farmers on fish production technology in Tikamgarh district of Madhya Pradesh

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Received: 09.10.15
Accepted: 04.03.16

ABSTRACT

The present study was undertaken to assess the knowledge level of fish farmers about fish production technology. The study was conducted in Tikamgarh District of Madhya Pradesh with 120 fish farmers randomly selected in 10 groups/sammitee of Tikamgarh block, which were results showed that. Fish farmers in Tikamgarh block were of comparatively middle age group, education up to primary to middle, low annual income, medium size of pond for fish farming , minimum experience of 1-3 years, fish farming+wages as their main occupation, medium attitude towards fish farming, medium market orientation, high scientific orientation, low aspiration level, medium use of information sources and high level of training exposure. The knowledge level of fish farmers about recommended fish practices was medium. It was also observed that there was considerable variation in their knowledge on different technological aspects.

Key words: Knowledge level of fish farmers, Production technology, Fish farming.

Fish farming is a lucrative business that can mitigate poverty in the country if practiced by adopting the necessary technologies. It requires less expand of land and it can be practiced in both rural and urban areas within the country. It also requires less time for its management and hence can be practiced by virtually everybody including the youths, house wives, working class and retirees. There is high level of awareness of fish production technologies. All the socio-economic characteristics considered, gender, educational status, level of fish production and other income generating activities of the respondents can be used to adoption of fish production technologies in the study area. In Tikamgarh district of Bundelkhand region there are 100 tanks/ponds with an area of 5090.61 hectare and annual fish production of 2356 tonnes. Further, the preparation of any development strategy mean information about the existing level of knowledge of the target group, unfortunately no data is available on this aspect. Low fish production in the district can be attributed to several factors. However, knowledge of the fish farmers on fish production technology is one of the main reason contributing to low fish production. To improve the adoption of fish production technology, it is necessary to assess the knowledge level of fish farmers. It is therefore, necessary to identify the knowledge level of fish production technology among fish farmers of Tikamgarh district in Madhya Pradesh.

The main objectives of the study were find out the knowledge level of the fish farmers and to establish the influence of socio economic characteristics of fish farmers on their knowledge level regarding fish production technology.

MATERIAL AND METHODS

The study was carried out in Tikamgarh district of Madhya Pradesh. The Tikamgarh district comprises of six blocks, out of which one block i.e. Tikamgarh block was selected purposively as the block comprises of maximum area covered under fish farming in the Tikamgarh district. The Tikamgarh block comprises of 36 fish farmers groups/sammitee, of which 10 groups/sammitee were selected purposively because of having maximum number of fish farmers. A comprehensive list of fish farmers of selected groups/sammitee were prepared with the help of fishery department, among them 12 number of fish farmers from each group were selected through random sampling method. Thus, the total sample drawn was 120 fish farmer. The data were collected and recorded using pre tested and well structured interview schedule. .Frequencies, percentage, standard deviation, and correlation analysis were used for analyzing the data statistically.

RESULT AND DISCUSSION

Profile of fish farmers

Table 1 shows profile of fish farmers. The study revealed that the majority of fish farmers 55.83 % belonged to middle aged group. The perusal of data indicates that their level of education was average. As many as 51.67% of the fish farmers had education up to primary to middle school and above. In case of annual income most of the respondents 38.33 % had low annual income below Rs.50, 000. The area covered under fish farming was 38.33% had medium pond size i..e. 1 to 1.5 ha. Due to scarcity of water resources the farmers found to unable maintain the water capacity of large ponds. In case of experience

in fish farming number of fish farmers 36.67 % had low experience of fish farming. In case of occupation most of the fish farmers 49.17 %were doing fish farming + wages as an occupation for livelihood of the family. The data regarding attitude towards fish farming indicates that majority of fish farmers 40.00% had medium attitude towards fish farming. In case of market orientation majority 36.67 % of fish farmers had medium market orientation and 41.67 % of fish farmers had high scientific orientation. It is evident from the data that about 37.500 % of fish farmers had low aspiration level. In case of use of information sources the majority of the fish farmer 40.83% had medium level. The data regarding training exposure the majority had high training exposure. Thus, the training exposure of fish farmers had high exposure.

Table 2 reveals that the mean knowledge score of fish farmers was 1.56. The Table further shows that the important technological aspects were , unwanted fishes and weed management , fish protection management , harvesting and storage, feed and fertilizer management, while the component of technology which have lower than average value were selection of seed and management and pond management .

The data in the Table 3 indicates that out of the total fish farmers, highest percentage i.e.53.33 per cent was found in medium knowledge category, whereas 25.83 per cent in high and 20.83 per cent in low knowledge categories. The standard deviation of level of knowledge of fish farmers regarding fish production technology were found to 2.60 with coefficient of variation 46.03 per cent. Thus, it can be concluded that the higher (53.33 %) of the fish farmers had medium level of knowledge of fish production technology. Goswami *et al.* (2010) and Rajan *et al.* (2013).

Table 4 shows that all the variables except age have significant positive relationship with the overall knowledge level. It suggest that in general, the farmers knowledge increases with the increase in their education level, annual income, area covered under fish farming ,experience of fish farming , occupation , attitude towards fish farming, market orientation, scientific orientation, aspiration level, use of information sources and training exposure.

Table 5 Shows that undeveloped cooperative structure for marketing (ranked Ist) reported by 62.50 per cent fish farmers followed by unorganized method of extension activities at rural level (ranked IInd) reported by 58.33 per cent fish farmers, high cost of production (ranked IIIrd) reported by 50.00 per cent fish farmers, lack of proper market (ranked IVth) reported by 45.83 per cent fish farmers, low market price of fish (ranked Vth) reported by 41.67 per cent fish farmers and unavailability of fish seed and their proper supply (ranked VIth) reportedby 37.50 per cent fish farmers respectively. While the constraint which have lower than average value were lack of technical advisement in time (ranked VIIth) reported by 33.33 per cent fish farmers followed by lack of training system (ranked VIIIth) reported by 25.00 per cent fish farmers, lack of transportation system (ranked IXth) reported by 20.83 per cent fish farmers, complex improved fish production technology (ranked Xth) reported by 18.33 per cent fish farmers, lack of water to maintain proper water level (ranked XIth) reported by 16.67 per cent fish farmers, unauthorized catching of fish(ranked XIIth) reported by 13.33 per cent fish farmers and unavailability of credit facilities through nationalized bank for fish farming (ranked XIIIth) reported by 12.50 per cent fish farmers respectively (*Apata, 2012).*

CONCLUSION

In relation to knowledge of various technological components, unwanted fishes and weed management, fish protection management , harvesting and storage, feed and fertilizer management, while the component of technology which have lower than average value were selection of seed and management and pond management. Similarly, maximum number of fish farmers had medium level of knowledge of fish production technology. Relationship between characteristics of fish farmers and their knowledge level revealed that, education, annual income, experience, occupation, attitude towards fish farming, marketing orientation, scientific orientation, aspiration level, use of information sources and training exposure were positively related with knowledge of fish production technology only age was negatively related with knowledge level of of fish farmer regarding fish production technology.

Constraints faced by the fish farmers are undeveloped cooperative structure for marketing, unorganized method of extension activities at rural level, high cost of production, lack of proper market, low market price of fish and unavailability of fish seed and their proper supply, while the constraints which have lower than average value are lack of technical advisement in time, lack of training system, lack of transportation system , complex improved fish production technology, lack of water to maintain proper water level , unauthorized catching of fish and unavailability of credit facilities through nationalized bank. Suggestions to overcome the problems that, there should be proper marketing system of fish in the area and aboard, followed by surety for availability of proper quality of fish seed, amount of subsidy should be increased and procedure to be made simple for availing subsidy scheme,

strategy for water development is paramount important, proper information and technical guidance should be provided time to time through training of extension/ fisheries department, higher cost of fish feed, needs to be reduce and formulation and making of the Self Help Groups and cooperatives should be encouraged respectively.

Table 1: Distribution of the fish farmers according to their socio-economic Characteristics.

Variables	Categories	Frequency	Percentage	S.D.	C.V.%
Age	Young	26	21.67	0.66	38.02
	Middle	67	55.83		
	Old	27	22.50		
Education	Illiterate	20	16.67	1.23	42.01
	Primary + middle education	62	51.67		
	Higher education	38	31.67		
Annual Income	Low	46	38.33	0.81	46.31
	Medium	40	33.33		
	High	34	28.34		
Area covered under fish farming	Small	33	27.50	0.78	10.39
	Medium	46	38.33		
	Large	41	34.17		
Expereience of Fish Farming	Low	44	36.67	0.80	47.17
	Medium	42	35.00		
	High	34	28.33		
Occupation	Fish Farming +wages	59	49.17	0.79	9.08
	Fish Farming+ business	35	29.17		
	Fish Farming+ other allied activities	26	21.67		
Attitude Toward Fish Farming	Low	32	26.67	1.31	42.43
	Medium	48	40.00		
	High	40	33.33		
Marketing Orientation	Low	37	30.83	1.86	15.78
	Medium	44	36.67		
	High	39	32.50		
Scientific orientation	Low	37	30.83	1.39	59.65
	Medium	50	41.67		
	High	33	27.50		
Aspiration Level	Low	45	37.50	0.80	6.56
	Medium	41	34.17		
	High	34	28.33		
Use of Information Sources	Low	48	40.00	1.42	38.02
	Medium	49	40.83		
	High	23	19.17		
Training Exposure	No	24	20.00	0.79	42.01
	Partial	33	27.50		
	High	63	52.50		

Table 2: Main components wise level of knowledge of fish farmers regarding fish production technology.

Main Component of technology	Extent of knowledge (frequency)		Mean Score	Rank
	No Knowledge	Knowledge		
Pond management	56	64	1.53	IV
Selection of seed and management	55	65	1.54	III
Feed and fertilizer management	53	67	1.56*	II
Unwanted fishes and weed management	52	68	1.57*	I
Fish protection management	52	68	1.57*	I
Harvesting and storage	53	67	1.56*	II
Overall Average	54 (45.00)	66 (55.00)	1.56	

Table 3. Distribution of fish farmers according to their overall knowledge regarding fish production technology.

Variable	Categories	F	%	S.D.	C.V. %
Overall	Low	25	20.83		
Knowledge	Medium	64	53.33	**2.60**	**46.03**
	High	31	25.83		
	Total	**120**	**99.99**		

Table 4. Relationship between the socio economic profile of the fish farmers and their knowledge level of fish production technology.

Code	Characteristics	'r' value
X1	Age	-0.111 N.S
X2	Education	0.272*
X3	Annual Income	0.149*
X4	Area Covered under fish farming	0.159*
X5	Experience of Fish farming	0.297**
X6	Occupation	0.219*
X7	Attitude toward Fish Farming	0.139*
X8	Market Orientataion	0.493*
X9	Scientific Orientation	0.336*
X10	Aspiration level	0.239*
X11	Use of information sources	0.210*
X12	Training exposure	0.22.*

* Significant at 5% level of probability
** Significant at 1 % level of probability
NS = non significant

Table 5. Constraints faced by fish farmers in adoption of improved fish production technology.

Constraints	F (N=120)	%	Rank
Unavailability of credit facilities through nationalized bank for fish farming	15	12.50	XIII
Unavailability of fish seed and their proper supply	45	37.50*	VI
High cost of production	60	50.00*	III
Low market price of fish	50	41.67*	V
Lack of training system	30	25.00	VIII
Lack of technical advisement in time	40	33.33	VII
Unorganized method of extension activities at rural level	70	58.33*	II
Undeveloped cooperative structure for marketing	75	62.50*	I
Lack of proper market	55	45.83*	IV
Lack of transportation system	25	20.83	IX
Lack of water to maintain proper water level	20	16.67	XI
Complex improved fish production technology	22	18.33	X
Unauthorized catching of fish	16	13.33	XII
Average	**40**	**33.53**	

** higher than average value*

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Impact assessment of training programme on kitchen gardening under waste water management at KVK Sriganganagar

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Received: 12.09.15
Accepted: 01.03.16

ABSTRACT

Kitchen gardening is the revolutionary step to increase vegetables production as well as provision of cheap and fresh vegetables to the rural women. The main focus of the study was to assess the impact of kitchen gardening training given by Krishi Vigyan Kendra Sriganganagr under waste water management project to rural women in Tamkot and 12 SPM villages. Capacity building of rural women in Kitchen Gardening was the focus and twenty trainees of kitchen gardening were selected randomly from each location to assess the impact of their livelihood. The study finding reveals that Kitchen gardening had increase environmental beauty and income of the growers to some extent in the targeted area. It was recommended that longer-term interventions required to support livelihoods with links to the market and to make strategies with communities to improve access to products and services. Kitchen gardens are indigenous livelihood practices, especially among women; scientific approach in provision and promotion of these livelihoods through training sessions aims to make these livelihoods sustainable. Most of the beneficiaries valued livelihood assistance. The results were especially visible in the poor households. Kitchen gardening training has benefited the target community to practice alternative livelihoods. Still, a follow up plan is needed to ensure that such techniques are practiced on a large scale with market links to assist ecological and economical development in the project area.

***Key words*:** Gender, Kitchen Gardening, livelihood and Training.

To overcome the malnutrition in the household the concept of kitchen gardening was introduced over the centuries. Kitchen gardening contributes to household food security by providing direct access to food that can be harvested, prepared and fed to family members, often on a daily basis. Even very poor, landless or rural people practice kitchen gardening on small patches of homestead land, vacant lots, roadsides or edges of a field, or in containers. Gardening may be done with virtually no economic resources, using locally available planting materials, green manures, "live" fencing and indigenous methods of pest control. Thus, kitchen gardening at some level is a production system that the poor can easily enter.

This study was conducted in the rural areas of Tamkot and 12 SPM villages of Sriganganagar district. It was observed during research of kitchen gardening activity conducted in the targeted area, social benefits that have emerged from kitchen gardening practices are; better health and nutrition, increased income, employment, food security within the rural household, and community social life. Rural communities take advantage of vacant land and contribute not only to their household food needs but also the needs of their resident city. Today, creating a kitchen garden have different aims. It may be a means to stretch the bud get by growing food at home that then need to be purchased at a grocery store. Usually the most expensive year for the kitchen garden is the first one, when things like soil or different things may need to be purchased and thereafter, food produced in a kitchen garden usually does save money and tends to taste better than grocery store purchased fruit and vegetables (Christensen, 2011).

This activity can not only save money and time but also can provide a healthy, useful and environment friendly hobby for whole rural family.(Cheema, 2011) In order to preserve health and prevent malnutrition, develop a kitchen garden, grow fresh and clean vegetables and make them a part of our daily diet (Rehman, 2013).

The KVK Sriganganagar has conducted training on kitchen gardening to improve the agricultural and poverty situation under waste water Management Project. KVK had the motive to understand and assess the impact the existing situation and prospects after the training of kitchen gardening in the sampled area. The study was aim to see the impact kitchen gardening training for food security and economic empowerment of the poor rural households especially the women with the following objectives:

- To study the impact of technical demonstration for efficient utilization of waste water resources;
- To study the impact of kitchen gardening on rural communities.
- To suggest policy recommendations for better utilization of water resources.

MATERIAL AND METHODS

KVK Sriganganagar extended kitchen gardening trainings in the sample area and this study was an effort to evaluate the impact of these trainings on the rural households and community. Data was collected through a well developed interview schedule to elicit information from the kitchen gardening trainees. Simple descriptive statistics was employed in order to have a summary description of the data collected. This involved the use of percentages, means and frequency distributions to describe parameters as socioeconomic characteristics. Chi-Square model was used for the interpretation of the results.

The chi-square test provides a method for testing the association between the row and column variables in a two-way table. The null hypothesis *H0* assumes that there is no association between the variables (in other words, one variable does not vary according to the other variable), while the alternative hypothesis *Ha* claims that some association does exist. The alternative hypothesis does not specify the type of association, so close attention to the data is required to interpret the information provided by the test.

RESULTS AND DISCUSSION

From the survey it was reported that the potential land availability of kitchen gardening in court yards (locally known as Nohra) was 60% while cultivated around house and fields was 25% and 15% respectively as clearly shown in Table 1. Majority of the trainees were of the view that drip irrigation is more efficient in using water.

Table 2 reveals the impact kitchen gardening on rural communities. Economically, kitchen gardening improved the livelihood of local community after starting kitchen gardening in the targeted area. It was acknowledged that after the training, all the participants were taking more interest. The practice of kitchen gardening is increase from 53% to 87%, similarly the cultivated land were also increase after the kitchen gardening training. It was also accredited that water source for kitchen gardening and water conservation technology were also improved after starting kitchen gardening. There were some constraints and shortcoming of kitchen gardening given by the respondents i.e. Water shortage for kitchen gardening, pest attacks & less awareness, which were tried to compensate through roof top water harvesting system, water tanks and capacity building of the trainees

The evaluation aimed to gauge whether the training activities in the sampled area had functioned effectively and more specifically, whether trainees had been able to get socio-economic benefits. The evaluation sought to understand the constraints and challenges to achieving the training objectives. The study result shows the kitchen gardening training effectiveness. Capacity building of rural women in kitchen gardening was the focus.

Results of the study analyzed by using Chi-square model (Table 3) which shows significant difference between organizers satisfaction level with respect to the training topics because chi-square value (Chi-Sq = 14.213) is large having a P value (P-Value = 0.076) less than 10% level of significant. In the case of training effectiveness, it is clearly observed in the data that there is a high significant difference between effectiveness responses and training topics because chi-square value (Chi-Sq = 54.265) is large having a P value (P-Value = 0.000) less than 1% level of significant. So that organizer satisfaction levels were quite satisfied in each training curriculum, similarly the effectiveness of the training was quite enormous in each topic of the study except of the Intercultural practices of the trainees.

Greater differences between expected and actual data produce a larger Chi-square value. The larger the Chi-square value, the greater the probability that there really is a significant difference. If, the Chi-square value is greater than or equal to the critical value. There is a significant difference between the groups. That is, the difference between actual data and the expected data (that assumes the groups are not different) is probably too great to be attributed to chance. So we conclude that our sample supports the hypothesis of a difference.

There were some issues in practical application of kitchen gardening .i.e. Water shortage in villages, transfer of package of technology, Crop management, Non availability of inputs/tools, and sustainability issue of the project were identified. As results shows many other constraints (listed below) but some suggestion were also highlights e.g. Promotion of Roof top water harvesting system can solve the water shortage problem in community and arranging seminar and some productive trainings for the capacity building for rural women on pest management, crop management is also needed. A concern have voiced for the provision of specifically high efficiency irrigation system, and provision of tools (gender specific tools).

CONCLUSION

According to the evaluation the following realistic impact were identified after kitchen gardening training. Here are some proven results in the rural community of Kitchen gardening training.

- Increase awareness to the kitchen gardening;
- Decrease expenditure for vegetable;
- Increase supply variety of vegetables;
- Increase crop diversity area of kitchen gardening;

- Increase the practice of kitchen gardening;
- Improved self esteemed and motivation;
- Increase community connection after starting kitchen gardening activity;
- Improved social environment.

SUGGESTIONS AND RECOMMENDATIONS

Following suggestions and recommendation were made to promote kitchen gardening among rural households

- Longer-term interventions required to support livelihoods in target area;
- Explore joint agency collaboration at the community level;
- Strategies with communities to improve access to products and services;
- Provide gender specific tool kits at community level to improve food sustainability through kitchen gardening;
- Establish improved seed sale point in community;
- To conduct different more productive training and seminars to encourage the rural community towards kitchen gardening

Table 1. Land availability for kitchen gardening.

Characteristics	Distribution (Percentwise)		
Potential land availability for Kitchen Gardening	**Court yard (60%)**	**Cultivated area around house (25%)**	**Cultivated area fields (15%)**
Make water use efficient	**Drip irrigation (45%)**	**Water tanks (30%)**	**Roof top water harvesting (25%)**

Table 2. Impact of Kitchen gardening on rural communities.

Impact	Before Training	After Training
Practice of Kitchen Gardening	52.3%	85.7 %
Time allocation for Kitchen Gardening	0.5 hour	2 hours
Impact on livelihood	Buy costly vegetables, health issues	Cost/saving, improvement in physical health (fitness)
Water source for Kitchen Gardening	Waste water of kitchen drain	Roof Top Water Harvesting System & Water Tanks(Drip irrigation)
Water Conservation technology	Lack of water Conservation technology	Fulfils water requirement for Kitchen garden & fields
Major constraints	Water shortage for Kitchen gardening, pest attacks & less awareness	Roof Top Water Harvesting System, Water Tanks (Drip irrigation) and Capacity Building

Table 3. Kitchen gardening training effectiveness

Type/Topic of training (list of topics)	Organizers satisfaction level (%)			Effectiveness (%)		
	Satisfied	**Fully Satisfied**	**Partially Satisfied**	**Trained**	**Fully trained**	**Partially trained**
Introduction & importance of kitchen gardening	50 54.00* 0.296**	40 40.00 0.00	10 6.00 2.667	25 20.00 1.250	65 62.00 0.145	10 18.00 3.556
Preparation & uses of soil	60 54.00 0.667	40 40.00 0.00	00 6.00 6.00	25 20.00 1.250	60 62.00 0.065	15 18.00 0.500
Methods of vegetable cultivation	50 54.00* 0.296**	45 40.00 0.625	05 6.00 0.167	25 20.00 1.250	70 62.00 1.032	5 18.00 9.389
Intercultural practices	55 54.00* 0.019	35 40.00 0.625	10 6.00 2.667	10 20.00 5.000	50 62.00 2.323	40 18.00 26.889
Seed & Seed varieties	55 54.00* 0.019	40 40.00 0.00	05 6.00 0.167	15 20.00 1.250	5 62.00 0.145	20 18.00 0.222
Total	**270**	**200**	**30**	**100**	**310**	**90**
Chi-Sq = 14.213, DF = 8, P-Value = 0.076				Chi-Sq = 54.265, DF = 8, P-Value= 0.000		

*Expected counts are printed below observed counts
**Chi-Square contributions are printed below expected counts

Table 4. Issues faced in the practical application of kitchen gardening

Issues	Possible Suggestions
Water shortage in Villages	Promotion Rooftop water harvesting system in community
Transfer of package of technology	Capacity building /FFS of community on pest/disease identification and management
Crop management	More training s on crop management
Non availability of inputs/tools	Provide improved seeds and establish seed points in rural areas
Proper tool kit for kitchen gardening	Provision of tools (gender specific tools)
Sustainability issue after project	Local skill transfer to service provider/ market linkages

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Field evaluation of spinetoram 12 sc mixtures against leaf damage due to *scelodonta strigicollis* mot on grapes

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Received: 13.11.15
Accepted: 10.01.16

ABSTRACT

Scelodonta strigicollis is a notorious leaf damaging pest in Tamil Nadu in grapes and responsible for considerable yield loss. Effect of a new biological insecticide molecule, spinetoram 12 SC alone and in combination with buprofezin 25 SC 375 g a.i./ha, carbendazim 50 WP 125 g a.i./ha and urea (2%) was studied on *S. strigicollis* at field conditions during 2012 and 2013 kharif seasons. The results of the field experiments showed that spinetoram 12 SC 45 g alone and in combination with buprofezin 25 SC 375 g a.i./ha, carbendazim 50 WP 125 g a.i./ha and urea (2%) were significantly effective in minimizing the *S. strigicollis* when sprayed thrice at 15 days interval and increases the fruit yield. All the tested doses of spinetoram 12 SC 45 g alone and in combination with buprofezin 25 SC 375 g a.i./ha, carbendazim 50 WP 125 g a.i./ha and urea (2%) were showed nil phytotoxic symptoms on grapes plants.

***Key words*:** Spinetoram, Grapes, Field efficacy, *Scelodonta strigicollis,* Yield

Grapevine, *Vitis vinifera* (L.) cultivation is one of the most remunerative farming enterprises in India as grapes are a sed for table purpose, resin and wine making with good medicinal value due to the presence of large amount of antioxidants. It is cultivated in an area of 1,17,632 ha with a total annual production of 24,83,094 MT and productivity of 21.1 tonnes per ha in 2012-2013 (*Anon*., 2013). Insect pests are the important production constraints in grape cultivation apart from diseases. In grape, 85 species of insect pests have been reported in India (Atwal and Dhaliwal, 2005). Among them, flea beetles, cause losses up to 10 to 30 per cent in severe cases in the vineyard (*Anon*., 2008a and *Anon*., 2008 b). Adult flea beetles caused damage to buds, tender shoots, tendrils, leaves and rarely bunches. They bite the sprouting buds or eat them completely. Damaged buds fall to sprout and dry up**.** They also scrape the tender shoots and tendrils resulting in white streaks initially and turning into brown patches later. In severe cases of infestation, the entire leaf is skeletonised (*Anon*., 2008a).

Synthetic insecticides provide dramatic effect initially, and hence chemical control methods are still in use among farmers. Earlier, conventional insecticides like endosulfan (Shivalingaswamy *et al.,* 2008 and Rath and Mukherjee, 2009), malathion and hostathion (Sanjeev Kumar and Gill, 2010), chlorpyriphos (Kuttalam *et al.,* 2008), azadirachtin 1%, phosalone and quinalphos (Anon. 2011), synthetic pyrethroids and endosulfan alternatively with NSKE 4% (Anon. 2009), and fenvalerate, methomyl, azinphosmethyl, carbaryl and pyrethrin/rotenone (Anon. 2012) were reported in management of pests on grapes.

In recent times, new insecticide molecules offer advantages over earlier chemistry in terms of greater levels of safety, better performance and reduced environmental impact. One such new insecticide molecule is spinetoram, has shown outstanding efficacy against tomato caterpillar (*Spodoptera litura* Fabricius) (Muthukrishnan *et al.,* 2013 a), shoot and fruit borer (*Leucinodes orbonalis* Guenee) (Muthukrishnan *et al*., 2013 b), codling moth (*Cydia pomonella* L.*)*, oriental fruit moth *(Grapholita molesta* Busck*)*, army worms (*Spodoptera spp*), cabbage looper (*Trichoplusia ni* Hubner), thrips such as western flower thrips (*Frankliniella occidentalis* Pergande) and onion thrips (*Thrips tabaci* Lindeman*),* leaf miners (*Liriomyzaspp*), chillithrips (*Scirtothrips dorsalis* Hood), fruit borer (*H. armigera*) (Dharne&Bagde, 2011) and stored product insects like *Sitophilus oryzae*, *Tribolium castaneum* and larvae of Indian meal moth *Plodia interpunctella* in stored wheat (Liang Fang and Frank, 2002). However, there are no reports on field effect of spinetoram 12 SC against the *S. strigicollis* on grapes. The present study was therefore conducted to test the field efficacy of spinetoram 12 SC on grapes for two kharif seasons during 2012 and 2013.

MATERIALS AND METHODS

Two field experiments with grapes (cv. Makkirikkodi local) were laid out to evaluate the effect of spinetoram 12 SC against *S. strigicollis* on grapes plants. The plot size of 5 X 5 m which 26 numbers of grape vines TNAU recommended agronomic practices were followed to maintain healthy grape vines throughout experimental period. Effect of eight insecticidal treatments such as spinetoram 12 SC (45 g a.i./ha) + buprofezin 25 SC

(375 g a.i./ha); spinetoram 12 SC (22.5 g a.i./ha) + buprofezin 25 SC (187.5 g a.i./ha); spinetoram 12 SC (45 g a.i./ha) + carbendazim 50 WP (125 g a.i./ha); spinetoram 12 SC (45 g a.i./ha) + carbendazim 50 WP (62.5 g a.i./ha); spinetoram 12 SC (45 g a.i./ha) + urea (2%); spinetoram 12 SC (45 g a.i./ha) alone; spinetoram 12 SC (22.5 g a.i./ha) alone; and untreated check were imposed and each treatment was replicated thrice. There were three applications at 20 days interval based on ETL of target pests. Thorough coverage of plants (to a run off point) with the spray fluid of 500 l/ha was ensured by using high volume knapsack sprayer with hydraulic cone nozzle. Per cent leaf damage (linear and rectangular shaped holes on the leaves) due to flea beetles per vine were assessed from 10 randomly selected vines on pre-treatment, 1, 3, 7 and 10 DAT after 1st, 2nd and 3rd sprays. Marketable fruit yield was recorded from 3 harvests and the total fruit yield was represented as tonnes per ha. Data obtained were subjected to analysis of variance (ANOVA) after transformation (arc sine for per cent data and square root for population data) of data as per the procedure suggested by Gomez and Gomez (1984) and original values are given in Tables. The observations on phytotoxicity symptoms (leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty) were recorded on 7th day after each spray by using visual scoring system.

RESULTS AND DISSCUSSION

Field evaluation of spinetoram 12 SC against *S. strigicollis* on grapes

Leaf damage by *S. strigicollis* varied from 13.2 to 15.5 per cent per vine during first season before imposing treatments (Table 1). Crossed the economic threshold level (ETL). Mean data revealed that leaf damage by *S. strigicollis* varied from 7.2 to 26.4 per cent per vine due to treatments. Significant effect was achieved due to spinetoram 12 SC 45 g + buprofezin 25 SC 375 g (7.2% /vine with 72.7% reduction), spinetoram 12 SC 45 g + urea (2%) (7.5%/vine with 71.5% reduction) and spinetoram 12 SC 45 g + carbendazim 50 WP 125 g (7.7%/vine with 70.8% reduction). Spinetoram 12 SC 45 g alone recorded 7.8 per cent leaf damage per vine with 70.4 per cent reduction. This was followed by spinetoram 12 SC 22.5 g + buprofezin 25 SC 187.5 g (11.8%/vine with 55.3% reduction), spinetoram 12 SC 22.5 g alone (13.5%/vine with 48.8% reduction) and spinetoram 12 SC 22.5 g + carbendazim 50 WP 62.5 g (14.0%/vine with 46.9% reduction) respectively.

Data pertaining to per cent leaf damage due to *S. strigicollis* during second season for 1, 3, 7 and 10 DAT after three sprays are presented in Table 1. Mean leaf damage caused by *S. strigicollis* ranged from 6.2 to 22.6 per cent per vine due to various treatments. Spinetoram 12 SC 45 g combination with buprofezin 25 SC 375 g (6.2%/vine with 72.5% reduction), spinetoram 12 SC 45 g alone (6.5% /vine with 71.2% reduction) and spinetoram 12 SC 45 g + carbendazim 50 WP 125 g (6.6%/vine with 71.6% reduction) recorded minimum leaf damage and on par with each other as against untreated check (22.6%/vine). Spinetoram 12 SC 45 g + urea (2%) (6.7%/vine with 70.3% reduction) was next best treatment. Spinetoram 12 SC 22.5 g + buprofezin 25 SC 187.5 g contributed leaf damage of 9.8 per cent per vine and registered 56.6 per cent reduction respectively. Spinetoram 12 SC 22.5 g + carbendazim 50 WP 62.5 g and spinetoram 12 SC 22.5 g alone were the least effective which achieved only 49.5 and 48.6 per cent reduction with 11.4 and 11.6 per cent leaf damage per vine.

The present findings are in accordance with the results of Mollaie *et al.* (2011) also reported that spinosad was very effective against *T. castaneum* on 14th day after treatment. Getchell (2006) reported that spinosad was more effective against the lesser grain borer, *R. dominica* than against *S. oryzae,* on grains treated with both dry and liquid formulations of spinosad. Flin *et al.* (2004) also stated that spinosad was very effective in suppressing *R. dominica* and *Tribolium castaneum* Herbst populations in stored wheat. In the same way, Toewss *et al.* (2003) concluded that spinosad had excellent contact activity against adults of stored-product insects. Mutambuki *et al.* (2003) found that concentrations of < 1ppm of spinosad dust were very effective against adults of *P. truncatus*, but less effective for the maize weevil, *Sitophilus zeamays* (Motschulsky). Thomas *et al.* (2012) who reported that spinetoram 12 SC was proved effective against *Rhizopertha dominica* (F.) and *Prostephanus truncates* Horn at a very low concentration (0.1 ppm) and moderately effective against *Sitophilus* spp., *Oryzaephilus surinamensis* (L.) and *Tribolium confusum* Jacquelin.

Effect of spinetoram 12 SC on fruit yield

Data on marketable grapes fruit yield ranged from 16.1 to 33.0 t/ha in first season experiment respectively due to all treatments. There was significant difference due to spinetoram 12 SC alone and in combination with other agrochemicals application. Highest fruit yield was recorded due to spinetoram 12 SC 45 g + buprofezin 25 SC 375 g a.i./ha (33.0 t/ha), spinetoram 12 SC 45 g + carbendazim 50 WP 125 g (32.5 t/ha), spinetoram 12 SC 45 g + urea (2%) (32.2 t/ha), and spinetoram 12 SC 45 g alone (32.0 t/ha) which were on par with each other. Spinetoram 12 SC 22.5 g + buprofezin 25 SC 187.5 g a.i./ha as the next best treatment, which contributed moderate fruit yield of 22.0 t/ha respectively. However, spinetoram 12 SC 22.5 g +

carbendazim 50 WP 62.5 g and spinetoram 12 SC 22.5 g alone registered fruit yield of 19.5 and 19.4 t/ha compared to untreated plot which recorded 16.1 t/ha fruit yield (Table 1).

Grapes fruit yield ranged from 17.0 to 33.8 t/ha during second season due to treatments. There was significant difference due to spinetoram 12 SC alone and in combination with other agrochemicals application. Highest fruit yield was recorded due to spinetoram 12 SC 45 g + buprofezin 25 SC 375 g (33.8 t/ha), spinetoram 12 SC 45 g + urea (2%) (33.4 t/ha) and spinetoram 12 SC 45 g + carbendazim 50 WP 125 g (33.0 t/ha). This was followed by spinetoram 12 SC 45 g alone (32.7 t/ha). Spinetoram 12 SC 22.5 g + carbendazim 50 WP 62.5 g was the next best treatment, which contributed yield of 21.7 t/ha. However, spinetoram 12 SC 22.5 g + buprofezin 25 SC 187.5 ml and spinetoram 12 SC 22.5 g alone were registered fruit yield of 22.0 and 20.2 t/ha respectively compared to untreated plot which recorded 17.0 t/ha fruit yield (Table 1).

These results are corroborating with the findings of Amalendu *et al.* (2011) who recorded maximum okra fruit yield in spinosad (84 g a.i/ha) treated plots. Sinha and Nath (2011a) and Wankhede and Kale (2010) also reported effectiveness of spinosad in reducing the fruit infestation and increasing good marketable fruit yield on brinjal. According to Singh and Gupta (2011), spinosad 45 SC at 0.1% was the most effective in reducing the shoot and fruit borer on okra and realized the maximum yield of 84.78 q/ha. Biswas *et al.* (2009) and Pareet and Basavanagoud (2012) reported that spinosad 45 SC recorded lowest mean shoot infestation (13.7%), lowest population of whiteflies (6.70/3 leaves), leaf hoppers (5.63/3 leaves) and highest fruit yield (153. 23 q $ha^{-1)}$ on brinjal. Spinosad 50 g a.i/ha recorded the highest protection over control in shoot and fruit infestation and highest fruit yield in brinjal (Anandkumar *et al.,* 2002).

ACKNOWLEDGEMENTS

The authors express sincere thanks to Dow Agro Science India Pvt. Ltd, Mumbai for providing financial help during the course of investigations.Authors are also thankful to Tamil Nadu Agricultural University, Coimbatore and Agricultural College and Research Institute, Madurai for granting permission to publish the results.

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Response of brinjal (*Solanum melongena* l.*)* to different planting density, irrigation and fertigation levels

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Received: 17.01.16
Accepted: 19.03.16

ABSTRACT

The planting density S_3 (175-50x50cm) showed significant variation with respect to mean NPK uptake by fruits, leaves, stem and total nitrogen, phosphorous, potassium uptake by plant and fruit yield (44.76 t ha^{-1}) of brinjal over the remaining planting density S_2 (75-50x90cm) and S_1 (75x75cm). While the irrigation scheduled at I_1 (100 per cent ET_{crop}) recorded significantly higher values of uptake by fruits, leaves, stem and total nitrogen, phosphorous, potassium uptake by plant and fruit yield (40.17 t ha^{-1}) of brinjal over remaining irrigation levels I_2 (80 per cent ET_{crop}) and I_3 (60 per cent ET_{crop}) under study. The fertigation level F_1 (100 per cent RDF through drip (WSF)) recorded significantly superior values of NPK uptake by fruit, leaves, stem and total nitrogen, phosphorous and potassium uptake and fruit yield (39.63 t ha^{-1}) of brinjal over the fertigation level F_2 (80 per cent RDF through drip (WSF)). The control C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) noticed less average values of NPK uptake by fruit, leaves and stem, total nitrogen, phosphorous and potassium uptake and fruit yield of brinjal. However, the lowest average values were recorded in control C_2 (surface irrigation with 1 IW/CPE ratio). The maximum fertilizer use efficiency of N, P, K i.e. 71.81, 62.52 and 153.7 per cent respectively was recorded in treatment F_2 (80 per cent RDF through drip) whereas in case of treatment F_1 (100 per cent RDF through drip) fertilizer use efficiency of N, P and K was 61.18, 58.06 and 140.6 per cent respectively which was comparatively less as compared to treatment F_2.

Key words: Nutrient uptake, yield, planting density, irrigation levels, fertigation levels and brinjal**.**

Drip irrigation is one such technology which can help to increase the irrigation potential by optimizing the use of available irrigation water. It allows precise timing and uniform distribution of water. Drip irrigation provides an efficient method of water delivery virtually free of cultural constraints that characterize other production systems. Achieving maximum fertilizer efficiency requires knowledge of irrigation scheduling, crop nutrient requirements, soil nutrient supply, fertilizer injection technology and crop and soil monitoring techniques. Improved efficiency results from small, controlled applications throughout the season, in contrast to large conventional type of water applications. Drip irrigation increases the nutrient uptake of NPK by plant as water through drip exactly applied in the vicinity of root zone which can be easily utilized by crop that results in higher fertilizer use efficiency over furrow irrigation. Drip irrigation reduces fertilizer usage and minimize groundwater pollution due to surface runoff from rain or excessive irrigation.

Plant nutrition plays an important role for enhancing yield of eggplant. Fertilizers applied under traditional methods are generally not utilized efficiently by the crop; while in drip fertigation nutrients are applied directly into the zone of maximum root activity and consequently fertilizer-use efficiency can be improved over conventional method of fertilizer application. Application of water soluble fertilizers through irrigation systems that increases the nutrient uptake and nutrient content in different parts of plant and further it improves fertilizer use efficiency which leads to saving of nutrients, higher yield, better quality of produce because the nutrients are to be applied in correct doses and at appropriate stage of plant growth and avoids the leaching, volatizationn losses (Yadav *et al*., 1993, Karlen and Robbins, 1985). In lateritic soil, crop gives better response to the dose of nutrients applied through drip due to lateral movement of water applied through drip is minimum (Salunkhe, 2006).

Crop geometry and plant population plays important role in nutrient uptake and FUE. Increase in nutrient uptake & fertilizer use efficiency by plant is a result of increase in dry matter and ultimately in yield which can be obtained throughout various planting densities. It is very necessary to quantify optimum plant population by adjusting the spacing for improving the nutrient content in fruit, leaf and stem, total nutrient uptake by crop.

Information on these aspects is very meager in brinjal crop and Hence present experiment was carried to study the nutrient uptake by brinjal plant, fertilizer use efficiency (FUE) and fruit yield as

influenced by different planting density, irrigation and fertigation levels in treatment combinations.

MATERIAL AND METHODS

A field experiment was conducted during *Rabi-hot* weather of 2009-2010 at Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.). The soil of experimental field was sandy clay loam in texture and moderately acidic in reaction, medium in available N, low in available P_2O_5 and high in K_2O content. The experiment was laid out in split plot design consisted of three planting density viz., (S_1-75x75cm, S_2-75-50X90cm, S_3-175-50x50cm) and three irrigation levels (I_1-100 per cent ET_{crop}, I_2-80 per cent ET_{crop}, I_3-60 per cent ET_{crop}). The sub plot treatments comprising of two fertigation levels *viz.,* (F_1-100 per cent RDF through drip (WSF), F_2-80 per cent RDF through drip (WSF)). Thus these eighteen treatments combinations were replicated thrice. There were two controls (check basin) with manual application of recommended dose of fertilizer (C_1) and without fertilizer (C_2) in combination of surface irrigation at 1.0 IW/CPE ratio respectively which kept separated beside main and submain treatments. The transplanting was done for three different spacing i.e. 75x75cm, 75-50x90cm, 175-50x50cm in case of drip irrigation system and 75x75cm in case of check basin to maintain uniform plant population per hectare. The irrigation was scheduled based on Pan evaporation of previous two days (Ep), Pan factor (Kp), Stage wise crop coefficient (Kc), Wetted area for Brinjal (Aw). For check basin, irrigation was applied to the crop with depth of 5 cm, IW/CPE=1.0. The recommended dose of brinjal was 150:50:50 NPK kg ha^{-1}. For all treatments of drip NPK dose was applied through water soluble fertilizers namely 19:19:19 grade (sujla) and remaining quantity of N is given through urea. Fertigation was given through the venturi of 0.75 inches. For the experimental treatments fertigation was given in three split doses at interval of 30, 60 and 90 DAT. For control C_1 (100 per cent RDF through soil application) $1/3^{rd}$ quantity of N and 100 per cent P, K was applied as a basal dose and remaining $2/3^{rd}$ quantity of N was applied at 30 ,60 and 90 DAT through manual application of solid fertilizers viz., Urea, SSP and MOP. For control C_2 no fertilizer was given which kept as absolute control. Total yield of each net plot was calculated by summation of weight of fruit per net plot from all pickings. The grand total of each plot was converted on hectare basis (t ha^{-1}).

Fertilizer use efficiency (FWUE)

The fertilizer use efficiency was worked out from the value obtained by nutrient uptake using following formula. (Singh *et al*., 1991)

$$\text{FUE (per cent)} = \frac{\text{Uptake in treated plot} - \text{uptake in control plot}}{\text{Amount of nutrient applied}} \times 100$$

RESULTS AND DISCUSSION

Effect of Planting Density

Data pertaining (Table 1) to mean uptake of nitrogen by fruit, leaf, stem and total nitrogen uptake as influenced by various planting density revealed that the planting density S_3 (175-50x50cm) recorded significantly superior values of mean uptake of nitrogen by fruit (95.28 kg ha^{-1}), leaf (22.17 kg ha^{-1}), stem (34.37 kg ha^{-1}) and total nitrogen uptake (151.8 kg ha^{-1}) over the rest of planting densities under study. Similarly, the planting density S_2 (75-50x90cm) noticed statistically superior to planting density S_1 (75x75cm). The results are in conformity with the results reported by Thakur *et al.* (1998), Kar *et al.* (2006).

The planting density S_3 (175-50x50cm) showed (Table 2) significantly higher values of mean uptake of phosphorous by fruit (18.65 kg ha^{-1}), leaf (11.38 kg ha^{-1}), stem (14.66 kg ha^{-1}) and total phosphorous uptake (44.70 kg ha^{-1}) than the rest of planting densities. Similarly, the planting density S_2 (75-50x90cm) observed statistically superior to planting density S_1 (75x75cm).

The mean uptake of potassium (Table 3) by fruit, leaf, stem and total potassium uptake was significantly influenced by different planting densities under study and revealed that spacing S_3 (175-50x50cm) recorded significantly superior values of mean uptake of potassium by fruit (167.5 kg ha^{-1}), leaf (13.58 kg ha^{-1}), stem (25.08 kg ha^{-1}) and total potassium uptake (206.2 kg ha^{-1}) over the rest of spacings under study. Also the similar trend was observed in spacing S_2 (75-50x90cm) over spacing S_1 (75-50x90cm).

Different planting density significantly influenced the fruit yield (Table 4) and revealed that closest spacing S_3 (175-50x50cm) showed significantly higher fruit yield (44.76 t ha^{-1}) over the rest of planting densities under study. Similarly, the planting density S_2 (75-50x90cm) registered statistically superior (37.66 t ha^{-1}) to planting density S_1 (75x75cm) 30.89 t ha^{-1}. The increase in fruit yield in treatment S_3 was to the tune of 30.99 and 15.8 per cent over the treatments S_1 and S_2 respectively. Similar kind of findings were reported by Harminder singh *et al*. (1997), Chadha *et al*.(1998) and Pundir and Porwal (1999).

Effect of Irrigation levels

Data pertaining to mean uptake of nitrogen by fruit, leaf, stem and total nitrogen uptake by crop (Table 1) was significantly influenced by various irrigation levels and registered that irrigation regime I_1 (100 per cent ET_{crop}) recorded significantly

superior value of mean uptake of nitrogen by fruit (90.94 kg ha^{-1}), leaf (21.50 kg ha^{-1}), stem (32.59 kg ha^{-1}) and total nitrogen uptake (145 kg ha^{-1}) over the rest of irrigation regimes under study. Similarly, the irrigation regime I_2 (80 per cent ET_{crop}) noticed significantly superior to irrigation regime I_3 (60 per cent ET_{crop}). While the control C_2 (surface irrigation with 1.0 IW/CPE ratio) showed reduced average values of mean uptake of nitrogen by fruit (29.69 kg ha^{-1}), leaf (9.04 kg ha^{-1}), stem (13.87 kg ha^{-1}) and total nitrogen uptake (52.62 kg ha^{-1}) as compared to all irrigation treatments.

In case of value of phosphorus uptake by fruit (Table 2) the treatment I_1 (18.47 kg ha^{-1}) and I_2 (18.09 kg ha^{-1}) were at par with each other. However, the treatment I_1 (100 per cent ET_{crop}) and I_2 (80 per cent ET_{crop}) both showed the significant improvement over the treatment I_3 (60 per cent ET_{crop}). The treatment I_1 showed significantly superior value of phosphorous uptake of leaf (10.86 kg ha^{-1}) and stem (13.97 kg ha^{-1}) over the rest of treatments. Similarly, the treatment I_2 was found statistically superior to treatment I_3. In case of total phosphorus uptake irrigation level I_1 recorded significantly superior value of total phosphorous uptake (43.31 kg ha^{-1}) over the rest of the irrigation levels. While the average values of control C_2 (surface irrigation with 1.0 IW/CPE ratio) noticed reduced values of mean uptake of phosphorous by fruit (5.03 kg ha^{-1}), leaf (4.03 kg ha^{-1}), stem (6.03 kg ha^{-1}) and total phosphorous uptake (15.10 kg ha^{-1}) as compared to all irrigation treatments.

In case of potassium uptake (Table 3) the irrigation level I_1 (100 per cent ET_{crop}) recorded significantly superior value of potassium uptake by fruit (164.4 kg ha^{-1}) and stem (23.50 kg ha^{-1}) over the rest of the irrigation levels. Similarly, the irrigation level I_2 (80 per cent ET_{crop}) found statistically superior to irrigation level I_3 (60 per cent ET_{crop}). With respect to value of potassium uptake by leaves the treatment I_1 (100 per cent ET_{crop}) showed significantly superior variation (13.25 kg ha^{-1}) over the rest of the treatments. The treatment I_2 (80 per cent ET_{crop}) was at par with the treatment I_3 (60 per cent ET_{crop}). In case of total potassium uptake irrigation intensity I_1 (100 per cent ET_{crop}) recorded significantly superior value (201.1 kg ha^{-1}) over the rest of irrigation intensities under study. While the control C_2 (surface irrigation with 1.0 IW/CPE) ratio showed reduced average values of mean uptake of potassium by fruit (116.75 kg ha^{-1}), leaf (6.39 kg ha^{-1}), stem (10.19 kg ha^{-1}) and total potassium uptake (133.3 kg ha^{-1}) as compared to all irrigation treatments. High intensity of irrigation facilitates more moisture in soil than low frequency of irrigation which was essential for the uptake of plant nutrients viz., N, P, K from soil. The uptake of NPK by plant is governed by the dry matter production of crop. The drip irrigation treatments recorded higher uptake of NPK than surface irrigation. Similar kind of results have been reported by Alkantar *et al.* (1999) and Agrawal *et al.* (2010).

Different irrigation levels significantly influenced the fruit yield of brinjal (Table 4) and revealed that irrigation scheduled at I_1 (100 per cent ET_{crop}) produced higher fruit yield (40.17 t ha^{-1}) than irrigation scheduled at I_2 (80 per cent ET_{crop}) i.e. 37.63 t ha^{-1} and I_3 (60 per cent ET_{crop}) i.e. 35.50 t ha^{-1}. Also the similar trend was observed in irrigation level I_2 (80 per cent ET_{crop}) over irrigation level I_3 (60 per cent ET_{crop}). The increase in fruit yield in treatment I_1 was to the tune of 6.32, 11.63, 33.58 and 68.11 per cent over the treatments I_2, I_3, C_1 and C_2 respectively. While the control C_2 (surface irrigation with 1.0 IW/CPE ratio) recorded lowest average value of fruit yield (12.81 t ha^{-1}) as compared to all irrigation treatments. Yield is directly proportional to the total amount of water applied to crop. Increased level of irrigation produced high yield as compared to decreased level. Dry matter production is an important prerequisite for higher yield as it signifies photosynthetic ability of the crop and also indicates other synthetic process during developmental sequences. Similar kind of results have been reported by Limbulkar *et al.* (1998), Christopher Lourduraj *et al.* (1998a), Anonymous (2003c), Imtiyaz *et al.*(2004), Gutal *et al.* (2005) and Bhanu Rekha *et al.* (2006).

Effect of Fertigation levels

Nitrogen is the major constituent of plant cell and it plays direct role in the plant growth. Potassium is important for maintaining water balance in plant system, photosynthesis and in the translocation of photosynthates while phosphorus plays an important role in the root growth and in the reproductive activities.

Data pertaining to mean uptake by fruit, leaf, stem and total nitrogen uptake (Table 1) as influenced by various fertigation levels revealed that the fertigation level F_1 (100 per cent RDF through drip (WSF)) recorded significantly higher values in respect of mean nitrogen uptake by fruit (90.59 kg ha^{-1}), leaf (21.43 kg ha^{-1}) and stem (32.39 kg ha^{-1}), total nitrogen uptake (144.4 kg ha^{-1}) over the fertigation level F_2 (80 per cent RDF through drip). While the control C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) showed lowest average values of mean uptake of nitrogen by fruit (66.29 kg ha^{-1}), leaf (15.98 kg ha^{-1}), stem (23.54 kg ha^{-1}) and total nitrogen uptake (105.8 kg ha^{-1}) as compared to all fertilizer treatments.

In case of mean phosphorous uptake by fruit, leaf, stem and total phosphorous uptake (Table 2) was significantly influenced by different fertigation levels. The treatment F_1 (100 per cent RDF through drip (WSF)) recorded significantly superior values of mean uptake by fruit (18.52 kg ha^{-1}), leaf (10.81 kg ha^{-1}), stem (14.80 kg ha^{-1}) and total phosphorous uptake (44.13 kg ha^{-1}) over the treatment F_2 (80 per cent RDF through drip (WSF)). While control C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) noticed less values of mean uptake of phosphorous by fruit (13.28 kg ha^{-1}), leaf (5.22 kg ha^{-1}), stem (10.10 kg ha^{-1}) and total phosphorous uptake (28.61 kg ha^{-1}) as compared to all fertilizer treatments.

The mean potassium uptake by fruit, leaf, stem and total potassium uptake (Table 3) was significantly influenced by different fertigation levels and revealed that fertigation level F_1 (100 per cent RDF through drip) recorded significantly superior values of mean uptake by fruit (166.6 kg ha^{-1}), leaf (13.59 kg ha^{-1}), stem (23.35 kg ha^{-1}) and total potassium uptake (203.6 kg ha^{-1}) over the fertigation level F_2 (80 per cent RDF through drip). While the control C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) showed lowest average values of mean mean uptake of potassium by fruit (150.05 kg ha^{-1}), leaf (9.70 kg ha^{-1}) and stem (16.35 kg ha^{-1}), total potassium uptake (176.1 kg ha^{-1}) as compared to all fertilizer treatments. This evident of NPK uptake by different plant parts of brinjal and total uptake by brinjal crop might be due higher availability of major nutrients and also due to fertigation in the soil around the active root zone of crop always remain at field capacity and there is no leaching losses of nutrients. These findings were in the line with those obtained by Tumbare and Bhoite (2002). Application of recommended dose of soluble fertilizers through drip increased the N, P, K content in fruit, leaf, stem and total uptake by crop than decreased level of soluble fertilizers and soil applied solid fertilizers. Similar kind of results were also reported by Kadam and Sahane (2002), Dademal *et al.* (2004).

In case of fruit yield (Table 4), different fertigation levels influenced significantly and registered that fertigation level F_1 (100 per cent RDF through drip (WSF)) found significantly superior fruit yield (39.63 t ha^{-1}) over the treatment F_2 (80 per cent RDF through drip (WSF)) i.e. 35.92 t ha^{-1}. The fruit yield increased to the extent of 9.34, 32.68 and 67.68 per cent in treatment F_1 in comparison with F_2, C_1 and C_2 respectively. While the control C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) was noticed reduced average value of fruit yield (26.68 t ha^{-1}) as compared to all fertilizer treatments. Similar kind of results were reported by Siviero *et al*. (2001), Shinde *et al.* (2002), Tumbare and Bhoite (2002), Shinde *et al.* (2004), Suthar *et al.* (2005) and Satpute *et al*. (2008). In case of soluble fertilizers the nutrients become available readily throughout the growth stages of crop which produces optimum yield. However, straight fertilizers when applied into soil they may get leach out, volatilize or get fixed into the soil and hence they become unavailable to crop for their growth and development and hence crop do not produce optimum yield with its full potential. Similar results were also reported by Deolankar and Firake (1999).

Interaction effects between Planting density, Irrigation levels and fertigatioin levels

Mean NPK content in fruit, leaf and stem, total NPK uptake by brinjal crop and total biomass production were not significantly influenced by interaction effects of planting density, irrigation levels and fertigation levels.

Fertilizer use efficiency:

The maximum values of fertilizer use efficiency (Table 5) of N, P and K i.e. 71.81, 62.52 and 153.7 per cent, respectively was recorded with treatment F2 (80 per cent RDF through drip) whereas in case of treatment F1 fertilizer use efficiency of N, P, K was 61.18, 58.06 and 140.6 per cent respectively. However, minimum fertilizer use efficiency of N, P, K to the tune of 35.45, 27.02 and 85.6 per cent, respectively was observed in treatment C1 (100 per cent RDF through soil application). Similar kind of results were reported by Vasane *et al.* (1995).

CONCLUSION

From the results it can be concluded that plant spacing of S_3 (175-50x50cm), irrigation level I_1 (100 per cent ET_{crop}) and fertigation level F_1 (100 per cent RDF through drip (WSF)) recorded statistically higher mean total NPK uptake by brinjal crop and fruit yield of brinjal over the rest of treatment combinations. The maximum fertilizer use efficiency of N, P, K i.e. 71.81, 62.52 and 153.7 per cent respectively recorded in treatment F_2 (80 per cent RDF through drip) as compared to treatment F_1 (100 per cent RDF through drip).

Table 1. Mean nitrogen uptake by fruit, leaf, stem and total nitrogen uptake (kg ha^{-1}) as influenced by different treatments

Treatments	N uptake (Kg ha^{-1})			Total N uptake (kg ha^{-1})
	Fruit	Leaf	Stem	
S_1-75x75cm	82.25	20.07	28.91	131.2
S_2-75-50x90cm	88.89	21.17	31.69	141.7
S_3-175-50x50cm	95.28	22.17	34.37	151.8
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.0469	0.0179	0.0515	0.1059
C.D. at 5 %	0.1407	0.0538	0.1544	0.3177
I_1-100% ET_{crop}	90.94	21.50	32.59	145.0
I_2-80% ET_{crop}	88.76	21.13	31.66	141.5
I_3-60% ET_{crop}	86.72	20.79	30.72	138.2
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.0469	0.0179	0.0515	0.1059
C.D. at 5 %	0.1407	0.0538	0.1544	0.3177
F_1-100%RDF through drip irrigation(WSF)	90.59	21.43	32.39	144.4
F_2-80%RDF through drip irrigation (WSF)	87.02	20.85	30.93	138.8
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.134	0.0288	0.0943	0.0841
C.D. at 5 %	0.402	0.0865	0.2828	0.2523
C_1-100 per cent RDF as soil application	66.29	15.98	23.54	105.8
C_2-Absolute control	29.69	9.040	13.87	52.62
Sp x Irr	0.0663	0.0254	0.0728	0.1498
Sp x Fer	0.2322	0.0500	0.1634	0.1457
Irr x Fer	0.2322	0.0500	0.1634	0.1457
Sp x Irr x Fer	0.4023	0.0866	0.2830	0.2524
C.D. at 5 per cent	N.S	N.S	N.S	N.S

Table 2. Mean phosphorous uptake by fruit, leaf, stem and total phosphorou uptake (kg ha^{-1}) as influenced by different treatments

Treatments	P uptake (Kg ha^{-1})			Total P uptake (kg ha^{-1})
	Fruit	Leaf	Stem	
S_1-75x75cm	16.96	9.788	12.77	39.52
S_2-75-50x90cm	17.91	10.59	13.63	42.14
S_3-175-50x50cm	18.65	11.38	14.66	44.70
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.2344	0.0164	0.0413	0.2384
C.D. at 5 %	0.7028	0.0493	0.1238	0.7147
I_1-100% ET_{crop}	18.47	10.86	13.97	43.31
I_2-80% ET_{crop}	18.09	10.57	13.68	42.35
I_3-60% ET_{crop}	16.96	10.33	13.41	40.71
'F' test`	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.2344	0.0164	0.0413	0.2384
C.D. at 5 %	0.7028	0.0493	0.1238	0.7147
F_1-100%RDF through drip irrigation(WSF)	18.52	10.81	14.80	.13
F_2-80%RDF through drip irrigation (WSF)	17.16	10.36	12.58	40.11
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.1637	0.0319	0.0469	0.1743
C.D. at 5 %	0.4909	0.0959	0.1408	0.5226
C_1-100 per cent RDF as soil application	13.28	5.220	10.10	28.61
C_2-Absolute control	5.030	4.030	6.030	15.10
Sp x Irr	0.3315	0.0232	0.0584	0.3371
Sp x Fer	0.2836	0.0554	0.0813	0.3019
Irr x Fer	0.2836	0.0554	0.0813	0.3019
Sp x Irr x Fer	0.4912	0.0959	0.1409	0.5230
C.D. at 5 per cent	N.S	N.S	N.S	N.S

Table 3. Mean potassium uptake by fruit, leaf and stem, total potassium uptake (kg ha^{-1}) as influenced by different treatments

Treatments	K uptake (Kg ha^{-1})			Total K uptake (kg ha^{-1})
	Fruit	Leaf	Stem	
S_1-75x75cm	158.8	12.72	20.31	191.9
S_2-75-50x90cm	163.1	13.12	22.71	199.0
S_3-175-50x50cm	167.5	13.58	25.08	206.2
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.1863	0.0344	0.0447	0.1990
C.D. at 5 %	0.5587	0.1033	0.1340	0.5966
I_1-100% ET_{crop}	164.4	13.25	23.50	201.1
I_2-80% ET_{crop}	163.0	13.11	22.72	198.9
I_3-60% ET_{crop}	162.1	13.05	21.88	197.0
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.1863	0.0344	0.0447	0.1990
C.D. at 5 %	0.5587	0.1033	0.1340	0.5966
F_1-100% RDF through drip irrigation(WSF)	166.6	13.59	23.35	203.6
F_2-80% RDF through drip irrigation (WSF)	159.7	12.69	22.05	194.4
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em ±	0.1664	0.0330	0.0444	0.1749
C.D. at 5 %	0.4991	0.0991	0.1332	0.5245
C_1-100 per cent RDF as soil application	150.05	9.70	16.35	176.1
C_2-Absolute control	116.75	6.39	10.19	133.3
Sp x Irr	0.2635	0.0487	0.0632	0.2814
Sp x Fer	0.2883	0.0572	0.0769	0.3030
Irr x Fer	0.2883	0.0572	0.0769	0.3030
Sp x Irr x Fer	0.4994	0.0992	0.1332	0.5248
C.D. at 5 per cent	N.S	N.S	N.S	N.S

Table 4. Fruit yield of brinjal (t ha^{-1}) as influenced by different treatments

Treatments	Yield (t ha^{-1})
Planting density	
S_1-75x75cm	30.89
S_2-75-50x90cm	37.66
S_3-175-50x50cm	44.76
'F' test	Sig.
S.Em ±	0.112
C.D. at 5 per cent	0.336
Irrigation levels	
I_1-100 per cent ET_{crop}	40.17
I_2-80 per cent ET_{crop}	37.63
I_3-60 per cent ET_{crop}	35.50
'F' test	Sig.
S.Em ±	0.112
C.D. at 5 per cent	0.336
Fertigation levels	
F_1-100 per cent RDF through drip irrigation (WSF)	39.63
F_2-80 per cent RDF through drip irrigation (WSF)	35.92
'F' test	Sig.
S.Em ±	0.094
C.D. at 5 per cent	0.282
Control treatments (Average values)	
C_1-100 per cent RDF through soil application	26.68
C_2- Absolute control	12.81
Interaction effect	
Sp x Irr	0.158
Sp x Fer	0.163
Irr x Fer	0.163
Sp x Irr x Fer	0.282
C.D. at 5 per cent	N.S

Table 5. Fertilizer use efficiency (per cent) as influenced by differenttreatments

Treatments	N	P	K
C_2 . Control	**-**	**-**	**-**
C_1-100 per cent RDF through soil application	**35.45**	**27.02**	**85.6**
F_1-100 per cent RDF through drip	**61.18**	**58.06**	**140.6**
F_2-80 per cent RDF through drip	**71.81**	**62.52**	**153.7**

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Studies on interrelationship in rice (*Oryza sativa* L.)

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Received: 03.01.16
Accepted: 08.04.16

ABSTRACT

Correlation and path analysis studies on eight characters with 21 F_1s and their seven parents in rice revealed that the genotypic correlations were slightly higher in magnitude than phenotypic correlations indicating that there was a strong inherent association between characters studied and their expression. Number of tillers per plant, number of filled grains per plant, panicle length, pollen fertility and plant height had positive and significant correlation with grain yield per plant at both phenotypic and genotypic level. Path analysis indicated that the number of tillers per plant exhibited highest direct positive effect on grain yield followed by number of filled grains per panicle, plant height and pollen fertility (%). Direct negative effect on grain yield was exhibited by spikelet sterility (%). Number of filled grains per panicle had high positive indirect effect on grain yield through panicle length, number of tillers per hill and pollen fertility (%). Pollen fertility exhibited positive indirect effect on grain yield per plant via panicle length and number of filled grains per panicle. Improvement in grain yield would be effective if the selection is exercised for more number of filled grains per panicle, productive tillers per plant and higher panicle length and pollen fertility percentage.

Key words: Rice, correlation, path, regression

Rice is the staple food for more than one third of world population. As the yield is a complex character and the multiplicative effect of individual components understanding the relationship between yield and its component traits is essential for making effective selections in plant breeding. Correlation coefficients provide information on the extent and nature of relationships between yield components whereas path coefficient analysis helps to know the direct and indirect contribution of individual components to yield. Path analysis splits the correlation coefficient into direct and indirect effects so as to measure the relative contribution of each variable towards yield (Mohsin *et al*., 2009). The yield contributing traits are interrelated each other showing a complex chain of relationship and also highly influenced by the environmental conditions (Prasad *et al*., 2001). Hence the present investigation was carried out to know the inter relationships as well as direct and indirect effects of different yield components on yield.

MATRIAL AND METHODS

The experiment was conducted by crossing seven parents in half diallel design at Regional Agricultural Research Station, Warangal. The resultant 21 F_1s and their seven parents were evaluated in randomized block design with three replications during kharif, 2008. Each genotype was planted in a row by adopting a spacing of 15 cm between rows and 10 cm with in the row. Recommended agronomic practices and plant protection measures were followed for the good maintenance of the crop during entire season. Data were recorded on five randomly selected competitive plants in each replication on days to 50% flowering, plant height (cm), number of tillers per plant, panicle length (cm), number of grains per panicle, spikelet sterility (%), pollen fertility (%) and grain yield per plant (g) were recorded. Phenotypic and genotypic correlation coefficients were estimated as per the method given by Johnson *et al*. (1955) and path coefficients as suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance revealed the presence of sufficient variation in the material studied. Significant differences were observed between the genotypes for all the traits under consideration. Maximum variation was registered in case of filled grains per panicle followed by pollen fertility (%), plant height and grain yield per plant.

Genotypic correlations were slightly higher in magnitude than the phenotypic correlations for some of the traits indicating less influence of environment on associations of these characters (Table-1). Plant height, number of tillers per plant, panicle length, number of filled grains per panicle and pollen fertility (%) had significant positive correlation with grain yield per plant as was observed by Hairmansis *et al*., (2010) for number of grains per panicle, Ullah *et al*., (2011) and Mulugeta *et al*., (2012) for panicle length and number of grains per panicle.

Among the other yield contributing traits, plant height and number of tillers per plant had significant and positive association with panicle length and number of filled grains per panicle. Panicle length had positive correlation with number of filled grains per panicle and pollen fertility. Significant and positive association was observed between number of filled grains per panicle and pollen fertility. This suggested that increased pollen fertility led to higher percentage of seed set which in turn resulted more number of grains per panicle. Elizabeth *et al*., (2011) reported that grains per panicle had significant positive correlation with plant height, panicle length and number of filled grains per panicle as in the case of present study. Spikelet sterility showed significant negative association with pollen fertility and grain yield per plant.

Path analysis indicated that number of tillers per plant and number of filled grains per panicle had exhibited high positive direct effects on grain yield (Table-2). Spikelet sterility (%) showed direct negative effect on grain yield. Number of tillers per plant exhibited highest direct effect on grain yield followed by number of filled grains per panicle, plant height and pollen fertility (%). In general, characters exhibiting high direct effects for grain yield also exhibited high degree of positive correlation with grain yield. Similar findings were reported by Babu *et al*., (2012), Shanthalatha *et al*., (2004) and Chandra *et al*., (2009) for number of productive tillers per plant, number of grains per panicle and plant height Thus, direct selection based on these traits will be valuable for yield improvement in rice. Number of filled grains per panicle had high positive indirect effect on grain yield through panicle length, number of tillers per hill and pollen fertility (%). Number of tillers per hill showed positive indirect effect on grain yield via number of filled grains per panicle, panicle length, pollen fertility and plant height. Pollen fertility exhibited positive indirect effect on yield via panicle length and number of filled grains per panicle. Different yield related traits influenced yield not only through their direct effects but also through indirect contributions.

Regression coefficient of yield (Table-3) on number of tillers per plant, panicle length, pollen fertility (%), number of filled grains per panicle and plant height was significant and positive whereas on spikelet sterility it was negatively significant. Yield components such as number of tillers per plant, number of filled grains per panicle and panicle length showed major contribution to grain yield. Estimates of coefficient of determination (r^2) and adjusted r^2 revealed that number of tillers per hill caused a variation of 60.75% in yield and number of filled grains per panicle caused a variation of 59.96% on yield and panicle length to an extent of 36.69%.

From this study it is concluded that direct selection for number of tillers per hill, number of filled grains per panicle, plant height, and indirect selection for panicle length and high pollen fertility (%) would be highly rewarding.

Table 1. Phenotypic and genotypic correlation coefficients for yield and yield contributing traits in rice

Traits		Days to 50% flowering	Plant height (cm)	No. of tillers / plant	Panicle length (cm)	No. filled grains / panicle	Spikelet sterility (%)	Pollen fertility (%)	Grain yield / plant (g)
Days to 50% flowering	P	1.000	0.105	-0.038	-0.053	-0.003	-0.136	0.005	0.061
	G	1.000	0.106	-0.060	-0.055	-0.002	-0.142	0.003	0.059
Plant height	P		1.000	0.205	0.353 **	0.325 **	-0.152	-0.064	0.389**
	G		1.000	0.242*	0.365**	0.343**	-0.156	-0.072	0.399**
No. of tillers / plant	P			1.000	0.391 **	0.453 **	-0.393 **	0.213	0.694**
	G			1.000	0.483**	0.563**	-0.513**	0.275**	0.834**
Panicle length	P				1.000	0.688 **	-0.344 **	0.450 **	0.601**
	G				1.000	0.709**	-0.345**	0.469**	0.608**
No. filled grains / panicle	P					1.000	-0.684 **	0.428 **	0.757**
	G					1.000	-0.718	0.461**	0.784**
Spikelet sterility (%)	P						1.000	-0.657 **	0.720**
	G						1.000	-0.679**	0.747**
Pollen fertility (%)	P							1.000	0.485**
	G							1.000	0.511**

* Significant at 5 % level **Significant at 1 % level

P - phenotypic correlation coefficient **G** - genotypic correlation coefficient

Table 2. Phenotypic and genotypic path coefficient analysis for yield contributing traits in rice

Traits		Days to 50% flowering	Plant height (cm)	No. of tillers / hill	Panicle length (cm)	No. filled grains / panicle	Spikelet sterility (%)	Pollen fertility (%)	Grain yield / plant
Days to 50% flowering	P	**0.031**	0.003	-0.001	-0.002	0.000	-0.004	0.000	0.061
	G	**0.036**	0.004	-0.002	-0.002	0.000	-0.005	0.000	0.059
Plant height	P	0.016	**0.148**	0.031	0.052	0.048	-0.023	-0.010	0.389
	G	0.020	**0.186**	0.045	0.068	0.064	-0.029	-0.013	0.399
No. of tillers / plant	P	-0.015	0.078	**0.380**	0.149	0.172	-0.149	0.081	0.694
	G	-0.034	0.135	**0.556**	0.269	0.313	-0.285	0.153	0.834
Panicle length	P	-0.007	0.043	0.048	**0.122**	0.084	-0.042	0.055	0.601
	G	0.002	-0.012	-0.015	**-0.032**	-0.023	0.011	-0.015	0.608
No. filled grains / panicle	P	-0.001	0.082	0.114	0.174	**0.252**	-0.172	0.108	0.757
	G	0.000	0.055	0.090	0.113	**0.159**	-0.114	0.073	0.784
Spikelet sterility (%)	P	0.023	0.026	0.067	0.059	0.116	**-0.170**	0.112	-0.720
	G	0.060	0.066	0.215	0.145	0.301	**-0.420**	0.285	-0.747
Pollen fertility (%)	P	0.000	-0.003	0.009	0.018	0.017	-0.026	**0.040**	0.485
	G	0.001	-0.015	0.058	0.099	0.097	-0.143	**0.211**	0.511

Phenotypic Residual effect = 0.4295 Genotypic Residual effect = 0.3073
P - Phenotypic direct and indirect effect **G -** Genotypic direct and indirect effect
Bold values are direct effects

Table 3. Simple regression coefficients, coefficient of determination (r^2) and adjusted r^2 of grain yield and its components in rice

Attributes	Simple regression coefficients	r^2	Adjusted r^2	SE
Days to 50 % flowering	0.1127559	0.0036	-0.0347	13.9242
Plant height	0.378436 *	0.1565	0.1241	12.8106
No. of tillers / hill	6.135843x **	0.6075	0.5924	8.7392
Panicle length	2.229007**	0.3669	0.3426	11.0984
No. of filled grains / panicle	0.382862**	0.5996	0.5842	8.8263
Spikelet sterility (%)	-0.76948**	0.5435	0.5259	9.4245
Pollen fertility (%)	0.42007176**	0.2518	0.2230	12.065

* Significant at 5 % level **Significant at 1 % level

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Impact of watershed development programme in distict Banka (Bihar)

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Received: 10.02.16
Accepted: 18.03.16

ABSTRACT

A study was conducted during 2015--16 in Katoriya micro watershed in block of Banka district of Bihar. To assess the impact of watershed development programme survey was under taken on management practices. Positive effect of programme was noticed an increase in area of Pigeon Pea and wheat while productivity of gram and Pigeon Pea was increased with a change in arable area, agricultural area, irrigated area, cropping intensity, water resources and area of horticultural crops. Using modern inputs like high yielding varieties, chemical fertilizers, irrigation and plant protection measures, etc. productivity of crops can be increased. The co-ordination of farmers and government functionaries, land development activities were some of the measures for improving the Katoria Micro Watershed. Better coordination between development agencies and voluntary organizations is also essential for effective implementation of water shed programmes.

***Key words*:** watershed programme, area, productivity, nutrients use, adoption, farming.

The rate of land degradation in rain fed areas in India in the 1990s is estimated to have been approximately twice the rate observed in the 1980s, basically on soil erosion and soil runoff (Reddy, 2000). Soil, water, vegetation, nutrients and energy are the basic natural resources needed for the agricultural production. Due to ever-increasing population pressure, these natural resources are shrinking very fast (Raju *et.al*., 2004). Since agricultural development is not possible on deteriorating natural base, thus , there is a need to lay emphasis on conservation and judicious utilization of these resources through adoption of sustainable management practices. It is an established fact that conservation of natural resources and their management holds key to sustainable agriculture. In basic resources to mankind, have been practiced since ancient times. However, there has been practiced since ancient times. However, there has been renewed emphasis in the recent past on conservation of these resources and their efficient utilization (Chauhan, M. 2010).

About two thirds of the centaury's cultivated land currently depends exclusively on rainfall, which is often erratic and poorly distributed. Water, soil and vegetation are the most vital natural resources for the survival of people. Watershed forms an integral component of these basic, natural resources. Watershed conditions influence the productivity of food, fuel, fodder, fibre and fruits. Growing demand for these items has extensively surface soils, which has resulted in partial to complete loss of nutrients and thereby reducing productivity and endangering vital life, support sys. Experiences of many have also indicated that it is not very difficult to organize people around a profitable activity for some time but sustaining of such interest for a long period has been difficult. Mobilization of people's participation would need much more intensive interaction while the communities would be needed to be involved in the process of planning, execution and management of the watershed to the extent possible. It is well known fact that after construction of water shed the water for irrigation was increased, which brings the changes in cropping pattern and increases the crop productivity in the respective watershed areas. Initially (2011-12) the projected was started in Katoria block of Banka district named as Integrated watershed development programme (IWDP), but presently project known as Pradhan Mantri Krishi Shinchai Yojna- Water shed development (PMKSY)-WD since 2015-16. After the availability of sufficient water in particular area, which impact may be found.

The impact of this micro- watershed on different aspect of agricultural production, structural, operational and extent of technological adoption needs to be examined. Hence the present study was under taken to assess the impact of watershed development programme in water shed zone of Banka, Bihar.

METERIALS AND METHODS

The Mohtabari, Jaipur, Katoria micro watershed is situated at Katoria block of district Banka (Bihar). This area comes under south Bihar agro ecological zone III B in Bihar having semi arid subtropical climate having maximum temperature 39 ^{o}C and minimum 8.2 ^{o}C. The most of the rainfall is received during mid July to early October. The annual rainfall is 723mm. Fine loamy to coarse sandy loamy soils 153.1 (000ha) i. e. (52.45%) of the total land area

found in Banka district and majority of the area comes under Katoria block. Therefore, soils are quite suitable for growing Paddy, Pigeon Pea, Wheat, Gram, Lentil, Horse Gram, Mustard and Sesame etc. (Agriculture contingency plan for Banka, 2011).

In Katoria block (Mohtabari, Jaipur and Katoria) micro watershed of Banka district was purposively selected for this study during 2011-12. Out of 1200 farmers 110 farmers were selected randomly for the study. All the farmers, who were selected as respondents for the benchmark survey of this project in the year 2011-12, were used for this study. For the study, pretest interview schedules were used for obtaining data and were compared with the data collected for the benchmark survey and from Block records. The secondary data for the year 2012-13 were collected by the Soil Conservation Department, Banka and project records of Govt. offices. Simple percentage distribution statistical methods were used for analysis of data. The impact of watershed development programme was studied in terms of change in area under different crops, productivity, land use pattern, land resources use, change in water resources, change in micro and macro soil nutrients availability and live stock status.

RESULTS AND DISCUSSION

Change in area: The data presented in table 1 revealed that total area under crops increased after implementation of watershed programme in the Katoria watershed area. The positive changes were observed in the area of Pigeon pea (9.09%) in Kharif and Sesame (60.86%), Mustard (21.15%), Gram (19.76%), Lentil (15.23%) and wheat (5.88%) in Rabi season over the period of implementation except Horse Gram recorded negative change in cultivated area (-2.2%). It indicates Horse Gram is low water loving crop and after implementation of the programme farmers left horse gram to grow.

All the crops recorded progressive increase in yield after implementation of the project. The figures implies that due to insufficient availability of irrigation water, timely availability of agricultural inputs and training imparted by extension agents, after implantation of water shed programme. Area of crops like wheat, mustard which needs timely irrigation, has significantly increased. Thus, the positive change clearly indicates the healthy impacts in the study area due to watershed development programme. These findings are similar to those of (Ahmad *et. al*., 2011)

Change in productivity: The impact of water shed development programme is also studied in terms of crop productivity from the post project status. It can be evident from the post project status.

It is revealed from table (2) that the highest increment in productivity was observed in paddy (33.33%) followed by Pigeon Pea (11.11%) in Kharif 2014-15. In Rabi season highest increase in productivity was observed in mustard (125%) followed by sesame (60%), gram (50%), lentil (40%), wheat (35.75%). Increase in productivity recorded for all the crops except Horse Gram negative productivity (-25%). It is revealed from the data due to water shed development programme farmers used modern inputs like high yielding varieties, chemical fertilizers, timely irrigation and use of plant protection measures etc. may increase the productivity of crops. Similar findings were also reported by Jat *et. al*. (2008).

Change in land use pattern: The inputs of watershed development programme in terms of change in land use pattern is presented in table 3. Availability of arable and non arable land (-8.05%) and increment in arable land (2.68%). The study showed that the average cropping intensity was observed 129 percent as compare to 124 percent in benchmark of survey during the year 2011-12 in Katoria watershed area. An increase in agricultural and irrigated area about 33.33 percent and 16.7 percent respectively in water shed area in the area 2015-16 as compared to starting of the programme 2012-13.

Thus, it could be inferred that due to the participation in the water shed management activities farmers were able to gear up their adoption on soil and water conservation practices. Similar findings were also reported by Desai *et.al.* (1997).

Change in the land use resources: Highly positive change was noticed in area of horticultural crops (Mango-61.9%), area under others (like agro forestry plants, shrubs and bushes-13.34%), increase in vegetable crops area (53.42%), status of waste land development 42.85 percent and increase area under pasture 40 percent.

Thus, the positive change clearly indicates healthy inputs by the adoption on horticultural and vegetable crops practices. Other crops like forestry programme was observed on waste land, panchayats and government land, very few farmers planted forest plants, bushes and grasses in the study area. This might be due to marginal and small land holdings, where they preferred to grow food grain crops rather than the tree plantation. These results in conformity with (Semual *et. al.,* 2004).

Change in water resources: The data presented in table 5 revealed that no soil and water conservation structures were constructed before implementation of watershed development programme whereas 57 numbers of structures have been constructed after watershed development programme. Due to increase

in ground water status some new wells and hand pumps also constructed. Water run-off reduced by small structures resulted in increased agriculture area. Deep hand pumps increased 42 in numbers.

Wells which used to dry up during the summers have been converted in to perennial sources of water, the conservation of soil in the farms has also resulted in the better productivity of crops in the water shed development programme. Similar results were found by (Verma, A. R. 2008).

Change in nutrients: The data presented in table (6) revealed that nutrients availability to major crops increased after implementation of water shed programme in Katoria- Block, district- Banka (Bihar). The positive changes were observed in the availability of nitrogen (11.00%), phosphorus (66.74%), potash (178%) and organic carbon (100%) after the period of implementation.

Thus, the positive change is clearly evident by the soil testing on grid basis by District Agriculture Department and Krishi Vigyan Kendra, Banka (2015-16) and recommended use of fertilizers in the study area (Yadav and Sharma, 2003). Increased organic content in the soil improves the potassium intake and availability in the soil as well as plants. It is already proven that organic matter increased the available phosphorus and potassium to the plants and soil. Similar findings reported by Chambers *et al*., 2006.

CONCLUSION

It would be concluded that overall watershed management practices in the study area have positive and effectivie changes on agricultural area, crop productivity, land use, use of land resources, water resources and availability of nutrients due to increase in availability of water in the watershed area. It was also found positive change in agricultural land (33.33%0 and irrigated area (16.7%), area under horticultural crops and vegetable crops (51.61%) and (53.42%) respectively. The results of the study suggested that appropriate steps needed to be taken by the farmers for rational use of cultivated land, waste land, forest and other common property resources. Using modern inputs like high plant yielding varieties, chemical fertilizers, irrigation and plant protection measures etc. increased the productivity of crops. The coordination of farmers and government functionaries, land development activities were some of the measures for improving the Katoria micro watershed. Better coordination between development agencies and voluntary organizations is also essential for effective implementation of watershed development programme. Lack of effective coordination among project officials, agriculture extension department, agriculture research station and farmers near the study area is a constraint in the adoption of watershed technique.

Table 1. Change in area of major crops in WS-Katoria after implementation of water shed programme

Primary data of water shed(WS) of Mohtabari, Jaipur, Katoria under Katoria block Banka					
Major crops		**Pre project status (ha)**	**Post project status (ha)**	**Absolute change (ha)**	**Relative change (%)**
Kharif	Paddy	4426	4502	76	1.71
	Pigeon Pea	286	312	26	9.09
Rabi	Wheat	866	917	51	5.88
	Gram	86	103	17	19.76
	Lentil	105	121	16	15.23
	Mustard	104	126	22	21.15
	Sesame	23	37	14	60.86

Table 2.Change in productivity of major crops in water shed area of Katoria Block (Banka)

Season	**Crops**	**Pre project status (ha)**	**Post project status (ha)**	**Absolute change (ha)**	**Relative change (%)**
Kharif					
	Paddy	18	24	6	33.33
	Pigeon Pea	6	8	2	11.11
Rabi					
	Wheat	14	19	5	35.71
	Gram	4	6	2	50
	Lentil	5	7	2	40
	Horse Gram	4	3	-1	-25
	Mustard	4	9	5	125
	Sesame	5	8	3	60

Table 3. Change in land use pattern in watershed under Katoria

Change in land use pattern	Pre project status (ha)	Post project status (ha)	Absolute change (ha)	Relative change (%)
Arable land (ha)	4770	4898	128	2.68
Non-arable land (ha)	1714	1576	-138	-8.05
change in cropping intensity (%)	124%	129%	5	4.03
Increase in agricultural land	96	128	32	33.33
change in area under irrigation	850	992	142	16.7

Table 4. Change in land resources use activities (ha) in micro watershed Mohtabari, Jaipur and Katoria.

Change in land resources use activities (ha)	Crop	Pre project status (ha)	Post project status (ha)	Absolute change (ha)	Relative change (%)
Increase area under pasture		5	7	2	40
Increase in area under horticultural crops	Mango	21	34	13	61.9
	Guawa	3	4.5	1.5	50
	Others	22	25	3	13.34
					51.61
Increase in vegetable crops area		73	112	39	53.42
Status of waste land development		112	160	48	42.85

Table 5. Development of water resources in watershed Mohtabari, Jaipur, Katoria under Katoria block Banka

Development of water resources	Pre project status (ha)	Post project status (ha)	Absolute change (ha)	Relative change (%)
Number of soil and water conservation structure	10	57	47	470
Number of wells	22	0	-22	-100
Number of hand pump	38	42	4	10.52

Table 6. Availability of major nutrients to major crops (kg/ha)

Availability of major nutrients to major crops (kg/ha)	Pre project status (ha)	Post project status (ha)	Absolute change (ha)	Relative change (%)
Nitrogen	210.8	234	23.2	11
Phosphorus	20.6	34.35	13.75	66.74
Potash	278	456	64.02	178
Organic carbon	0.34	0.48	0.14	100

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A study on aspiration of government field functionaries and beneficiary farmers about NWDPRA in Rajsamand District of Rajasthan

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Received: 13.12.15
Accepted: 15.03.16

ABSTRACT

The study was conducted in Bhakroda watershed of Rajsamand district in Rajasthan, to analyses the aspiration of watersheds development for field functionaries and beneficiaries farmers. All the eight villages of Bhakroda watershed were included in the study. 14 field functionaries and 180 beneficiaries' farmers were purposively selected in the study. The study concludes that Government Field Functionaries have very high aspiration about their personal life and also towards watersheds activities. In case of beneficiary's high levels of aspiration for which they have joined the programmes were to increase their production and to improve their land.

***Key words*:** *Field functionaries, beneficiary farmers, users committees and aspiration.*

The government of India has launched NWDPRA for regeneration of rainfed areas through conservation of natural resources. This technique will help in sustainable agricultural production system in rural areas and will generate employment opportunities for rural youths. The psychological factors like aspiration of field functionaries of programme implementing agency as well as beneficiaries plays a significant role in the success of the programme. The level of these parameters varies from person to person and dependent on other variables. A study concludes that most of the farm youths had high level of aspiration for animal husbandry (Chaudhary 1976).the study of aspiration of beneficiaries farmers helps in understanding the behavior of the beneficiaries about the NWDPRA activities. The aspiration of the beneficiary farmers explains the need or desire for which they have motivated and joined the programme. Therefore, a study was conducted in Bhakroda watersheds of Rajsamand district of Rajasthan to analyse the aspiration of government field functionaries and beneficiary farmers about NWDPRA.

MATERIALS AND METHODS

The study was conducted in Bhakroda watershed of Rajsamand district of Rajasthan located 30 km away from district headquarter. A list of the villages and the presidents of the users committees of Bhakroda watersheds was obtained from the office of the Deputy Director, Watershed Development and Soil Conservation, district Rajsamand, Rajasthan. All the eight villages of Bhakroda watershed were included in the study. The president of users committee of each village was approached to obtain a list of beneficiaries of their village for the purpose of personal interview. 23 respondents from each 1st four villages were selected and 22 respondents were selected from each last four villages, thus a total of 180 respondents who were available in the village and were willingly ready to give his response were purposively selected in the study. The data related to aspiration of watersheds for field functionaries and beneficiaries' farmers' two separate tools were designed. The aspiration tool was designed with facility to record the response in the form of Yes or No and score was assigned as 1 and 0 respectively for each item for both types of beneficiaries.

RESULTS AND DISCUSSION

Aspiration of Government Field Functionaries

The review of table 1 states that very high response (more than 92.86 per cent) of Government Field Functionaries has been obtained for their aspiration related to their daily life and also towards NWDPRA activities. The morale of these personnel can be maintained high by imparting in-service refresher training courses including trainings on social aspects for community development. This will enable them in understanding the behavior of rural people and organizing their activities according for better implementation of the project activities.

Aspiration Level of beneficiaries

The respondent's response was recorded on a data collection tool and with the help of standard deviation and mean the obtained score were grouped into three categories i.e. High aspiration, Medium aspiration and low aspiration.

The review of table 2 indicated 18.89 per cent respondents have joined the programme with high level of aspiration whereas, 13.33 per cent respondents have joined the programme with low level of aspiration and 67.78 per cent respondents have joined the programme with medium aspiration.

Aspiration of beneficiaries to join the NWDPRA

The areas of aspiration for which the farmers have joined the NWDPRA have been presented in the table 3. The review of the table 3 indicates that high areas of aspiration for beneficiaries to join the programme were to increase his agriculture and allied production and they also wanted to improve their farmland.

The areas of low aspiration of farmers were establishment of their own dairy and non-farm occupation. The table further explains that majority of farmers joined the programme with an aspiration that they will get reliable information about agriculture and allied fields, wanted to be more skilled, family member aspired to join the programme ect.

CONCLUSIONS

The study concludes that Government Field Functionaries have very high aspiration about their personal life and also towards watersheds activities. In case of beneficiarys high levels of aspiration for which they have joined the programme were to increase their production and to improve their land. The areas of low aspiration identified were establishment of own dairy and non-farm occupations. In rest of the areas they have average aspiration.

Table 1. Aspiration of government field functionaries (N= 14)

Statement	Score	Per cent
Work is worship	13	92.86
I work for job satisfaction	14	100.00
I have to give something for nation	14	100.00
Work with rural family gives me satisfaction	14	100.00
My boss is of positive attitude	13	92.86
Office working environment aspires me to work hard	14	100.00
Adequate programme fund smoothen target achievement	14	100.00
Villagers co-operation helping in project target achievements	13	92.86
I am always ready to do new things	14	100.00
Successful implementation of programme gives credit to my profession	14	100.00
This programme will give me a recognition	14	100.00
This is really a worthwhile programme	14	100.00
I wanted to maintain my image among office staff	14	100.00
This is really a right programme at right time aspired me to associated with it	14	100.00

Table 2. Aspiration Level of beneficiaries N=180

Level of Aspiration	No. of respondents	Per cent (%)
High Aspiration (>14 score)	34	18.89
Medium Aspiration (8to 14 score)	122	67.78
Low Aspiration (< 8 score)	24	13.33

Average Score= 120.41, Standard deviation = 30.62

Table 3. Aspiration of beneficiaries to join the NWDPRA (Max. possible score=180)

Statement	Score	Per cent	Level of Aspiration
I have join the programme to increase your production	167	92.78	High
I have join the programme to improve your farm land	156	86.67	High
I have join the programme to get reliable information about agriculture and allied fields	148	82.22	Medium
I wanted to be more skilled in my profession	146	81.11	Medium
My family members aspired me to participate	143	79.44	Medium
Govt. field functionaries have aspired me to participate	139	77.22	Medium
I wanted to improve my living standard	126	70.00	Medium

Statement	Score	Per cent	Level of Aspiration
I have joined the programme to learn vegetable/ fruit production technologies for marketing purpose	124	68.89	Medium
User's committee aspired me to participate	123	68.33	Medium
Programme impact in the treatment area have aspired me to participate	121	67.22	Medium
Grass, fuel and timber wood production of the programme have aspired me to participate	118	65.55	Medium
I wanted to establish my agricultural/ allied profession	117	65.00	Medium
Project period was the correct time for me to woek hard and get something	106	58.89	Medium
I wanted to get some social position through this programme	97	53.89	Medium
I wanted to show my capability to my family members through this programme	96	53.89	Medium
I have joined the programme to establish my own dairy	77	42.78	Low
I have joined the programme to improve my nonfarm occupation	43	23.89	Low

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Morphological and biochemical characterization of bacterial diversity under the rhizospheric soils of fruit orchard: A case study

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Received: 28.10.15
Accepted: 10.03.16

ABSTRACT

Soil microorganisms play an important role in soil microbiological quality and productivity. The development of effective methods for studying the diversity, distribution, and behavior of agriculturally important microorganisms in soil habitats is essential for a broader understanding of soil health and fertility parameters. The present work aims to critically evaluate some agriculturally important microorganisms (AIMs), through appropriate microbiological and biochemical methods, the study demonstrated the presence of AIMs in the rhizosphere of Pomegranate (*Punica granatum),* Mango *(Mangifera* indica) in Rajasthan state. The microbial diversity existing within top 0–20 cm fruit orchard rhizospheric soil, was isolated and characterized morphologicaly and biochemically and found the promising microbes, namely (Genus), *Bacillus, Pseudomonas and Micrococcus*. The optimum temperature, pH and EC for isolated AIMs were found to be 33.83ºC and 7.3, 0.34 respectively. The bacteria utilize glucose, sucrose and starch as sole carbon source. The isolated microbial strains from fruit orchard rhizospheric soils have such Plant growth promoting rhizobacteria (PGPR) , PSB (Phosphate solubilizing bacteria), auxin producing bacteria, that use one or more direct or indirect mechanisms to improve the growth and health of plants.

***Key words*:** Rhizospheric Soil, AIMs, biochemical, microbiota.

Plant growth-promoting rhizobacteria (PGPR) are the rhizosphere bacteria that can enhance plant growth by a wide variety of mechanisms like phosphate solubilization, siderophore production, biological nitrogen fixation, Rhizosphere engineering, production of 1-Aminocyclopropane-1-carboxylate deaminase (ACC), quorum sensing (QS) signal interference and inhibition of biofilm formation, phytohormone production, exhibiting antifungal activity, production of volatile organic compounds (VOCs), induction of systemic resistance, promoting beneficial plant-microbe symbioses, interference with pathogen toxin production etc.

Soil bacteria and fungi play pivotal roles in various biogeochemical cycles (BGC) (Molin and Molin, 1997; Trevors, 1998; Wall and Virginia, 1999) and are responsible for the cycling of organic compounds. Soil microorganisms also influence above ground ecosystem by contributing to plant nutrition (George et al., 1995; Timonen et al., 1996), plant health (Filon et al., 1999), Soil structure and soil fertility(Yao et al., 2000).

Our knowledge of soil microbial diversity is limited in part by our inability to study soil microorganisms. It has also been estimated that about 5000 Bacterial species have been described (Pace, 1999). Plant growth promoting rhizobacteria facilitate the plant growth directly by either assisting in resource acquisition (nitrogen, phosphorus and essential minerals) or modulating plant hormone levels, or indirectly by decreasing the inhibitory effects of various pathogens on plant growth and development in the forms of bio-control agents. Various studies have documented the increased health and productivity of different plant species by the application of plant growth promoting rhizobacteria under both normal and stressed conditions. The plant-beneficial rhizobacteria may decrease the global dependence on hazardous agricultural chemicals which destabilize the agro-ecosystems.

MATERIALS AND METHODS

Soil Test

Collection of Samples- Soil samples were collected from the field of *Punica granatum, Mangifera indica* in the month of March 2015. In present study soil samples were collected from three different blocks A, B and C from Saradhana, Ajmer district in Rajasthan. The area lies in Latitude 26º 34161N and Longitude 74º 57614E. There are three different field's soils, that is block A is the Blank field (without any crop), Block B have anaar (Pomegranate) and block C have aam (mango) were selected for the present study (Table 1). The samples were collected from 0-15 cm, 15-30 cm depths. Soil profile is the place where most of the microbial activity takes place, and thus most of the bacterial population is concentrated. Soil samples were collected (Approx 100 gm) in clean, dry and sterile polythene bags using sterilized spatula.

Determination of soil temperature- The temperature of the soil at the three different blocks (A, B and C) was determined by the use of thermometer. The thermometer was inserted into the soil up to depth of 5-10 cm and allowed to stay for 10 minutes, after which the temperature reading was obtained.

Determination of soil pH- Soil pH is the measure of the acidity or alkalinity of a soil. The term pH applies to solutions, so analysis must be conducted on a soil. The soil sample is mixed with water, allowed to equilibrate for at least an hour, then the pH measured. Several factors affect measurement. Primary among these is the salt concentration of a soil (a salt is any molecule that, when placed in water, separates into positively and negatively charged components and ions). The salt concentration of a soil may vary with the season or with fertilizer application, and is generally greater immediately following fertilizer application than before. The result may be an apparent pH drops up to one- half a pH unit. When samples are collected from blocks A, B and C, frequently or at various times may be noted that pH values tend to increase and decrease, seemingly at random, (B. Nandini et al., 2013).

Determination of Soil EC (Electrical conductivity) – The electrical conductivity of soil samples (Block A, B and C) are determined using electrode with a ratio of soil and water, 1:2 parts suspension (10 gm scoop of soil to 20ml of water).

Microbial Analysis by morphological and biochemical characterization:

Dilution of samples- The collected samples were processed using soil dilution plate method. One gram of soil sample was diluted with sterilized distilled water up to 10^{-1}, 10^{-2}, 10^{-3}, 10, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} and 1 ml of each dilution was added to 20 ml of nutrient agar medium in 90mm diameter sterile Petri dishes and then enumerated.

Microbial population count: Counting of isolated bacterial cultures had been done by serial dilution agar plate technique. Serial dilutions were prepared by transferring a known volume of the dilution to second dilution blank and so on. Once diluted, the specified volume of the dilution sample (1ml) from various dilutions was added to sterile petri plates to which melted and cooled (45-50º C) suitable agar medium was added. The colonies were counted on Quebec colony counter. The number of organisms developed on the plates after an incubation period 24-48hours per ml is obtained by multiplying the number of colonies obtained per plate by the dilution factor, which is the reciprocal of the dilution. (Table 2).

$$\text{Number of cells/ml} = \frac{\text{Number of colonies}}{\text{Amount plated X dilution}}$$

Isolation of agriculturally important microorganisms (AIMs) - Single separate colonies on the agar plates were selected at random according to standard medium and streaked on the nutrient. Agar plates were incubated for 24 hrs at ±30ºC. Code names were given to each isolated plates and stored for further characterization and identification by standard methods. Once colonies rise in the media, the sub cultures were obtained. Identification of isolated AIMs was done with the help of standard literature. Nutrient agar medium were prepared for isolation of bacteria and to differentiate between gram positive and gram negative bacteria, gram staining was done (Table 2).

Catalase Test- Certain organisms produce hydrogen peroxide during aerobic respiration and sometimes extremely toxic superoxide radicals. Catalase test is used to check the presence of catalase enzyme in microorganisms. These superoxide radicals are extremely toxic because they are powerful oxidizing agents and destroy cellular constituents very rapidly. A bacterium must be able to protect itself against such O_2 products or it will be killed. Many bacteria possess enzymes that afford protection against toxic O_2 products (Figure 1- A).

Citrate Utilization Test- By Using Citrate Utilization test we are able to determine the ability of the microbes to ferment citrate as sole carbon source. When bacteria oxidize citrate, they remove it from the medium and liberate CO_2. CO_2 combines with sodium (supplied by sodium citrate) and water to form sodium carbonate - an alkaline product. This raises the pH, turns the pH indicator to a blue color, and represents a positive citrate test; absence of a color change is a negative citrate test (Figure 1- B).

Nitrogen Fixation Ability Test- A Qualitatively experiment to evaluate nitrogen fixation capacity of rhizobacterial isolates. Rhizobacterial isolates, fixing nitrogen shows growth on the Nitrogen free malate medium with bromothymol blue indicator, changing the color from blue to green. The uninoculated plates serve as control (Figure 1- C).

Carbohydrate Degradation Test- Carbohydrate Degradation test performs to determine the ability of microbes to ferment carbohydrates (Glucose, lactose, sucrose etc.) with the production of an acid and/or gas. Sugars are metabolized through different metabolic pathways depending on types of microbial species and aerobic or anaerobic environment. If fermenting bacteria are grown in a liquid culture medium containing the carbohydrate, they may produce organic acids as by-products of the fermentation. These acids are released into the medium and so lower pH of medium. If a pH indicator such as phenol red is included in the

medium, the acid production will change the medium from its original color to yellow (Figure 1- D).

Indole Production Test- Indole production Biochemical Test performs to determine the ability of microbe to degrade the amino acid tryptophan. Development of cherry red color at the interface of the reagent and the broth, within seconds after adding the Kovacs' reagent indicates the presence of indole and the test is positive. If no color change is observed, then the test is negative and so organisms are not capable of producing tryptophanase (Figure 1- E).

Phosphate Solubilizing Ability- To assess the insoluble phosphate solubilising ability of microorganisms, Pikovaskaya media (N free medium) is used. The zone of clearance in medium is showing the positive result (Figure 1- F).

Starch Hydrolysis- Starch Hydrolysis Biochemical test is used to detect the ability of isolated microbial strains to use starch as energy source (Figure 1- G).

Bacterial Enumeration- Advances in microbial methods have demonstrated that globally microorganisms are the dominating organisms both concerning biomass and diversity. Their functional and genetic potential may exceed that of higher organisms. Studies of Agriculturally important microorganism diversity have been hampered by their dependence on phenotypic characterization of bacterial isolates. Molecular techniques have provided the tools for analyzing the entire bacterial community including those which we are not able to grow in the laboratory.

RESULTS AND DISCUSSION

Soil pH, EC and temperature- Physiochemical properties of soil sample of the different three blocks A, B, C with variation of the pH values ranged from 7.22- 7.84 and EC (Electrical conductivity) ranged from 0.00 to 0.02 volt. Temperature of the soil at the time of this investigation (summer season) revealed that the soil environment had temperature range between 30 to 38ºC (Table 1). Microbial measurements for the present study were analyzed systematically and formal statistical analysis were employed to determine the amount of sample to be withdrawn from rhizospheric soils of Rajasthan that best represents the microbial community. Soil electrical conductivity (EC) is ranged between 0.00 to 0.002 dS/m whereas pH is ranged from 7.22 to 7.84 were recorded. Similarly, Mishra et al., (2015) have analyzed the EC ranged between 1.02 to 0.15 dS/m where pH of collected fennel soil samples of Rajasthan ranged from 8.8 to 7.6. All the bacterial isolates were small, circular with an entire margin, and light to dark yellow in color on nutrient agar medium.

Morphological characterization of isolated bacterial diversity- The sampling of total three blocks A, B and C soils, a total seventeen microbial strains of bacteria were isolated, such as *Bacillus, pseudomonas, Micrococcus*. Dilutions (10^{-4} and 10^{-5}) were used for the determination of the number of cultured cells as colony forming units (CFU) by spread-plating them onto nutrient agar. Two replicates for each dilution were prepared. The agar plates were incubated in the dark at 29.4 º C for 48 h. The number of bacteria was expressed as cells/ml in Table No. 2. Colonies of Isolated bacteria were obtained on nutrient agar medium after incubation at 29.4°C for two days. The colonies were having sticky appearance showing the production of mucous though at lower levels. Analysis of colony morphology indicated round colonies, white, cream, and yellow colored till 3-4 days of growth. Typical colonies had a diameter of 5-7 mm. The pH of the medium and broth during growth of isolates was changed from 7.0 to 6.0 (De Oliveira et al. 2007).

Biochemical characterization of isolated bacterial diversity- All the seventeen microbial isolates were analyzed gram negative, and positive for catalase biochemical test. Six isolates (AS-A-1, AS-A-3, AS-B-1, AS-B-2, AS-C-1, AS-C-7) for citrate utilization, five bacterial isolates (AS-A-1, AS-A-3, AS-B-4, AS-C-5, AS-C-7) for phosphate solubilizing ability, eight bacterial isolates (AS-A-4, AS-A-5, AS-B-3, AS-B-4, AS-B-5, AS-C-3, AS-C-4, AS-C-5) for indole production, nine isolates (AS-A-1, AS-A-3, AS-A-4, AS-A-5, AS-B-1, AS-B-2, AS-C-2, AS-C-6, AS-C-7) for carbohydrate (glucose) and six isolates (AS-A-2, AS-A-3, AS-B-2, AS-B-5, AS-C-1, AS-C-7) for PGPR had given positive results in biochemical analysis (Table 3). According to Prakash et al., (2011), all the identified isolates, except for the control showed positive reaction on motility, oxidase, catalase and growth at 4º C. Future studies of soil microbial communities must necessarily rely on a combination of both culture-dependent and culture independent methods and approaches. Only then we will be able to develop a more complete picture of the contribution of specific AIMs (Agriculturally important microorganisms) to the overall quality and health of soils.

ACKNOWLEDGEMENTS

Authors are thankful to Director, ICAR-NRC on Seed Spices, Ajmer for providing necessary facilities during the present study.

Table 1. Soil pH, temperature and EC of collected samples.

Block	Crop (Seed spice and fruit)	Soil pH	Soil Temperature (ºC)	Soil EC (dS/m)	Location	
					Village and District	Latitude Longitude
A	Open area (Without any crop/ fruit orchard)	7.84	38	0.37	Saradhana, Ajmer	26º 34161N 74º 57614E
B	Pomegranate *(Punica granatum)*	7.73	33.5	0.34	Saradhana, Ajmer	26º 34161N 74º 57614E
C	Mango *(Mangifera indica)*	7.22	30	0.13	Saradhana, Ajmer	26º 34161N 74º 57614E

Table 2- Morphological characteristics of bacterial field isolates

Bacterial Isolates	Motility	Growth on medium	Gram's Staining	Shape and Arrangements	Identified Genus	No. of cells/ ml
AS-A-1	+	+	_	Cocci, single	*Micrococcus*	6.0×10^6
AS-A-2	+	+	_	Cocci, Single	*Micrococcus*	5.8×10^5
AS-A-3	+	+	_	Comma, single	*Micrococcus*	7.1×10^4
AS-A-4	+	+	_	Cocci, cluster	*Micrococcus*	4.0×10^4
AS-A-5	+	+	_	Cocci, single	*Micrococcus*	2.5×10^6
AS-B-1	+	+	_	Cocci, single	*Micrococcus*	4.8×10^5
AS-B-2	+	+	_	Comma,cluster	*Pseudomonas*	4.35×10^5
AS-B-3	+	+	_	Sphere, single	*Pseudomonas*	5.23×10^4
AS-B-4	+	+	_	Short rod,chain	*Bacillus*	3.10×10^4
AS-B-5	+	+	_	Sphere, cluster	*Pseudomonas*	6.1×10^5
AS-C-1	+	+	_	Comma, single	*Pseudomonas*	2.1×10^4
AS-C-2	+	+	_	Rod, chain	*Bacillus*	3.4×10^5
AS-C-3	+	+	_	Cocci, tetrad	*Micrococcus*	6.7×10^5
AS-C-4	+	+	_	Sphere, cluster	*Micrococcus*	5.9×10^4
AS-C-5	+	+	_	Rod, single	*Bacillus*	4.1×10^5
AS-C-6	+	+	_	Rod, chain	*Bacillus*	1.4×10^4
AS-C-7	+	+	_	Cocci, single	*Micrococcus*	2.3×10^4

Table 3- Biochemical characteristics of bacterial field isolates

Bacterial isolates	Catalase Test (A)	Citrate Utilization (B)	Nitrogen fixation (C)	Carbohydrate degradation (Glucose) (D)	Indole production (E)	PSB (F)	Starch Hydrolysis (G)
AS-A-1	+	+	_	+	_	+	_
AS-A-2	+	_	+	_	_	-	+
AS-A-3	+	+	+	+	_	+	+
AS-A-4	+	_	_	+	+	_	_
AS-A-5	+	_	_	+	+	_	+
AS-B-1	+	+	_	+	_	_	+
AS-B-2	+	+	+	+	_	_	+
AS-B-3	+	_	_	_	+	_	+
AS-B-4	+	_	_	_	+	+	+
AS-B-5	+	_	+	_	+	_	+
AS-C-1	+	+	+	_	_	_	+
AS-C-2	+	_	_	+	_	_	+
AS-C-3	+	_	_	_	+	_	+
AS-C-4	+	_	_	_	+	_	+
AS-C-5	+	_	_	_	+	+	_
AS-C-6	+	_	_	+	_	_	+
AS-C-7	+	+	+	+	_	+	_

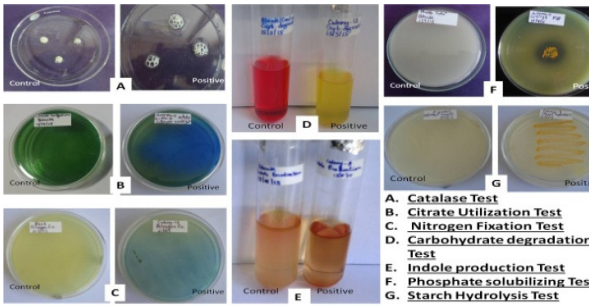

FIG 1: Biochemical Characterization of isolated microbial strains

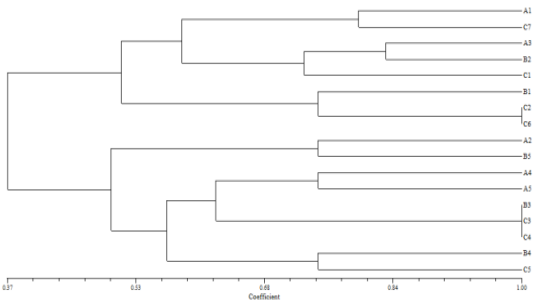

FIG 2: Phylogenetic relationship based on biochemical characters

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Tribal farmers reaction towards goat farming in Banswara district

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Received: 03.02.16
Accepted: 28.03.16

ABSTRACT

This study was conducted in ten adopted villages viz., Masotia, Nokala, Devlia and Sageta of block Talwara, and Sagwaria, Deyana, Sundni, Jantora, Bhudanpura, Vajakhara of Block Garhi District Banswara, Rajasthan. Total 62 goat farmers were selected Because of 62 Goat Units were given to trebles in NAIP component III by KVK Banswara's . The study was undertaken after conducting transfer of technology programs on different improved goat production practices in above adopted villages. Majority of the selected respondents goat farmers learnt more skill on use of lime for sanitation followed by use of vaccine like, PPR, ET,FMD etc., proper housing management for keeping goats , use of salt, deworming of goats , feeding of colostrum to kids in time , keeping improved bucks , plantation/ keeping fodder trees/grasses , use of mineral mixture or khadia , dipping of goats to control ectoparasite etc. Goat has been a ready cash riding dependence on high cost private credit, increased share of income from goat to family's total income, increase profit/goat/annum, increased awareness about commercial goat farming and its advantages, increased access to goat milk for family consumption and increase in employment generation through goats reported by the 98.38, 96.77, 88.77, 80.64, 72.58 and 100 percent selected respondents goat farmers as socio-economic indicators respectively. Similarly, bicycle, construction of house, construction of goat shed, television/ radio, scooter/motor cycle, jewellery, children education and Mobile phone reported by the 56.45,48.38,80.64,32.25,8.06,27.41and25.17 percent selected respondents goat farmers as status of family's assets, respectively.

The Krishi Vigyan Kendra, Banswara had made extension efforts for transferring the improved goat production practices to the end users. These efforts were done in one ICAR funded project namely "Livelyhood and nutritional security of tribal dominated areas through integrated farming system and technology models". Therefore, it is necessary to conduct impact study of these practices for guiding need based research and development of appropriate production systems. With this ideology in view, an attempt has been made to study the socio-economic impact of the transferred improved goat production practices in adopted villages with the following objectives:

1. To study the skill improvement of selected goat farmers.
2. To study the socio-economic indicators of selected farmers.
3. To study the status of family's assets of selected goat farmers.

METERIAL AND METHODS

This study was conducted in ten doped villages viz, *Masotia, Nokala, Devlia and Sageta of block-Talwara, and Sagwaria, Deyana, Jantora, Bhudanpura, Vajakhara of Block Garhi Distt. Banswara, Rajasthan.* These all villages are adopted by KVK under NAIP Project. The investigation was undertaken after Providing one unit of goat (Two goats with kids) and conducting transfer of technology programmes on different improved goat production practices in above adopted villages. Fifteen improved goat production practices, six socio-economic indicators and eight status of family's assets were identified with the help of experts and goat farmers for this study. The data were collected through personal interview with the help of pre-tested structured schedule. The data collected were tabulated and statistical tools like frequency and percentage were used for logical conclusion.

RESULTS AND DISCUSSION

The findings on the socio-economic impact of the transferred improved goat production practices in adopted villages are presented and discussed in terms of skill, socio-economic indicators and status of family's assets.

Practice wise skill improvement in recommended/ demonstrated improved goat production practices :

Fifteen practices in goat rearing as recommended/ demonstrated by Krishi Vigyan Kendra on Goats in ten adopted villages were considered for assessing the skill improvement. The Data generated on this aspect were analyzed and presented in Table 1.

It could be seen from Table1 that 15 practices recommended /demonstrated by KVK Banswara in goat rearing in adopted villages. The majority of the

selected respondents goat farmers learnt more skill on use of lime for sanitation (91.93%), use of vaccine like, PPR, ET, FMD etc., (90.32%), proper housing management for keeping goats (88.77%), use of salt (87.1%), deworming of goats (85.48%), feeding of colostrum to kids in time (83.87%), keeping improved bucks (80.64%), plantation/ keeping of fodder trees/grasses (69.35%) and use of mineral mixture or khadia (72.58%). Anthalt (1994) reported that he skills are required by the extension agents to diagnose farmers problems and the willingness to do so effectively, listen to and learn from farmers and the willingness to do so, communicate effectively with farmers and farmers groups, present options based on principles of science and good agricultural practices which widen the real choices available to farm families and work under complex and fluid circumstances with little supervision. The skill level seemed to be poor in the areas of dipping of goats to control ectoparasite preparation of goat milk ghee, use of berseem culture, keeping of appropriate proportion between male and female, making of pelleted feed and weeding in fodder crops. Trainability refers to a person's ability to acquire the skills, knowledge or behaviour necessary to perform a job at a given level and to achieve these outcomes in a given time (Robertson and Downs, 1979).

Socio-economic indicators The socio-economic indicators of selected respondents goat farmers were selected, tabulated and presented in Table 2.

It is clear from Table 2 that majority of the selected respondents goat farmers (98.38%) reported that goat has been a ready cash riding dependence on high cost private credit followed by increased share of income from goat to family's total income (96.77%), increase profit/ goat/ annum (88.70%), increased awareness about commercial goat farming and its advantages (80.64%), increased access to goat milk for family consumption (72.58%) and increase in employment generation through goats (100%). Kumar and Singh (2005) also observed that the goats have become steadily important in the rural economy particularly in the arid, semi-arid and mountainous regions of the country. Similarly, goat provided an opportunity for efficient utilization of family labour (Kumar and Deoghare, 2003). *Status of family's assets :* The status of family's assets of selected respondents goat farmers presented in Table 3.

It may be seen from the Table 3 that 56.45 percent of the selected respondents goat farmers had possessed bicycle and construction of house and goat shed reported by 48.38 and 80.64 percent, respectively. 32.25 percent of each possessed television and radio. The data shows that 27.41 per cent farmers send their children in English school and 25.19 per cent purchage mobile phones. There were fewer respondents having scooter/motor cycle, jewellery . Acharya and Singh (1992) also highlighted the crucial role of the goats in livelihood security of resource poor rural households.

CONCLUSION

The study indicated that recommended /demonstrated practices in goat rearing, the majority of the selected respondents goat farmers learnt more skill on use of lime for sanitation, use of vaccine like, PPR, ET, FMD etc., proper housing management for keeping goats, use of salt, deworming of goats, feeding of colostrum to kids in time, keeping improved bucks, plantation/ keeping of fodder trees/ grasses and use of mineral mixture or khadia.

In the case of socio-economic indicators, majority of the selected respondents goat farmers had reported that the goat has been a ready cash riding dependence on high cost private credit, increased share of income from goat to family's total income, increase profit/goat/annum and increased awareness about commercial goat farming and its advantages. Most of the selected respondents goat farmers (80.64%) had constructed goat shed as assets.

Table 1. Distribution of selected goat farmers according to skill improvement in improved goat production practices (N= 62).

Learnt more skill on	Frequency	Per cent
Use of lime for sanitation	57	91.93
Use of vaccine like, PPR, ET, FMD etc.	56	90.32
Proper housing management for keeping goats.	55	88.7
Use of salt in diet.	54	87.1
Deworming of goats.	53	85.48
Feeding of colostrums to kids in time.	52	83.87
Keeping improved bucks.	50	80.64
Plantation/keeping of fodder trees/grasses.	47	69.35
Use of mineral mixture or khadia.	45	72.58
Dipping of goats to control ectoparasite.	42	67.74
Preparation of goat milk ghee.	21	32.87
Use of Berseem culture.	21	32.87
Keeping of appropriate proportion between male and female.	20	32.25
Making of pelleted feed.	7	11.3
Weeding in fodder crops.	4	6.45

Table 2. Distribution of selected goat farmers with respect to socio-economic indicators (N=62.

Particulars	F	%
Goat has been a ready cash riding dependence on high cost private credit.	61	98.38
Increased share of income from goat to family's total income	60	96.77
Increase profit/goat /annum	55	88.7
Increased awareness about commercial goat farming and its advantages	50	80.64
Increased access to goat milk for family consumption.	45	72.58
Increase in employment generation through goats.	62	100

Table 3. Distribution of goat farmers based on status of family's assets (N=62)

Particulars	F	%
Purchased Bicycle.	35	56.45
Construction of house.	30	48.38
Construction of goat shed.	50	80.64
Television/ Radio	20	32.25
Scooty /Motor Cycle.	5	8.06
Children Education	17	27.41
Jewellery.	3	4.8
Mobile Phone.	15	25.19

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Impact of adoption of scientific interventions in mung bean on grain yield and farmers income: An assessment by FLD's in Jhunjhunu district of Rajasthan.

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Received: 05.01.16
Accepted: 12.03.16

ABSTRACT

Front line demonstrations on mungbean were conducted at farmers fields in district Jhunjhunu (Rajasthan) during kharifseasons since the year 2010-11 to 2014-15. On five years overall average basis about 23.40per cent higher grain yield was recorded under demonstrations over the farmer's traditional practices. The extension gap, technology gap and technology index were 149.8 kg per ha, 425.20 kg per ha and 35.43per cent, respectively.FLD programme found effective in changing attitude, skill and knowledge of demonstration farmers about improved practices of mung bean cultivation. This also improved the relationship between farmers and scientists and built confidence between them.

Key words: Mung bean, Demonstration, Extension gap, Technology gap, Potential yield, Technology index, Effective gain, IBCR.

The Indian Council of Agricultural Research had evolved a new concept of "First Line Demonstrations" in 1990-1991, which later on termed as "Front Line Demonstrations".To organise front line demonstrations (FLD) on various crop, is one of the most important mandate of the KrishiVigyanKendras. Along with transfer of technology, the basic purpose of these demonstrations is to test research findings on farmers fields and to get direct feed back from the farmers to help the scientists to reorient their research & training programmes. In front line demonstrations latest and proven technologies are demonstrated at farmers field for the first time before being fed into the main extension system of the state department of agriculture.Field demonstration is a long term educational activity conducted in systematic manners on a farmers field to show worth of a new practice or idea. Field demonstration educates farmers through results obtained in terms of higher yield as well as income and it follows the principle of "seeing is believing".

The world population is projected to grow from 7.3 billion (in 2015) to about 8.9 billion by 2050 (United Nations Report, 2004) therefore, to provide nutritional security is a challenge. Pulses play a very important role in nutritional security. Pulses form a important part of human daily diet especially in developing and developed countries and sometimes pulses are considered as "poor man's meat". The global pulse production, area and productivity during 2013 was about 73 million tonnes (MT), 80.8 million hectares and 904 kg per ha, respectively (Gowda, CLL et al. 2015).In India pulse production, area and productivity during same period was 19.78 MT, 25.21million hectare and 785 kg/ha, respectively. In India mung bean covers an area of 3.38 million hectares, production is 1.61 MT and productivity is 474 kg/ha (Anonymous, 2016). In Rajasthanmung bean grown in 0.89 million hectare area, production is 0.42 MT and productivity is 473 kg/ha (Anonymous, 2015). Whereas in Jhunjhunu district it is grown in 17991 ha area, production is 11674 tonnes and productivity is 652 kg/ha (Anonymous, 2014). Due to stagnant production of pulses, the net availability of pulses per capita has come down from 65.5 gm/day in 1960 to 31.6gm/day in 2011 (Anonymous 2011, Thefinancial express, New Delhi). A shortage of pulses can have devastating effect on our national nutritional standard in the long run.

Mung bean *(Vignaradiata L.)* is the main kharif pulse crop raised under limited moisture condition in vast area but the productivity is very low i.e. 474 kg/ha only in state (2014-15). Other reasons of low productivity are use of local genotypes of long duration, sowing by broadcasting, poor soil fertility with no use of fertilizer & manure, no seed treatment and no use of plant protection measures. Productivity of this crop can be enhanced by adopting the improved package of practices as recommended by the research institutes and agricultural universities. Hence KrishiVigyan Kendra, Abusar-Jhunjhunuconducted FLD programmes at farmers field since 2010. Due to encouraging results, demonstrations were continued in the following years at farmers field.The objectives of study were as follows.

1. To enlist the cultivation practices of mung bean crop under FLD

2. To know the impact of technologies transfer through FLD on mung bean crop.

MATERIALS AND METHODS

Farmers of operational area of KVK, Jhunjhunu were selected as per allotment of FLD's to KVK by Agricultural Technology Application Research Institute (ICAR-ATARI, Zone-VI). Accordingly the FLD's of mungbean were laid out in the villages namely Chudela, Bhodki,DiloiDaxin,Kumas, Keharpura, Jharodaetc. In general soils of the area under study were sandy to sandy loam in texture which is low in nitrogen, low to medium in phosphorus and medium to high in potash & totally rainfed. The farmers were provided full recommended package of practices with quality seed of mung bean variety RMG-268,RMG-492 &RMG-344 during the years of the study. In case of local check plots existing practices being used by farmers. Regular visits by the KVK Scientists to demonstration fields were ensured and guided the farmers time to time. These visits were also utilized to collect feedback information for further improvement in the research and extension programmes. Field days and group meeting were also organized at the demonstration sites to provide the opportunities for other farmers to witness the benefits of demonstrated technologies. Data were collected from the FLD farmers. The grain yield of demonstration crop was recorded & analysed. Different parameters as suggested by Yadav et al. (2004) and G. Lal (2014) were used for calculating gap analysis and economics. The detail of different parameters is as follows:

1. Extension gap = Demonstration yield - Farmers practice yield
2. Technology gap = Potential yield - Demonstration yield
3. Technology index = Potential yield - Demonstration yield x 100/ Potential yield
4. Additional return = Demonstration return - Farmers practice return
5. Effective gain = Additional return- Additional cost
6. Incremental B:C ratio = Additional return / Additional cost

RESULTS AND DISCUSSION

Cultivation practices

The cultivation practices of mung bean demonstrated at farmers field are mentioned in Table-1 and compared with existing practices (local practices). Subhash Chandra and Atul Chandra (2002) &Verma, R.K. and Dayanand (2013) stated that similar practices gave good results at farmers field.

Grain yield

The increase in grain yield under demonstration was 12.41 to 33.78 per cent overfarmers local practices. On the basis of five years,23.40 per cent yield advantage was recorded under demonstrations carried out with improved cultivation technology as compared to farmers traditional way of mung beancultivation. However year wise fluctuations in yield were observed mainly on account of variation in rainfall, mid season dry spells & change in the locations of trial every year. Yield improvementupto the extent of 33.78 per cent is due to combined effect of high yielding & short duration varieties, seed treatment with fungicide & bio-fertilizer, use of herbicide, use of recommended seed rate, appropriate method & time of sowing, appropriate method of fertilizer application and insect pest control practices adopted under the demonstrations.

It was also observed that low productivity of mung bean under local check plots was mainly due to use of low yielding long duration local genotypes without application of fertilizers, herbicide& pesticides. The local genotypes are prone to viral mosaic disease. The results confirm the findings of Sharma,O.P. (2003), Kirar, B.S. (2006), Yadav, V.P.S. (2007), Meena, O.P. et al (2012), Verma, R.K. &Dayanand (2013) and G.Lal (2014).

Gap analysis

An extension gap of 58-224 kg per hectare was found between demonstrated technology and farmers practices during five years and on average basis the extension gap was 149.8 kg per hectare (Table 2). The extension gap was lowest (58 kg/ha) during 2013-14and highest (224 kg/ha) during 2011-12. Such gap might be attributed to adoption of improved technology in demonstrations which resulted in higher grain yield than the traditional farmers practices. Wide technology gap were observed during different years and this was lowest (219 kg/ha) during 2010-11 and was highest (675kg/ha) during 2013-14. On five years average basis the technology gap of total 150 demonstrations was found as 425.20kg per hectare. The difference in technology gap during different years could be due to more feasibility of recommended technologies during different years. Similarly, the technology index for all the demonstrations during different years were in accordance with technology gap. Higher technology index reflected the inadequate proven technology for transferring to farmers and insufficient extension services for transfer of technology. The results confirm the findings of Meena, O.P. et al (2012), Verma, R.K. &Dayanand (2013) and G.Lal (2014).

Economic Analysis

Different variables like seed, fertilizers, bio fertilizers, herbicide and pesticides were considered as cash inputs for the demonstrations. Onan average an additional investment of Rs. 872.40 per ha was made under demonstrations. Economic returns as a function of grain yield and sale price varied during different years. Maximum returns (Rs. 8960 per ha) during the year 2011-12 was obtained due to higher grain yield and saleprices. The higher additional returns and effective gain obtained under demonstrations could be due to improved technology, non-monetary factors, timely operations of crop cultivation and scientific monitoring. The lowest and highest incremental benefit: cost ratios (IBCR) were2.29&12.8 in 2013-14 and 2011-12, respectively (Table 3) depends on produced grain yield and sale rates. Overall average IBCR was found as 7.55.The results are in conformity with the findings of Yadav, V.P.S. (2007), Meena, O.P. et al (2012), Verma, R.K. &Dayanand (2013) and G. Lal (2014).

CONCLUSION

Front line demonstration programme was effective in changing attitude, skill and knowledge of farmers about improved practices of mung bean cultivation that helped the demonstration farmers in adoption of improved practices of mung bean cultivation. Besides adoption of improved practices of mung bean cultivation it also improved the relationship between farmers and scientists and built confidence between them. The demonstration farmers also acted as primary source of information on the improved practices of mung bean cultivation and also acted as source of good quality pure seeds in their locality and surrounding area for the next crop. The concept of Front line demonstration may be applied to all farmer categories including progressive farmers for speedy and wider dissemination of the recommended practices to other members of the farming community. This will help in the removal of the cross-sectional barrier of the farming population. By conducting effective front line demonstrations of proven technologies, yield potential of crops can be increased to a great extent.

Table 1. Cultivation practices of Mungbean followed by farmers under FLD

Operations	Existing practices	Improved practices
Use of seed	Local seed	Short duration variety RMG-268, RMG -344 &
Sowing method	Broadcasting	Line sowing
Seed treatment	Not practiced	Seed treatment with fungicide & rhizobium culture
Seed rate	10 kg/ha.	15 kg/ha.
Use of herbicide	Not used	Pendimethalin 30 % pre sowing, 4.0 lit/ha.
Fertilizer application	Not used	Phosphate & sulphur was applied through SSP & gypsum
Insect pest management	Not done	Protection measures were adopted as per need
Marketing	Grain sold in local market	Grain sold tofarmers as a quality seed

Table 2.Grain yield and gap analysis of front line demonstrations ofMung bean

Year	Area/ha	No. of Demons.	Variety	Potential yield (Kg/ha)	Demons. yield (Kg/ha)	Farmers practice yield (Kg/ha)	Increase over Farmers practice (%)	Extension gap (Kg/ha)	Technology gap (Kg/ha)	Technology Index (%)
2010-11	12	30	RMG-268	1100	881	696	26.58	185	219	19.90
2011-12	12	30	RMG-492	1200	887	663	33.78	224	313	26.08
2012-13	12	30	RMG-492	1200	717	571	25.56	146	483	40.25
2013-14	12	30	RMG-492	1200	525	467	12.41	58	675	56.25
2014-15	12	30	RMG-344	1300	864	728	18.68	136	436	33.53
Overall average	12	30	-	1200	774.8	625	23.40	149.8	425.20	35.43

Table 3. Economic analysis of front line demonstrations on Mung bean

Year	Cost of cash input (Rs./ha)		Additional cost in Demo. (Rs./ha)	Sale price of grain (Rs./kg.)	Total returns (Rs./ha)		Additional return in Demo. (Rs./ha)	Effective gain (Rs./ha)	Incremental B:C ratio (IBCR)
	Demo.	Farmers practice			Demo.	Farmers practice			
2010-11	1550	750	800	35	30835	24360	6475	5725	8.63
2011-12	1600	900	700	40	35480	26520	8960	8260	12.8
2012-13	1600	850	750	40	28680	22840	5840	5090	7.78
2013-14	2337	1300	1037	45	23625	21015	2610	1473	2.29
2014-15	2425	1350	1075	60	51840	43680	8160	7085	7.59
Overall average	1902.40	1030	872.40	44	34092	27500	6592	5719.60	7.55

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Effect of sowing date and plant spacing on growth, yield and quality of castor (*Ricinus communis* L.) in Transitional Luni Basin Plain Zone of Rajasthan

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Received: 01.11.15
Accepted: 18.03.16

ABSTRACT

A field experiment was conducted during *kharif* 2011 *and* 2012 at farmer's fields and Krishi Vigyan Kendra, Jalore to study the time of sowing and plant spacing for castor. The experiment was laid out in a split-plot design with five replications. The treatments consisted of three main plots (Time of sowing – 15 July, 30 July and 15 August) and three sub plots (Plant spacing 60x45 cm, 90x45 cm and 90x 60 cm). Sowing of castor hybrid 'RHC-1' was done as per the time of sowing treatment at different spacing. The oil content increased gradually, while the plant population, plant height, number of branches per plant, number of effective spikes per plant, number of capsules per spikes, 100 seed weight, seed yield, biomass production, harvest index, oil yield, net return and BC ratio was decreased gradually to delay sowing dates from 15 July to 30 July and 15 August. Further, wider sowing of castor in spacing 90x60 cm observed significantly higher plant height, number of branches per plant, number of effective spikes per plant, number of capsules per spikes, 100 seed weight, seed yield, harvest index, oil content, oil yield, net return and BC ratio over 90x 45 cm and 60x45 cm plant spacing.

Interaction effects of sowing dates and plant spacing revealed that 15 July sowing of castor produced significantly highest seed yield (4513 kg ha^{-1}), oil yield (2395 kg ha^{-1}) and net return (104200 Rs ha^{-1}) with wide plant spacing of 90x60 cm, further sowing at 30 July, produced maximum seed yield (3807 kg ha^{-1}), oil yield (1848 kg ha^{-1}) and net return (83599 Rs ha^{-1}) with plant spacing of 90x45 cm.

***Key words*:** Castor, Economics, Plant spacing, Time of sowing, Yield**.**

Castor (*Ricinus communis* L.) is an important non edible oil seed crop of India being cultivated in 6.15 lacs hectares with a production of 5.90 lacs tones (FAO, 2003). India is the greatest producers of castor (Lima *et al.,* 2011). In Rajasthan castor occupies 0.26 lacs hectare areas with the production of 0.22 lac tonnes. Its seeds have high oil content (40–60%) (Baldwin and Cossar, 2009) used mainly in the chemical industry (Barnes *et al*., 2009; Severino *et al*., 2010), where it has numerous applications. Recently, it has also been used to produce biodiesel in several countries (Baldwin and Cossar, 2009). Castor crop is raised on light textures soils under dry land by small farmers with low inputs and poor management resulting in reduced yield and net returns in rainfed farming system. In Rajasthan, where castor is grown under rain fed conditions during *Kharif* season is often caught by vagaries of monsoon namely delay in onset of monsoon or prolonged dry spell during critical stages of crop growth and flowering/capsule development stage affecting the yield (Sudhakar *et al*., 2010).

In India, Castor crop grown during rainy season is often affected by early/mid/terminal drought leading to partial loss or even complete crop failure. Planting date which is a non-monetary input in crop production can influence the castor yield. The ratio of female to male flowers is highly sensitive to environmental conditions. The proportion of female flowers is reduced by temperatures above 30 ◦C (Neeraja *et al.,* 2010). Planting date also impacted the occurrence of pests and diseases (Zuchi *et al*., 2010). Keeping in view the potential of crop, in terms of industrial uses and ever growing demand for castor oil and derivatives across the globe, there is a need to enhance castor productivity in India. Cultivation of castor as an irrigable dry (ID) crop during post rainy season since castor is free from BGR menace provides an opportunity and reduces risk (Ramanjaneyulu *et al.,* 2010). As far as post rainy season castor is concerned, the crop may be subjected to low temperature stress in the initial stages and high temperature stress in the terminal stages. Further, rainfall received in the early stages may be helpful for better establishment of the crop. Though castor has high level of drought tolerance, but seed yields are reduced under limited water supply. However, with adequate water supply, seed yield can be optimized (Severino *et al*., 2012). Seed yields of rainfed castor fields can be increased by small amounts of supplementary irrigation (Sharma *et al*., 2010).

Among the different production factors, important of planting methods is considered as a

major factor on determining growth and yield of castor. Correctly defining plant populations is a cultural practice that has a great impact on yield and various other aspects of farming. In determining plant populations, the climate, soil characteristics, the cultivar to be planted and the management style to be employed all must be considered. Crop geometry is an important factor to achieve higher production by better utilization of moisture and nutrients from the soil and with above soil by harvesting the maximum possible solar radiation and in turn better photosynthate formation (Thavaprakaash *et al.,* 2005). The space in the field which is made available to the individual plant is an important factor affecting the growth and yield of crop. The study of the plant response to the changes with certain land arrangement is necessary as the yield per unit area is dependent not only on the number of plants unit area but also on the arrangement of these plants on the ground. Srinivas *et al*. (2005) and Veeranna *et al*. (2004) also reported increased production per unit area from castor by optimizing row ratio and planting geometry. Thus keeping in view the importance of sowing date and plant spacing in castor, an experiment was carried out to study the effect of sowing date and plant spacing on growth, yield and economics in castor.

MATERIALS AND METHODS

The study was conducted at different location of the district at progressive farmers field who were growing castor crop and instructional farm of Krishi Vigyan Kendra, Keshwana, Jalore during *Kharif* 2011 and 2012 having silty loam soil with pH 8.2, EC 0.17 dS m^{-1},organic carbon 0.25 %, available phosphorus 8.6 kg P $ha^{-1}$and available potassium 279.7 kg Kha^{-1}. The experiment was laid out in a split-plot design with five replications. Each farmers field act as one replication. The treatments consisted of three main plots of sowing time (15 July, 30 July and 15 August) and three sub plots of plant spacing (60x45 cm, 90x45 cm and 90x 60 cm apart row and plant). Sowing of castor hybrid 'RHC- 1' was done as per the time of sowing treatment at different spacing. The recommended doses of nitrogen (40 kg N) and phosphorus (40 kg P_2O_5) fertilizers per ha were applied as basal. The remaining half of 40 kg N was applied in three equal splits at 30, 60 and 90 DAS. Urea and single super phosphate were used as source for supplying N and P_2O_5 nutrients respectively. Besides time of sowing and plant spacing, the crop was raised with recommended package of practices.

The field was visited regularly and two hoeing were also carried out in order to provide optimum crop growth conditions. The slow emergence and early growth of castor means the plants in the first growth period are not strong competitors against weeds, so first hoeing were done when plant grew 20-25 cm and the second hoeing was done after one month. The plots were irrigated three times using flood irrigation, a) after branching, b) during flowering, and c) pod filling. Spikes are picked up trice when capsules were dried and harvested by hand when all the remaining capsules are dry and the leaves have fallen from the plants. In this research; seed yield, oil content and oil yield were investigated. Seed yield (kg ha^{-1}) was determined from the plants of the four ridges in each plot and the yield per hectare was calculated. Seed oil content was determined by using Soxhlet continuous extraction apparatus with petroleum either. Seed oil yield (kg ha^{-1}) was calculated by multiplying oil percentage with seed yield per ha. Analysis of variance was used to test the significance of treatment effects at 5 percent level of probability. Least Significant Difference (LSD) Test was used to compare treatment means.

RESULTS AND DISCUSSION

Effects of Sowing Dates

As the three dates of sowing of castor were tested, the plant population, plant height, number of branches per plant, number of effective spikes per plant, number of capsules per spikes, 100 seed weight, seed yield, biomass production, harvest index, the oil content, oil yield, net return and BC ratio was decreased gradually to delay sowing dates from 15 July to 30 July and 15 August (Table 1&2).

The 15 July sowing of castor enhanced significantly by 0.87 and 2.57 percent plant population, 5.82 and 15.82 per cent plant height, 8.83 and 24.98 per cent number of branches per plant, 15.94 and 50.71 per cent number of effective spikes per plant, 21.86 and 63.95 per cent number of capsules per spikes, 3.71 and 9.78 per cent100 seed weight, 13.25 and 35.61 per cent seed yield, 12.11 and 20.91 per cent biomass production, 0.92 and 11.78 per cent harvest index, 1.52 and 3.75 per cent oil content, 15.57 and 40.67 per cent oil yield, 17.05 and 49.97 per cent net return and 12.54 and 37.37 per cent BC ratio, respectively, over 30 July and 15 August sowing of castor in pooled of both the year. The same trend was observed by Sukhadia and Dhoble (1992) and Nirmal *et al.* (1995). The gradual decrease in yield with subsequent delay in sowing might be due to prevailing low temperature and less remnant moisture in the soil and other environmental factors at vegetative growth phase period which in turn adversely affected the overall development of the plant. Similar findings were reported by Dudhade *et al.* (1996).

The data of oil content as influenced by sowing date are presented in Table 2. Significant differences

were found among all the sowing dates for oil content. The sowing date of July 15 produced higher oil content (46.72 %) followed by July 30 and August 15. The lowest oil content (45.03 %) was observed for August 15. Oil content percentage in oilseed crops is of enormous importance as more oil increases the economic importance of crop and provides more return to the farmer. In total, seed oil content is mainly determined by climatic conditions and planting date so that late planting will decrease the oil content. The difference for oil content among sowing dates may be because of different temperature and moisture levels as oil content is greatly influenced by temperature and moisture during seed development and oil formation period. Unger and Thompson (1982) have reported higher oil content at higher temperature, supporting the results of our studies. Our findings are in line with Reddy *et al*. (2007) who reported that castor crop sown during July gave the highest oil content as compared to the crop sown in August. On the other hand, Deligiannis *et al*. (2009) in a research obtained 40.3% oil in castor cultivars.

Effects of plant spacing

An appraisal of pooled data of the year 2011 and 2012 reveled that wider sowing of castor in spacing 90x60 cm statistically at par with spacing 90x 45 cm observed significantly higher plant height, number of branches per plant, number of effective spikes per plant, number of capsules per spikes, 100 seed weight, seed yield, harvest index, oil content, oil yield, net return and BC ratio over 60x45 cm plant spacing (Table 1&2). Castor sowing in spacing of 90x60 cm increase plant height by 3.63 per cent, number of branches per plant by 10.72 per cent, number of effective spikes per plant by 29.72 per cent, number of capsules per spikes by 11.91 per cent, 100 seed weight by 3.79 per cent, seed yield by 4.50 per cent, harvest index by 3.41 per cent, oil content by 3.10 per cent, oil yield by 8.40 per cent, net return by 6.46 per cent and BC ratio by 4.24 per cent, respectively, as compared to castor sowing in plant spacing of 60x45 cm.

These increases in yield attributes could be ascribed to significant increases in growth parameters of the crop under wide spacing of castor (90 x 60 cm). This system allows more interception of solar radiation by the crop canopy on account of higher inter and intra row space. This might have enabled the crop to maintain higher net photosynthetic rate and resulted in greater dry matter production per unit area. It appears that higher value of NAR, CGR, LAI, dry matter accumulation under this planting pattern reflected in enhanced vigour and yield attributes which might have contributed in significantly higher seed stalk and biological yield of the crop. Similar findings were reported by Agarwal and Porwal (2006) in castor.

Interaction effects of sowing dates and plant spacing

Pooled data (Table 3,4&5 and Fig 1,2&3) revealed that 15 July sowing of castor produced significantly highest seed yield (4513 kg ha^{-1}), oil yield (2395 kg ha^{-1}) and net return (104200 Rs ha^{-1}) with wide plant spacing of 90x60 cm, further sowing at 30 July, produced maximum seed yield (3807 kg ha^{-1}), oil yield (1848 kg ha^{-1}) and net return (83599 Rs ha^{-1}) with plant spacing of 90x45 cm. This might have enabled the crop to maintain higher net photosynthetic rate and resulted in greater dry matter production per unit area due to luxurious growth in early sowing. This system allows more interception of solar radiation by the crop canopy on account of higher inter and intra row space in prevailing higher temperature and favorable environmental factors at vegetative growth phase period which in turn overall development of the plant (Dudhade *et al.* 1996). However, late sowing of castor at 15 August, produced higher of seed yield, oil yield and net return with low plant spacing 60x45 cm and decrease with increasing plant spacing of 90 x 45 and 90 x 60 cm. The gradual decrease in per plant yield with subsequent delay sowing might be due to prevailing low temperature, adversely affected vegetative growth, further plant required low space for vegetative growth phase, however higher plant population increase production per unit area (Nirmal *et al.*1995).

Table: 1 Effect of sowing dates and plant spacing on plant population, growth and yield attributes of castor (pooled of 2011 and 2012)

Treatments	Plant population per ha	Plant height at harvest (cm)	No. of branches per plant	Spikes per plant	Capsules per spike	100 seed weight (g)
Effect of sowing dates						
15-July	23642	177.96	18.36	17.09	27.15	26.47
30-July	23438	168.17	16.87	14.74	22.28	28.02
15-August	22851	153.65	14.69	11.34	16.56	29.06
SEm	458.51	1.131	0.329	0.502	0.736	0.308
CD at 5%	1412.81	3.48	1.01	1.55	2.27	0.95
Effect of plant spacing						
60x45 cm	30828	162.78	15.67	12.35	20.48	26.89
90x45 cm	21900	168.31	16.90	14.80	22.60	28.75
90x60 cm	17203	168.69	17.35	16.02	22.92	27.91
SEm	189.55	0.762	0.272	0.339	0.530	0.209
CD at 5%	537.90	2.16	0.77	0.96	1.50	0.59

Table: 2 Effect of sowing dates and plant spacing on yield, quality and economics of castor (pooled of 2011 and 2012)

Treatments	Seed yield (kg/ ha)	Biomass production (kg/ ha)	Harvest index (%)	Oil content in seed (%)	Oil yield (kg/ ha)	Net return (Rs/ha)	B C Ratio
Effect of sowing dates							
15-July	3989.94	11594.00	34.07	46.72	1877.01	88498	3.84
30-July	3499.38	10342.08	33.76	46.02	1624.10	74381	3.43
15-August	2983.76	9589.34	30.48	45.03	1334.29	58713	2.91
SEm	73.416	191.973	0.629	0.386	52.111	2202	0.072
CD at 5%	226.22	591.53	1.94	1.19	160.57	6786	0.22
Effect of plant spacing							
60x45 cm	3392.83	10620.87	31.98	45.15	1535.02	70918	3.30
90x45 cm	3534.79	10673.99	33.26	46.07	1636.35	75177	3.43
90x60 cm	3545.45	10230.57	33.07	46.55	1664.02	75497	3.44
SEm	46.307	156.194	0.455	0.254	37.061	1389	0.045
CD at 5%	131.41	443.25	1.29	0.72	105.17	3942	0.13

* Selling price of castor Rs. 3000/- qt

Table 3: Interaction effects of sowing dates and plant spacing on seed yield of castor (Pooled of 2011 & 2012)

Effects of plant spacing	Seed Yield(kg ha^{-1}) Effects of Sowing Dates		
	15-July	30-July	15-August
60x45 cm	3489	3287	3403
90x45 cm	3968	3807	2830
90x60 cm	4513	3405	2718
SEm	65.49		
CD at 5%	185.84		

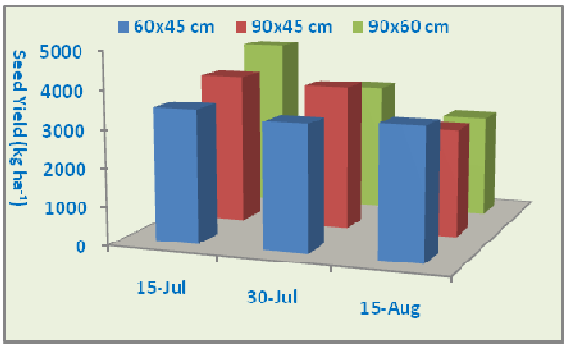

Fig.1: Effects of sowing dates and plant spacing on seed yield of castor

Table 4: Interaction effects of sowing dates and plant spacing on oil yield of castor (Pooled of 2011 & 2012)

Effects of plant spacing	Oil Yield (kg ha^{-1}) Effects of Sowing Dates		
	15-July	30-July	15-August
60x45 cm	1457	1451	1697
90x45 cm	1779	1848	1282
90x60 cm	2395	1574	1024
SEm	52.41		
CD at 5%	148.73		

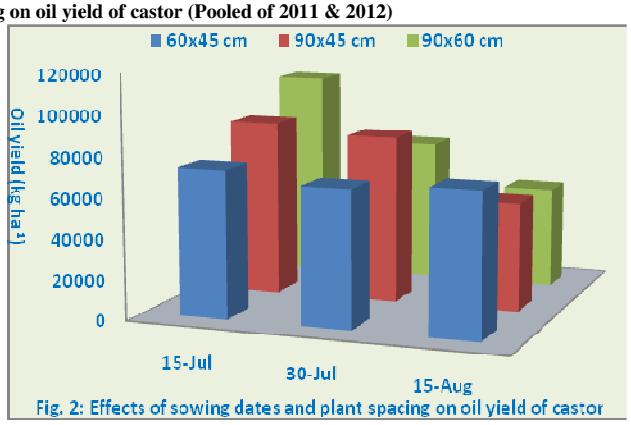

Fig. 2: Effects of sowing dates and plant spacing on oil yield of castor

Table 5: Interaction effects of sowing dates and plant spacing on net return of castor (Pooled of 2011 & 2012)

Effects of plant spacing	Net Return (Rs ha^{-1}) Effects of Sowing Dates		
	15-July	30-July	15-August
60x45 cm	73463	68006	71286
90x45 cm	87833	83599	54100
90x60 cm	104200	71539	50752
SEm	1964		
CD at 5%	5575		

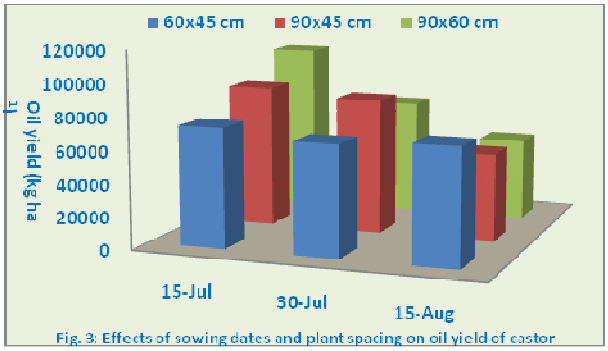

Fig. 3: Effects of sowing dates and plant spacing on oil yield of castor

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A study on reduction in fruit drop to improve yield and quality of kinnow (*Citrus reticulata* BLANCO) fruit

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Received: 16.12.15
Accepted: 20.03.16

ABSTRACT

Kinnow (*Citrus reticulata* Blanco) fruit is one of the best commercial fruits cultivated in Sriganganagar district of Rajasthan. It is cultivated on a large area in Sriganganagar province due to its reasonably higher yield, better quality, taste and flavour. Fruit dropping is one of the main reason of low citrus fruit yield, which is thought to be mainly due to hormonal imbalance in the plants. This imbalance may occur as a result of nutrient deficiency in orchard soils, water shortage, disease and insect-pest attack on the kinnow trees. Therefore, experiments were conducted at farmers field to assess the influence of growth regulators [2,4-D and Gybralic acid (GA_3)] and nutrients [zinc (Zn), Ferrous (Fe) and sulphur (S)] to improve yield and quality of Kinnow fruit and control the fruit drop. During the month of May, June and September foliar applications of treatment 15 ppm 2-4, D + 25 ppm GA_3 with micronutrients (0.3 % zinc sulphate + ferrous sulphate) find significantly better to reduce the fruit drops and showed beneficial effects on improve the fruit quality, fruit diameter, juice %, TSS etc. as compared to recommendation treatment (T_2) and farmers practice (T_1). In general application of growth regulators resulted in improved fruit retention and fruit quality.

Key words: Fruit drop, Kinnow, Plant Growth Regulators and Quality.

Citrus (*Citrus sinensis* L.) is one of the most significant fruit crop known from antiquity being a very good source of vitamin "C" with great antioxidant potential (Gorinstein *et al*., 2001). Citrus is the member of family Rutaceae that comprises about 158 genera and 1900 species. It includes perennials that produce fruits of variable diameters. Citrus is placed among the important fruit crops worldwide being sown in more than 125 countries between latitude 35°-36° with suitable climates and in temperature range of 4^oC-50^oC. Citrus fruit appeared on globe 30 million years ago. Citrus cultivation is considered to have started in Nippur (Mesopotamia) that dates back to 4000 B.C. (Mabberley, 2008). Citrus fruits have a prominent place among popular and extensively grown tropical and subtropical fruits. Their whole some nature, multi fold nutritional and medicinal values have made them so important, sometimes indispensible in several parts of the world. Citrus is primarily valued for the fruit which is either eaten alone as fresh fruit, processed into juice or added to dishes and beverages (lemon, lime, etc.). Among citrus fruits Kinnow ranks first with respect to area and production followed by sweet orange, limes and lemons. Total area under citrus fruits in Rajasthan is 24100 hectares out of which Kinnow occupies 14890 hectares in Sriganganagar district. Annual production of citrus fruits in Rajasthan is 433200 MT and productivity 18.0 MT/ha (NHB, 2015, Anonymous, 2015).

Kinnow is a hybrid between King (*Citrus nobilis*) and Willow leaf (*Citrus deliciosa*) mandarins. In 1915, Dr. H.B. Frost made the cross at Citrus Research Centre, University of California, Riverside, USA. After evaluation Kinnow was released as a new variety for commercial cultivation in 1935. Kinnow mandarin (easy peal citrus) has assumed special economic importance and export demand is being acknowledged for its high juice content, special flavour, delicious taste and as a rich source of vitamin C. Progressive farmers prefer to grow kinnow because of its high yielding characteristics and its attractive quality that possesses the potential to give the lucrative return in form of profit. But even then, average yield of Kinnow in Sriganganagar is just 9.0 tons ha^{-1}, while in many other citrus producing countries of the world like USA and Australia it is much higher. The main reasons for low productivity are excessive malnutrition, high or low temperatures stress, high rainfall, pests and diseases, poor fruit set and fruit drop at different stages of fruit development. Severe Pre harvest fruit drop during the month of June to September onwards is major reason of low yield in Sriganganagar. Pre harvest fruit drop is due to malnutrition, water stress, excessive insect pest attack and most important is the hormonal imbalance. Tree drops its fruit when the concentration of auxins decreases and the concentration of abscissic acid (ABA) increases

(Marinho *et al*., 2005) as the endogenous hormones and their balance play a modulating role in the mobilization of nutrients to the developing organs. The use of growth regulators has become an important component of agro technical procedures for most of the cultivated plants and especially for fruit plants (Monselise, 1979). In citrus fruits, excessive fruit drop can be controlled by the exogenous application of plant growth regulators. Application of PGRs including GA_3 and cytokinins for quality fruit production is well documented in mature trees of 'Satsuma' mandarin (Garcia-Luis *et al*., 1985), 'Sunbrust' mandarin (Pozo *et al*., 2000), grapefruit (EI-Zeftawi, 1980), 'Hamlin', 'Valencia', and 'Navel' oranges (Fidelibus *et al*., 2002). The auxins and gibberillins are used to control the fruit drop in citrus and to improve the quality of fruit (Almeida *et al*., 2004). However, the work on exogenous application of PGRs on fruit quality of young citrus trees is rare. Some studies revealed that young plants are low in endogenous GA_3 (Wadhi and Ram, 1967) and cytokinins (Hendry *et al*., 1982) as compared to mature plants. This showed the difference in endogenous levels of PGRs between young and mature plants, which might be a possible reason for poor quality of fruit in young orchards. Although some references are available in the literature and efforts have been made to control the fruit drop by exogenous application of growth regulators but there is limited precise recommendation for the control of fruit drop in Kinnow mandarin. So there was a need to test the efficacy of plant growth regulators with proper nutrient management to reduce fruit drop and improve the quality and yield under agro-environmental conditions of Sriganganagar district of Rajasthan. Therefore, the present experiments were conducted to study the reduction in fruit drop and improvement in quality parameters in Kinnow (*Citrus reticulata* BLANCO) by exogenous application of Plant Growth Regulators and microelements.

MATERIALS AND METHODS

The study was conducted at farmers orchard in Sriganganagar district of Rajasthan under randomized complete block design with three replicates and single tree was treated as treatment unit at seven locations during 2011-12 and 2012-13. Laboratory work was carried out in Fruit Laboratory, Agricultural Research Station (SK Rajasthan Agricultural University), Sriganganagar. Ten years old, sixty three trees of Kinnow mandarin (*Citrus reticulata* Blanco) with uniform vigour and age budded on Rough lemon (*Citrus jambhiri* Lush.) rootstock were selected. Aqueous solution of all the treatments was prepared and sprayed on whole trees. Growth regulators (**i.**) Not using any chemicals or plant growth regulators (farmers practice). (**ii.)** Spray of Propineb 70 WP or Antracol 2.0 gm per litter + GA_3 20 ppm during the month of April, August and September. (**iii.)** During the month of May, June and September spray of 15 ppm 2-4, D + 25 ppm GA3 with micronutrients (0.3 % zinc sulphate + ferrous sulphate) were used to check the effect on preharvest fruit drop and physiochemical properties of the fruit. All the experimental trees were maintained under similar agro-climatic condition. At optimum fruit maturity ten fruits from each experimental unit were harvested carefully and sent to Fruit Laboratory, Agricultural Research Station (SK Rajasthan Agricultural University), Sriganganagar. On arrival, the fruit of all treatments were washed in tap water and air dried. The variables evaluated were as follows:

No. of fruits per plant: At optimum fruit maturity number of fruits per plant was counted.

Fruit drop (%): Number of fruits per plant at spray time and after spray was counted by tagging 4 branches of one inch diameter on each side of the tree. To calculate fruit drop % from tagged branches of the experimental tree, number of fruits were counted and fruit drop percentage was calculated using the following formula (Din *et al*., 2012; Nawaz *et al*., 2008):

$$\text{Fruit drop \%} = \frac{\text{Total number of dropped fruits}}{\text{Total number of fruits before application}} \times 100$$

Physicochemical analyses of fruit samples: All collected samples of Kinnow mandarin were subjected to measure fruit weight and fruit diameter. Physicochemical characteristics like juice content, total soluble solids (TSS), acidity and ascorbic acid were also measured to assess the fruit quality. Detail is given below:

Fruit diameter (mm) : The diameter of ten randomly selected fruits from each lot was measured at equator of each fruit with the help of vernier calliper and average fruit diameter was calculated.

Fruit weight (g): Average weight of randomly selected ten fruits from each lot was measured with weighing balance (Sartoius, Japan) and then their average weight was calculated in grams.

Total soluble solids (º Brix): Total soluble solids (TSS) of juice were estimated by Refractometer. Drops of juice were placed on clean prism of Refractometer (Erma Inc., Tokyo, Japan) and results were expressed as º Brix.

Juice content (%): Juice of each of 10 harvested fruit was extracted and weighed; average juice weight was calculated separately for each

treatment. The average juice percentage per fruit was obtained from the following formula:

$$\text{Juice content (\%)} = \frac{\text{Juice weight per fruit}}{\text{Average fruit weight}} \times 100$$

Acidity of juice (%): Acidity was measured by using AOAC. Acidity of juice was determined by taking 10 ml of juice from each sample and diluted with distilled water in a 100 ml beaker then 2 - 3 drops of phenolphthalein as an indicator were added and samples were titrated against 0.1N NaOH upto the light pink colour end point. The results were expressed as percent citric acid (Rangana, 2001).

$$\text{Acidity (\%)} = \frac{\text{0.1 N NaOH used x 0.0064}}{\text{Volume or weight of sample used}} \times 100$$

Ascorbic Acid: The Ascorbic Acid (mg 100 mL-1) was determined by titration method using 2, 6 dichlorophenolindophenol dye. (Khalid *et al*., 2012, Maqbool and Malik, 2008).

RESULTS AND DISCUSSION

The Results of present study revealed that during the month of May, June and September spray of 15 ppm 2-4, D + 25 ppm GA_3 with microelements (0.3 % zinc sulphate + ferrous sulphate) significantly reduced the pre harvest drop compared to control. This treatment significantly lowest mean fruit drop (11.5 %) however it showed no significant impact on fruit physical quality parameters such as average fruit diameter (68.46 mm), fruit weight (148.53 g) (Table 1).

This treatment also significantly impact on other fruit physical and biochemical quality parameters such as No. of fruits per plant (723.50) fruit weight per plant (102.02 kg), Total soluble solids (12.76º Brix) (Table 2), juice content (48.74 %), Acidity (0.98 %) and Ascorbic Acid (42.83 mg per 100 ml) (Table 3) followed by Spray of Propineb 70 WP or Antracol 2.0 gm per litter + GA3 20 ppm during the month of April, August and September mean fruit drop (21.0 %) average fruit diameter (65.79 mm), fruit weight (145.72 g) (Table 1), No. of fruits per plant (588.00) fruit weight per plant (90.88 kg), Total soluble solids (11.22º Brix) (Table 2), juice content (47.35 %), Acidity (1.15 %) and Ascorbic Acid (38.36 mg per 100 ml) (Table 3). In farmers practice higher mean fruit drop occurs (45.5 %) and average fruit diameter (62.04 mm), fruit weight (138.71 g) (Table 1), No. of fruits per plant (434.50) fruit weight per plant (62.49 kg), Total soluble solids (9.11º Brix) (Table 2), juice content (42.00 %), Acidity (1.24 %) and Ascorbic Acid (33.91 mg per 100 ml) (Table 3). Higher fruit drop significantly reduce total production as well as income of farmers. Result of current study shows that exogenous application of Plant Growth Regulators and microelements increase fruits retention and improve in quality parameters of Kinnow mandarin. (Ortola *et al*.1991) found that likely abscission of very small and weak fruilets at beginning of auxin spraying causes to reduce pre harvest drop. At final stages, small and weak fruits, in competition with large and strong fruits which are good sinks for nutritional materials, loss are. Abscission of weak fruits after auxin spraying, cause to remain on the tree, only the fruits which can able to become mature fruits and prevent from loss of tree potential and energy. This may be one reason for improving fruit quality. Exogenous application of GA_3 not only reduces early fruit abscission in citrus but it also delays senescence (Ashraf *et al*., 2013). Literature also confirmed that application of plant growth regulators and nutrients supply is necessary for controlling the premature fruit drop and fruit yield Our results were accordance with reports by Almedia *et al*., (2004), Ashraf *et al*., (2013), Davies and Zalman (2006) and Saleem *et al*., (2007) which clearly depict that foliar application of macro- and micro-nutrients, and plant growth regulators reduced the pre harvest fruit drop and enhances citrus fruit yield. Keeping in view the above results it can safely be recommended that 15 ppm 2-4, D + 25 ppm GA_3 with microelements (0.3 % zinc sulphate + ferrous sulphate) can be applied to minimize the preharvest fruit drop, increase yield and improve the quality attributes of kinnow mandarin.

CONCLUSION

The variations in quality attributes were observed to be originated from poor pre- harvest management practices. During the month of May, June and September spray of treatment 15 ppm 2,4-D + 25 ppm GA_3 with microelements (0.3 % zinc sulphate + ferrous sulphate) find better to reduce the fruit drops and improve the fruit quality attribute such as fruit diameter, TSS, juice content etc. as compared to recommendation treatment and farmers practice. The quality variation has negative impact on fruit marketing. It is therefore, suggested that use plant growth regulators with recommended agricultural practices like proper irrigation, time of fertilizer application, application of organic manure to reduce fruit drop, increase yield and improve the quality attributes of kinnow mandarin under agro-environmental conditions of Sriganganagar district of Rajasthan.

Table 1: Effect of exogenous application of plant growth regulators and micronutrients on pre harvest fruit drop, fruit size and fruit weight of kinnow mandarin.

Treatment	Pre harvest fruit drop (%)		Mean	Fruit size (mm)		Mean	Fruit weight (g)		Mean
	2011-12	2012-13		2011-12	2012-13		2011-12	2012-13	
T1	51	40	45.5	65.54	58.54	62.04	142.41	135.01	138.71
T2	20	22	21	68.54	63.04	65.79	150.91	140.54	145.725
T3	15	8	11.5	70	66.92	68.46	152.04	145.02	148.53
SEm	2.81	2.47	2.64	4.22	4.21	4.21	3.52	4.57	4.04
CD at 5 %	5.91	5.2	5.55	8.87	8.85	8.86	7.4	9.6	8.5
CV	18.38	19.87	19.12	11.62	12.54	12.08	4.44	6.1	5.27

Table 2: Effect of exogenous application of Plant growth regulators and micronutrients on number of fruits/plant, fruit weight (kg)/plant and total soluble solids (TSS) of kinnow mandarin.

Treatment	Number of fruits/plant		Mean	Fruit weight (kg)/plant		Mean	TSS (%)		Mean
	2011-12	2012-13		2011-12	2012-13		2011-12	2012-13	
T1	422.00	447.00	434.50	60.00	64.98	62.49	9.00	9.21	9.11
T2	575.00	601.00	588.00	91.58	90.18	90.88	11.01	11.42	11.22
T3	700.00	747.00	723.50	103.64	100.40	102.02	12.48	13.04	12.76
SEm	6.39	7.30	6.85	3.02	3.67	3.35	0.47	0.37	0.42
CD at 5 %	13.42	15.34	14.38	6.35	7.71	7.03	1.00	0.79	0.90
CV	2.11	2.28	2.20	6.65	8.07	7.36	8.26	6.32	7.29

Table 3: Effect of exogenous application of Plant Growth Regulators and micronutrients on juice content, acidity and ascorbic acid of kinnow mandarin.

Treatment	Juice content (%)		Mean	Acidity (%)		Mean	Ascorbic Acid (mg/100 ml)		Mean
	2011-12	2012-13		2011-12	2012-13		2011-12	2012-13	
T1	42.14	41.85	42.00	1.04	1.44	1.24	33.47	34.35	33.91
T2	47.72	46.98	47.35	0.99	1.30	1.15	37.17	40.14	38.66
T3	49.34	48.14	48.74	0.85	1.10	0.98	42.54	43.11	42.83
SEm	2.01	2.33	2.17	0.04	0.06	0.05	1.62	2.56	2.09
CD at 5 %	4.22	4.90	4.56	0.10	0.13	0.12	3.41	5.39	4.40
CV	8.11	9.57	8.84	9.71	9.47	9.59	8.06	12.25	10.16

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Occurrence and correlation of *Catopsilia cracle* Cramer on Bahawa, *Cassia fistula* Linn. with major weather parameters under Konkan conditions of Maharashtra

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Received: 17.12.14
Accepted: 20.10.15

ABSTRACT

Survey was conducted to study the seasonal incidence and correlation of *Catopsilia cracle* Cramer with major weather parameters on Bahawa trees (*Cassia fistula* Linn.) during the period January, 2012 to December, 2012 at university area.The results of study found that the incidence of pest was highest in the thirty-ninth meteorological week. Major weather parameters such as Maximum and minimum temperature, morning and evening relative humidity and rainfall were found affecting pest population (R^2= 0.339) during the study.

***Key words*:** *Catopsilia cracle* Cramer,*Cassia fistula* Linn., weather parameters, incidence, etc.

'Forest' constitutes the most important asset of mankind and plays a vital role in the maintenance of our environment. They provide products, services and amenities. Important forest products includes woods, nuts, fruits, mushrooms, litter for cattle bedding, pharmaceutical plants, gums, resins, leaf extractives, greenery, forage and many other plant products. Forest gives abundant opportunity for outdoor recreation and also adds to life's amenities by softening and beautifying the landscape.

In India, forest constitutes an area of about 78.29 mha. This is 23.81 per cent of total geographical area of the country. At the end of 2010-11 area under forest in Maharashtra was about 61939 sq. km. which is 20.13 per cent of total geographical area of the state. (Anon. 2011)

However, the success of forest tree plantation as well as nursery is suffered a lot due to several problems. The major problem of forest nurseries and plantation is damage caused by insect pests. Forty-nine insect pests belonging to Coleoptera (eight spp.), Lepidoptera (fourteen spp.), Orthoptera (nine spp.), Hemiptera (nineteen spp.) and Isoptera (one spp.) have been recorded by Naik*et al*. (1996) on forest nurseries including *Terminalia spp*.. Regarding pest problem in Maharashtra particularly in Konkan region, about thirty insect pests have been recorded on different forest trees (Ghorpade and Patil, 1991).

MATERIALS AND METHODS

A survey was carried out at Forest Nursery and Biodiversity Park of the College of Forestry, Dapoli during January 2012 to December 2012.Ten trees from Bahawa plantation were selected randomly and marked permanently to record infestation of pest at weekly intervalaccording to Meteorological week.Larvae and adults on trees were counted by the quadrat method. The area of 50 cm^2 was randomly selected and marked at 4 sides of tree canopy for further observations. Total number of larvae and adults present per quadrat was counted and the average pest wise population per tree was calculated. The average pest population was then correlated with major weather parameters such as Temperature (Maximum and Minimum), Humidity (Morning and Evening) and Rainfall etc.

RESULTS AND DISCUSSION

Incidence of Cassia Leaf Eating Caterpillar, *Catopsilia cracole* Cramer

During thestudy, it was found that the freshly hatched larvae of *C. cracole* fed on the epidermal tissues of the leaflets making minute holes, while the older larvae always ate the entire leaflets leaving only bare ribs.Nair, K.S.S.*et al.* (1986) also noticed the total defoliation of bahawa trees by the attack of *Catopsilia pyranthe* Herbst in Kerala State.

The incidence of *C. cracole* was not observed upto the twenty-seventh meteorological week. The incidence noticed in the twenty-eighth meteorological week (1.0 larva per tree) which gradually increased and reached its peak in the thirty-ninth meteorological week (7.25 larvae per tree). The pest incidence declined from the fortieth meteorological week (7.0 larvae per tree) upto the forty-fourth meteorological week (2.75 larvae per tree). There was no incidence of the pest from the forty-fifth meteorological week onwards (Table 1) (Fig. 1).

Table 2 indicated that the average pest incidence during infestation period ranged from 1.00 to 7.25 larvae per tree with a mean population of 4.33 larvae per tree. These observations are quite similar to observations from Soloman Raju (2004) and Kulkarni (2005) who also reported that the incidence of *Catopsilia* was observed from March to November.

Correlation of pest with major weather parameters: During observation period, it was found that the maximum temperature (-0.413) correlated negatively and significantly with pest population which indicated that when maximum temperature increases, population of the pest decreases. The minimum temperature (0.453) and evening relative humidity (0.463) correlated positively and significantly with population of the pest which indicated that when minimum temperature decreases and when evening relative humidity increases, the pest population increases. The maximum temperature, minimum temperature, relative humidity (morning and evening) and rainfall were found affecting the pest population (R^2 = 0.438) during the observation period (Table 3).

Table1: Intensity of *Catopsilia cracole* Cramer on Bahawatrees During January, 2012 to December, 2012

Meteoroogical week	Mean Pest Population per Tree	Meteoroogical week	Mean Pest Population per Tree
1	-	**27**	-
2	-	**28**	1.0
3	-	**29**	1.5
4	-	**30**	1.25
5	-	**31**	2.0
6	-	**32**	2.5
7	-	**33**	3.25
8	-	**34**	4.5
9	-	**35**	5.25
10	-	**36**	5.75
11	-	**37**	6.25
12	-	**38**	7.0
13	-	**39**	7.25
14	-	**40**	7.0
15	-	**41**	6.75
16	-	**42**	5.50
17	-	**43**	4.25
18	-	**44**	2.75
19	-	**45**	-
20	-	**46**	-
21	-	**47**	-
22	-	**48**	-
23	-	**49**	-
24	-	**50**	-
25	-	**51**	-
26	-	**52**	-
Range	1.00 to 7.25		
Average	4.33		

Table 2: Correlation between *Catopsilia* population and weather parameters

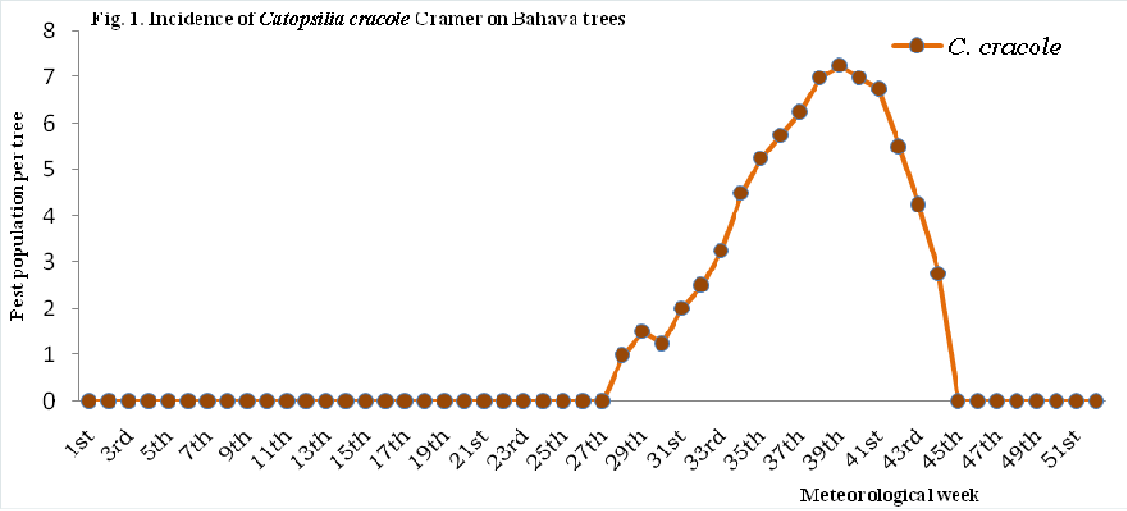
Scientific name of the Pest	Temp. Max. (°C)	Temp. Min. (°C)	R.H. Mor. (%)	R.H. Evn. (%)	Rainfall (mm)	R^2 values
Catopsilia cracole Cramer	-0.413*	0.453*	0.173	0.463*	0.259	**0.339**

(*- Significant at 5 %)

APPENDIX I

Weekly weather data during the period of study at Dapoli Station (January. 2012 to December. 2012)

Period	MW	Tmax. (ºC)	Tmin. (ºC)	RH (Mor.) (%)	RH (Evn.) (%)	Rainfall (mm)
01.01 - 07.01	1	31.8	14.8	91	58	0.0
08.01 - 14.01	2	30.0	9.6	91	57	0.0
15.01 - 21.01	3	28.8	10.4	93	59	0.0
22.01 - 28.01	4	29.0	12.6	93	58	0.0
29.01 - 04.02	5	31.3	13.1	93	49	0.0
05.02 - 11.02	6	30.7	10.4	86	44	0.0
12.02 - 18.02	7	30.1	10.4	91	54	0.0
19.02 - 25.02	8	35.6	14.2	91	48	0.0
26.02 - 04.03	9	32.6	11.0	91	52	0.0
05.03 - 11.03	10	30.8	11.9	90	54	0.0
12.03 - 18.03	11	34.2	14.1	89	42	0.0
19.03 - 25.03	12	33.6	15.6	92	47	0.0
26.03 - 01.04	13	31.8	19.7	92	64	0.0
02.04 -08.04	14	32.5	20.5	93	67	0.0
09.04 - 15.04	15	32.4	20.4	94	64	0.0
16.04 - 22.04	16	34.1	22.4	91	65	0.0
23.04 - 29.04	17	34.4	20.4	86	75	0.0
30.04 - 06.05	18	31.8	20.5	92	71	0.0
07.05 - 13.05	19	32.7	22.6	85	68	0.0
14.05 - 20.05	20	32.9	22.4	81	78	0.0
21.05 - 27.05	21	32.7	22.7	82	70	0.0
28.05 - 03.06	22	33.0	22.9	83	79	0.0
04.06 - 10.06	23	32.0	23.8	91	85	100.7
11.06 - 17.06	24	29.8	23.7	96	87	116.6
18.06 - 24.06	25	29.4	23.8	95	77	490.2
25.06 - 01.07	26	29.4	23.4	96	80	243.9
02.07 - 08.07	27	28.2	24.0	96	89	355.0
09.07 - 15.07	28	29.2	24.1	96	86	145.8
16.07 - 22.07	29	27.9	23.9	96	92	313.9
23.07 - 29.07	30	28.9	24.1	94	92	140.6
30.07 - 05.08	31	27.9	23.9	95	89	212.6
06.08 - 12.08	32	28.0	24.0	95	93	224.5
13.08 - 19.08	33	28.8	24.4	94	86	57.0
20.08 - 26.08	34	29.1	24.1	95	88	48.2
27.08 - 02.09	35	26.9	23.2	97	93	505.2
03.09 - 09.09	36	27.3	23.8	97	93	274.4
10.09 - 16.09	37	28.1	23.9	93	89	155.0
17.09 - 23.09	38	28.7	22.7	93	89	12.4
24.09 - 30.09	39	30.1	22.0	94	78	5.0
01.10 - 07.10	40	29.7	23.4	91	94	253.0
08.10 - 14.10	41	31.3	22.2	89	69	0.0
15.10 - 21.10	42	33.4	19.5	86	50	0.0
22.10 – 28.10	43	33.0	22.1	87	53	0.0
29.10 – 04.11	44	32.0	19.3	85	54	0.0
05.11 – 11.11	45	32.2	18.1	89	55	0.0
12.11 – 18.11	46	31.9	15.8	95	49	0.0
19.11 – 25.11	47	32.2	15.0	89	40	0.0
26.11 – 02.12	48	31.9	15.6	90	50	0.0
03.12 – 09.12	49	33.7	18.1	89	48	0.0
10.12 – 16.12	50	30.8	14.0	90	49	0.0
17.12 – 23.12	51	32.5	13.9	91	43	0.0
24.12 – 31.12	52	31.7	13.8	92	39	0.0



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On Farm Testing on effect of mineral mixture and hormonal catalyst in reduction of calving interval in Mehsani buffaloes

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Received: 19.09.14
Accepted: 21.10.15

ABSTRACT

On Farm Testing (OFT) was under taken to study the effect of mineral mixture and hormonal catalyst in recently parturated Mehsani buffaloes from the year 2009 - 2013. Twenty seven recently parturated Mehsana buffaloes were selected in each year and divided into three groups for three year continuously. Each group comprises of seven animals. Group I animals were kept under normal feeding and animal husbandry practices of farmers. Group II animals were fed with mineral mixture 30 gm/day/animal and Group III animals were fed mineral mixture and hormonal catalyst. The calving interval of group I,II and III was 18.33, 16 and 14.67 months, respectively. The inter calving period of group III was lower than that of group I and group II. Thus On Farm Testing reveals that the feeding of mineral mixture and hormonal catalyst in recently parturated buffaloes lower the inter calving period in buffaloes.

***Key words*:** Buffaloes, Calving intervals, Mineral mixture, Hormonal catalyst

The major cause of low reproductive efficiency in the buffaloes are relatively late onset of puberty and longer calving intervals. The lossess due to prolonged calving intervals are summarized as follows: loss of milk, excessive additional feed costs and delay in replacement stock. So reproductive efficency in dairy animals plays a pivotal role in profitable dairy farming. Minerals are the essential nutrients bearing a significant role in the animal reproduction because their deficiency produces detrimental effect on the performance of the livestock (Akhtar et al. 2009). On mineral supplementation, improvement in reproduction status was reported by many workers (Newar et al. 1998 and Hussain, A 2001). The present On Farm Testing was under taken to find out the effect of mineral mixture and hormonal catalyst on reduction of calving intervals in Mehsani buffaloes.

MATERIALS AND METHODS

An On Farm Tsting was carried out in the different villages of Mehsana District for continuous three years. 27 animals were selected from different villages for one year. All the animals were free from physiological and anatomical disorder and recently parturated. Animals were then alloted to three groups with 7 animals in each group. The experimental treatment of the animal in group-I comprises 7 recently parturated Mehsana Buffaloes. They were maintained under normal feeding and animal husbandry practice of farmer (control group); group - II comprises 7 recently parturated buffaloes supplemented with mineral mixture @ 30 gm per day per annimal ; group-III comprises 7 recently parturated buffoloes supplemented with mineral mixture 30 gm per day per animal with hormonal catalyst (prajana 3 capsules per day for 3 days)

RESULTS AND DISCUSSION

14.67, 16.00 and 18.33 months calving interval found in group-III, II, and I, respectively (Table.1). The longer calving interval in group - I was in closed agreement with finding of Puls 1994. In group - III the calving interval was 14.67 month which nearly agree with Nasir Hussain Shah (2007) that reported the optimal calving interval for dairy buffaloes is found to be 12-13 months. The zinc element from mineral mixture improves conception rate and embionic development in animal and is also known to be essential element for the onset of estrus, repair and maintainance of the uterine lining following parturation and normal reproductive function (Underwood 1977). This finding are also supported by Mourer and Echternkamp (1982) noted that hormone administration may affect the time of ovulation, fertilization rate, corpus luteum development, progesterone secretion and embryo survival.

CONCLUSION

The finding of present study reveals that the use of mineral mixture and hormonal catalyst in recently calving buffaloes shorten the calving interval in Mehsana Buffaloes.

Table.1 Calving interval months of three years

Group	Duration of calving interval (Months)			Pooled of three years (Months)
	First year	Second year	Third year	
I	17	19	19	18.33
II	15	17	16	16
III	14	15	15	14.67

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Effect of storage on milling and cooking quality of raw and parboiled *kodo* (Paspalum scrobiculatum L.)

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Received: 03.02.16
Accepted: 02.04.16

ABSTRACT

Kodo, a neglected but useful grain, holds promise for future food security. As paddy is parboiled to improve milling, cooking and nutritional properties, similarly raw kodo grains were parboiled by soaking at 50°C for 3 h and steaming for 5, 10, 15 min followed by shade drying for 24 h. Raw and parboiled kodo samples were stored in polyethylene bags which were then kept in stainless steel containers. The stored samples were tested for milling and cooking qualities after 30, 60 and 90 days of storage. The storage of parboiled kodo continued to hold better milling and cooking quality in comparison to that of raw kodo.

***Keys words*:** Millets, milling quality, cooking quality, raw *kodo*, parboiled *kodo*.

Minor millets are small seeded annual cereals cultivated for food, feed, forage and other industrial uses. The term minor millets embrace at least 10 to 14 spieces of the grass family. These millets possess unusual ability for adaptation due to tolerance to drought and low soil fertility. The world production of minor millets in the year 2009 was 26.7 Million Tonnes [1]. *Kodo* millet is a highly drought resistance crop. Generally, it is termed under a group of minor millets. This grain can be easily preserved and so already proved as a good famine reserve. *Kodo* grains contain 8.35% protein, 1.4 % fat, 65.65% carbohydrate and 2.95% ash. Due to its high nutrient content, it is regarded as 'nutricereal'. *Kodo* grains provide a cheap source of proteins, minerals and vitamins to poor people of the society. This grain is recommended as a substitute of rice for patients suffering from diabetes disease [2] Parboiling is a hydrothermal treatment followed by drying before dehulling for the production of parboiled milled grain. Parboiling makes the grain hard enough to withstand stress during milling without breakage [3]. It also imparts changes in cooking and nutritional quality of the grain. Dehulling is the process of removal of hull from the endosperm to make the edible portion of grain available for consumption. It can be done by impact force or applying grinding action on the grains.

[4] The milling characteristics of foxtail millet, proso millet, little millet, barnyard millet and *kodo* millet by dehusking in Satake sheller and debraning in a laboratory grade McGill polisher. They reported that milling yield of polished *kodo* millet was 63.2%. The milling performance of minor millets has been studied [5, 6]. The milling (dehusking and polishing) was done with centrifugal dehusker and Kisan rice polisher. The total recovery of husked *kodo* grain was observed to be 56.25% after polishing. The reason for lower recovery was due to the fact that some grains are powdered and get mixed with bran. Because of the higher husk content (18.94%) the machine has to be operated for more time and this gave more breakage. The yield of milled grains was lowest for *kodo* millet (63%). The literature available shows some work on milling characteristics of *kodo* but cooking quality has not been studied by investigators. Similarly, effects of parboiling and effect of storage on parboiled grain have not been investigated. Therefore, present investigation was taken up to assess the effects of storage of raw and parboiled *kodo* in terms of milling and cooking qualities.

MATERIALS AND METHODS

The raw material *kodo*, in the present investigation, was purchased from grain market of Raipur city of Central India. The cleaning of grains was done manually. Foreign matters, light impurities, stones, immature grains, damaged grains and discolored grains were removed manually. After cleaning, *kodo* grains were kept in gunny bags till use. Initial moisture content of *kodo* grains was found to be 5.56% (w.b.). All the experiments were conducted with 3 replications. The layout of experimental plan is given in Fig. 1.

Parboiling experiment

Cleaned *kodo* grains (2 kg) were taken in stainless steel containers. To the container, 6 litres of hot water at about 55°C was added in order to attain the desired mixture temperature. The container was covered with lid and placed in the hot water where

temperature was maintained at 52°C to attain desired 50°C soaking temperature. To ensure uniform soaking, the *kodo* was stirred at regular intervals by using an iron ladle. The soaked samples of *kodo* of even thickness were subjected to steaming in autoclave at 1 kg/cm^2 for 5 min (T_2), 10 min (T_3) and 15 min. (T_4). The raw sample of *kodo* (0 min. soaking, 0 min steaming) is coded as T_1 treatment in the present experimentation.

Storage experiment

The 90 days storage of *kodo* (from 10th May to 10th August) was done at room temperature and relative humidity prevailing in atmosphere. Raw and parboiled *kodo* samples (150 g) were placed in polythene (50 micron thickness) bags and mouth of bags were tied with rubber bands. Then the tied bags were kept in stainless steel containers, which were covered with lids. Then containers were placed in a separate shelf at prevailing temperature and relative humidity of room. Stirring of samples was done at an interval of 7 days throughout all individual samples. After desired storage duration (30, 60 and 90 days) samples were taken out and subjected to milling and cooking quality evaluation tests.

Moisture content determination

Moisture content of raw and parboiled unhusked samples was determined after each storage duration. *Kodo* sample (5 g) was taken out and dried in a thermostatically controlled hot air oven maintained at 105°C for 24 h. After drying, sample was cooled in a desiccators containing moisture absorbing material *i e*. silica gel and weighed on an electronic balance.

Milling experiment

Kodo sample (100 g) from each treatment were weighed on an electric balance and then dehulled on a dried mud hand grinder (32 cm diameter, 5.7 kg), in two passes. Dehusking was based on grinding of grains between two discs, lower one was stationary and upper one rotating. After dehulling/milling brokens, head, unhulled and husk fractions were separated manually by using different domestic sieves. Each fraction was weighed separately and accurately. The head yield, broken percentage and hulling efficiency were calculated by following equations [7].

$$Head\ yield\ (\%) = \frac{W_{hg}}{W_{mg}};$$

$$Broken\ percentage\ (\%) = \frac{W_{bg}}{W_{mg}};$$

$$Hulling\ efficiency.E\ (\%) = \left\{1 - \frac{W_{uh}}{W_t}\right\}\left\{1 - \frac{W_{bg}}{W_t}\right\} \times 100$$

Where,

W_{uh} = weight of unhusked *kodo* remained after dehusking (g)

W_{bg} = weight of broken including mealy waste (g)

W_t = total weight of grains before dehusking (with no broken and mealy waste) (g)

W_{hg} = weight of head grains (g)

W_{mg} = weight of milled grains (g)

Cooking quality experiment

(i) Water uptake

Cooking tests were carried out by using a boiling water bath. For conducting this test, 2 g of *kodo* samples from each treatment including raw *kodo* were taken in test tubes to which 15 ml distilled water was added. The test tubes were then placed in boiling water bath for 30 minutes. After cooking, the contents of the test tubes were emptied into a small perforated tray. The cooked grains were spread on a filter paper, gently touched to remove surface moisture and quickly weighed. Moisture content of the cooked sample was determined by standard oven drying method.

(ii) Leaching loss of solids in gruel during cooking

For determination of leaching loss of solids, 2 g of dehusked *kodo* from each treatment including raw *kodo* were taken in test tubes to which 15 ml of distilled water was added. The test tubes were then placed in boiling water bath for 30 minutes. After cooking, the gruel along with one or two rinses of the test tube was collected in moisture box and dried by hot air oven drying method. The solid loss was expressed in terms of percent dry material of the particular sample.

RESULTS AND DISCUSSION

In the present investigation there were four main experiments viz parboiling of *kodo*, storage of raw and parboiled *kodo*, hulling and cooking of *kodo* grains. In parboiling experiment, temperature and time of soaking were kept constant while steaming time was varied (5, 10 and 15 min) followed by 24 h shade drying.

Effect of storage on moisture content

Raw samples as well as parboiled samples gave a fluctuating trend for their moisture contents (Fig.2). Moisture content of raw as well as parboiled samples initially declined because samples were stored at room temperature and during first 30 days atmospheric temperature was high (around 45°C). For the rest storage period, moisture contents of all samples have attained an increasing trend. This increase was possible due to comparatively low atmospheric temperature and high relative humidity during prevailing rainy season.

Effect of storage on hulling quality

Effects of storage on milling quality (head yield, broken percentage and hulling efficiency) of *kodo* have been represented graphically in Figs. 3, 4 and 5. Upon storage of *kodo*, it is noticeable that in head yield of raw sample, the decrease was 3.66%, while for parboiled samples, it was less than 1.5%. Broken percentage increased for all samples throughout the storage period. For raw sample, increase in broken was about 3% and for parboiled samples it was only about 1%. Hulling efficiency also acquired a declining trend with increasing storage period for all samples. But, parboiled samples achieved better hulling efficiency than that by raw samples at all stages of storage. These data are in agreement with the findings of Pal and Pandey (2000) [8] on paddy storage. They obtained a decrease in head yield of rice ranging from 1.73 to 3.44% depending on degree of polish at the end of storage period of 180 days. Decrease in head yield may be due to ageing which leads to breakage of grains.

Effect of storage on cooking quality

(i) Water uptake

Effects of storage on water uptake of raw as well as parboiled samples of *kodo* have been represented graphically in Fig. 6. The results reveal that water uptake of raw and parboiled samples increased throughout the storage period. But at every stage of storage, raw samples attained higher water uptake than all parboiled samples. As storage period increased, increasing values of water uptake were observed. In the present investigation, this may be due to associated changes in physic-chemical structure of grain during ageing.

(ii) Leaching loss of solids during cooking

The results of experiments on leaching loss of solids during cooking of *kodo* in boiling water are represented in Fig. 7. The results reveal that loss of solids declined throughout the storage period for raw and all parboiled samples except for sample steamed for 15 min, which had shown a very small rise in leaching loss after 60 days. A general decreasing trend was observed during the entire storage period. Leaching loss was highest at the beginning of storage period for all samples whether raw or parboiled. But leaching loss of solids, for raw sample owing to its ungelatinized starch was found to be higher than all parboiled samples. Among all the samples, highest leaching loss was found with raw sample (9.88%) at the beginning of storage. The decline in leaching loss of solids can be explained on the basis of natural effect of ageing during storage irrespective of treatment.

CONCLUSION

The value obtained for milling quality parameters (head yield, broken percent and hulling efficiency) and cooling quality parameters (leaching loss, water uptake) for parboiled grains were better than those obtained for raw grains for both before and after storage. Therefore, it may be concluded that storage of parboiled *kodo* is a safe, unchallengeable operation leading to better hulling and cooking properties in comparison to storage of raw *kodo*.

Table 1 Variable involved in storage experiment

Independent variables	Dependent Variables	
Parameter	Parameter	
Initial moisture content of raw and parboiled *kodo* grains	Moisture content of raw and parboiled *kodo* grains	
Storage temperature	Hulling quality	Head Yield
		Broken percentage
		Hulling efficiency
Storage relative humidity	Cooking quality	Water Uptake
		Leaching loss of solid in gruel
Storage duration		

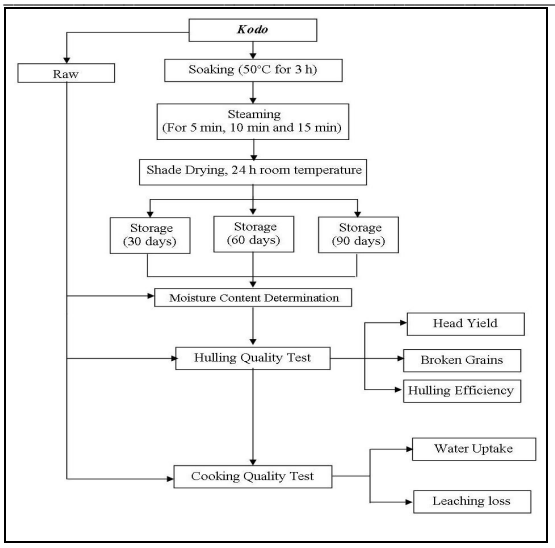

Fig.1: Experimental plan for determination of hulling and cooking qualities of raw and parboiled *kodo* samples

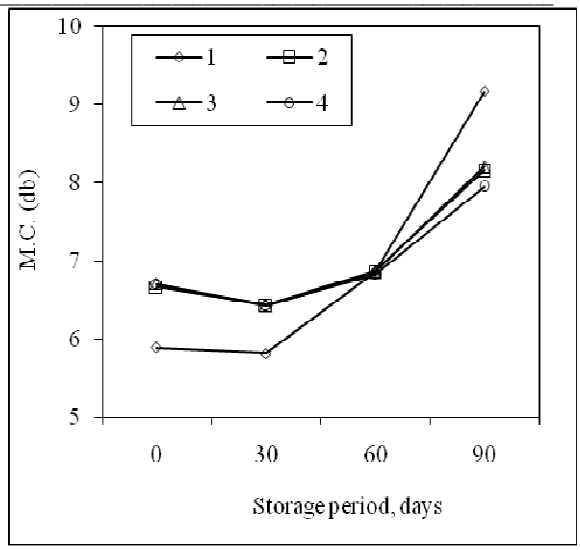

Fig. 2: Effect of storage on moisture content of raw and parboiled kodo

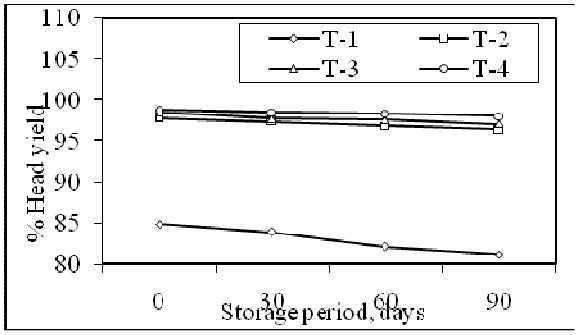

Fig. 3: Effect of storage on milling quality (head yield) of raw and parboiled kodo

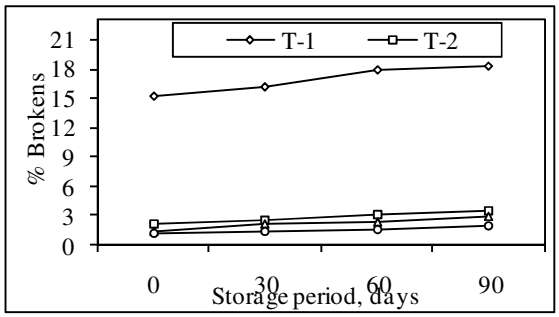

Fig. 4: Effect of storage on milling quality (broken percentage) of raw and parboiled *kodo*

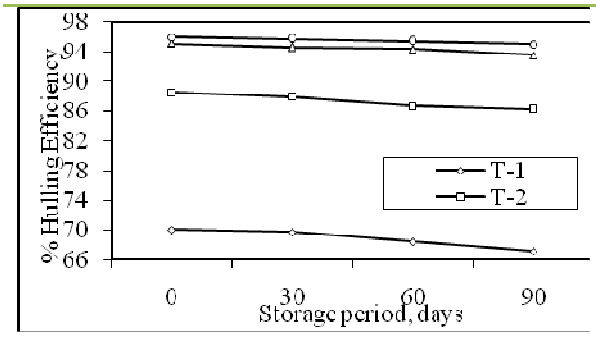

Fig. 5: Effect of storage on milling quality (hulling efficiency) of raw and parboiled *kodo*

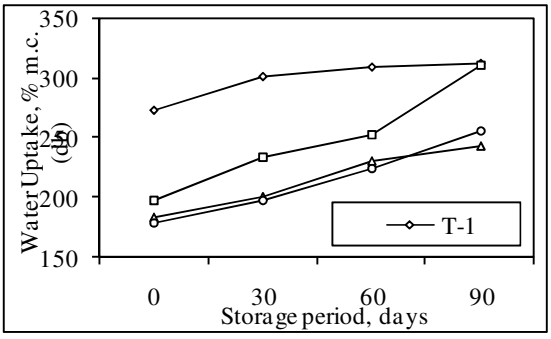

Fig. **6**: Effect of storage on cooking quality (water uptake at 97°C) of raw and parboiled *kodo*

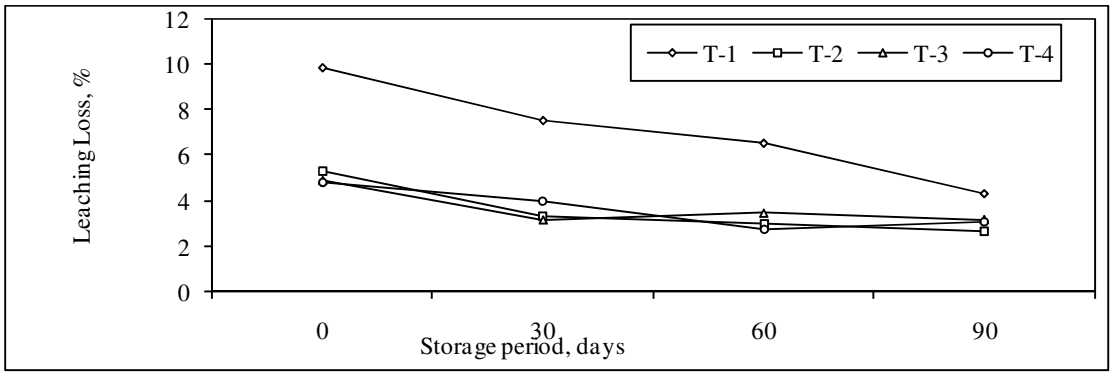

Fig. 7: Effect of storage on cooking quality (leaching loss) of raw and parboiled kodo

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Livelihood and Nutritional Security of Tribal Family Through Nirbheek Backyard Poultry Rearing in Banswara District of Rajasthan

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Received: 25.02.16
Accepted: 04.04.16

ABSTRACT

The present study was conducted on backyard poultry production systems in rural area of Banswara district of Rajasthan. Ten villages were selected from the identified tehsils on the basis of maximum numbers of beneficiaries under NAIP.Ten farmers from each village were selected randomly,Five of them having Nirbheek birds (beneficiaries under NAIP) and rest five having desi birds (non-beneficiaries) were selected thus making a sample of 100 respondents. The average egg production per bird per year was recorded 144 in Nirbheek birds and 52 in desi bird, the average age of first egg laying 5.4 months in Nirbheek and 6.3 month in local birds. Hence, it is concluded that the performance of beneficiaries respondents (under NAIP i.e.Nirbheek bird) was better than non beneficiaries respondents(under non NAIP i.e.desi bird)

Key words: Nirbheek bird, desi bird, livelihood and nutritional security, tribal family.

Backyard poultry farming play an important role in the economic upliftment of poor farmers. Stress free and harmful residue free birds obtained from backyard poultry farming get a great scope in the availability of quality meat. Generally in rural areas farmers have been maintaining backyard poultry for income generation, home consumption, gifts and sacrifice for guests. Backyard poultry is a great need to increase the availability of protein food source in rural areas to alleviate protein malnutrition. This can be achieved by adopting poultry farming in small scale in the back yard of rural households or rearing them under intensive farm conditions in small numbers by utilizing locally available, less expensive feed and housing inputs. Backyard poultry is identified as a significant livelihood activity for many poor and landless families and particularly for women who looks for additional income. Banswara is the tribal dominated district of Rajasthan. The socio economic condition of the farmers does not permit them to adopt any new technology there by resulting in low productivity and low level of income.To increase there income of such family a need was to introduced Nirbheek strain of backyard poultry for livelihood and nutritional security of tribal family through conducting front line demonstration and training. Therefore, the present study was carried out on Nirbheek backyard poultry in rural area of Banswara district of Rajasthan.

MATERIALS AND METHODS

Under front line demonstrations The KVK had distributed 300 units of Nirbheek birds, each unit having 20 chicks of 6 weeks of age under National Agriculture Innovation Project (NAIP) in 10 selected villages of Talwara and Garhi blocks of Banswaradistrict. These birds were dual purpose and have found great acceptance and good adaptability to local conditions.The special features of Nirbheek birds in comparison to desi bird given in Table-1. A survey was conducted on 20 beneficiaries farmers for performance evaluation of Nirbheek birds at different stages of growth with respect to income received from sale of eggs and meat over local birds. Data were collected by direct interview of the beneficiaries.

RESULTS AND DISCUSSION

Success of the Nirbheek birds in rural area was judged by feedback received from beneficiaries in three diamensions i.e. in adoption by non-beneficiaries, income generation and nutritional security.

Adoption by non-beneficiaries : The egg laying capacity of Nirbheek birds was recorded 171.69% higher as compared to desi birds thats why the numbers of farm families have purchased eggs from beneficiaries by paying Rs 7 per egg and hatched with their own local hen. The second generation had started laying eggs after 25 weeks of hatching .

Income generation: Backyard poultry rearing become income source for the family in the study area. Net profit per bird Rs 329.50 and benefit cost ratio is 1:2.45 for rearing of one unit of Nirbheek birds(Table-2).These results get support from earlier observations of Shetter and Jadhave (1999) and Yadav and Khan(2011).

Nutritional security: The rural tribal families rearing Nirbheek birds (provided under NAIP) as backyard poultry experienced on economic

upliftment along with an alleviation of nutritional status due to higher egg production (171.29%) and weight gain of males (52.38%) as compared to local birds(Table-2). The data revealed that the annual average egg production of Nirbheek birds in comparsion to desi birds were 144 and 53, respectively.The result of present study are similar to the work of Mandal and Gautam (2003),Singh et. al. (2003) and Yadav and Khan(2011) . Average weight gain (kg) of adult male and female of Nirbheek birds was recorded 3.20 and 2.10 while, for desi birds 2.10 and 1.35, respectively. The similar trends in gain in body weight of Nirbheek over local birds was reported by Yadav and Khan (2011).

Concluded on the basis of findings of theis study it can be that Nirbheek birds in backyards of traibal family should be reared in order to secure their livelihood and to over come with malnutrition problem.

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अजमेर में जैन धर्म का शिक्षा के विकास में योगदान

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प्राप्ति : **21.01.16**
स्वीकारयता : **15.03.16**

सारांश

जैन धर्म और शिक्षा का विशलेषण किया गया है जिससे स्पष्ट होता है कि जैन धर्म में प्राचीन काल से ही शिक्षा का बहुत महत्व रहा है। जैन धर्म में अध्ययन, मनन स्वाध्याय व चिन्तन आदि को महत्वपूर्ण स्थान मिला है। शिक्षा को यशकारी श्रेयस्कारी, कामदायिनी, चिन्तामणि व कल्याणकारिणी के रूप में वर्णित किया है इस अध्याय में शिक्षक व शिक्षार्थी के विशेष गुणों का भी उल्लेख किया गया है। जिस प्रकार हिन्दु धर्म में संस्कारों का महत्व है, उसी प्रकार जैन धर्म में शिक्षा विषय लिपिक्रिया, उपनीति क्रिया, वृतचर्या व वृताचरण क्रिया का महत्व है। शास्त्रीय ज्ञान में वेद, वेदांग (शिक्षा, कल्प, व्याकरण, छन्द, ज्योतिष व निरूक्त), इतिहास, पुराण एवं कला की भी शिक्षा प्रदान की जाती थी। शिक्षा का कार्य प्रायः साधु वर्ग द्वारा किया जाता था। महिलायें भी (उपाध्यायिनी) शिक्षा देने का कार्य करती थी। प्राचीनकाल में शिक्षा, मंदिर, मठ व गुरूकुलों में दी जाती थी। अजमेर में शिक्षा के क्षेत्र में भट्टारकों का विशेष योगदान रहा। तेरहवीं से सत्रहवीं शताब्दी तक भट्टारकों द्वारा विपरीत परिस्थितियों में भी शिक्षा द्वारा जनता को जागरूक किया गया। बाद में समाज के धनी लोगों द्वारा स्थान-स्थान पर विद्यालय व महाविद्यालय की स्थापना की गई। जैन विद्यालयों में धार्मिक व रात्रि शिक्षा भी प्रदान की जाती थी। इस अध्याय में अजमेर के प्रमुख जैन शिक्षण संस्थानों का भी वर्णन किया गया है। निष्कर्षतः जैन समाज ने प्रारम्भ से ही शिक्षा के महत्व को अज्ञान-अंधकार, परम्परागत रूढ़ियों, अन्धविश्वासों एवं दुर्व्यसनों से मुक्ति के रूप में अंगीकार किया था। इसी भावना से प्रेरित होकर जैन समाज ने प्रत्येक नर-नारी को शिक्षित करने हेतु यथा सम्भव अवसर प्रदान किये थे।

मुख्य शब्द :- अजमेर, जैन संस्कृति, जैन मन्दिर, जैन धर्म और शिक्षा

शिक्षा समुदाय या व्यक्ति द्वारा परिचालित एक सामाजिक प्रक्रिया है, जो समाज को उसके द्वारा स्वीकृत मूल्यों और मान्यताओं की तरफ अग्रसर करती है। सांस्कृतिक विरासत की उपलब्धि एवं जीवन में ज्ञान का अर्जन शिक्षा द्वारा ही सम्भव है। जीवन समस्याओं की खोज, आध्यात्मिक तत्वों की छान-बीन एवं मानसिक क्षुधा की तृप्ति के साधन, कला कौशल का परिज्ञान आदि शिक्षा द्वारा ही प्राप्त किये जा सकते है। मानव में सुप्त आत्म-शक्तियों का विकास एवं जीवन का परिष्कार शिक्षा का मूल उद्देश्य रहा है। मानसिक पवित्रता, दृढ़ता, सांसारिक पदार्थो की क्षणभंगुरता का बोध, अनासक्त भाव, स्वाध्याय-चिन्तन, कर्तव्यबोध, सहिष्णुता, सद्गुण और मानवता आदि इसी की परिकल्पना में आते है।

साधु, उपाध्याय, आचार्य, अर्हन्त और सिद्व इन पाँच सोपान सिद्वियों की उपलब्धि जैन शिक्षा पद्वति की देन है। त्रिरत्न-सम्यक दर्शन, सम्यक-ज्ञान और सम्यक-चरित्र को शिक्षा साधना का कल्याण पक्ष माना गया है। शिक्षा के क्षेत्र में साधनों का विशुद्व होना अत्यावश्यक है। साधना यदि विशुद्व होती है तो साध्य स्वतः ही विशुद्व बन जाता है। अतः शिक्षा का क्षेत्र, आध्यात्मिकता से ओत-प्रोत होना नितान्त आवश्यक है। अहिंसा, सत्य, अस्तेय, ब्रह्मचर्य और अपरिग्रह इन पाँच व्रतों का पालन, मैत्री, प्रमोद, कारूण्य व माध्यस्थ भावनाओं का चिन्तन, क्षमा एवं मार्दव आदि दस धर्मो का अनुकरण तथा मद्य-मांस आदि दुर्व्यंसनो का परित्याग करने से भाव विशुद्व हो जाते है और अन्ततः निर्वाण की प्राप्ति हो जाती है। जिनसेन ने शिक्षा को यशस्कारी, श्रेयस्कारी, कामदायिनी, चिन्तामणि एवं कल्याणकारिणी आदि रूप में वर्णित किया है। व्यक्ति के सर्वांगीण विकास का आधार मुख्यतः शिक्षा ही है।

जैन शिक्षा में णमोंकार मन्त्र का अत्यधिक महत्व रहा है। मंत्र इस प्रकार है :-

"णमों अरिहंताणं, णमों सिद्वाणं, णमों आइरियाणं।
णमों उवज्झायाण, णमों लोए सव्व-साहूणं।।

सरलार्थ- अरिहन्तो या अर्हन्तों को नमस्कार हो, सिद्वों को नमस्कार हो, आचार्यो को नमस्कार हो, उपाध्यायों को नमस्कार हो, और लोक के सर्वसाधुओं को नमस्कार हो।

णमोंकार मन्त्र ही समस्त द्वादशांग जिनवाणी का सार है। इसमें समस्त श्रतुज्ञान की अक्षर संख्या निहित है। जैन दर्शन के तत्व, पदार्थ, द्रव्यगुण, पर्याय, नम, निक्षेप, आस्त्रय एवं बन्ध आदि इस मन्त्र में विद्यमान है। समस्त मन्त्र एवं मन्त्रशास्त्र की उत्पत्ति, इसी महामन्त्र से हुई है। [1] समस्त धार्मिक और सामाजिक कृत्यों के प्रारम्भ में, इस महामन्त्र का उच्चारण किया जाता है। जैन सम्प्रदाय का यह दैनिक जाप मन्त्र है। इस मन्त्र का प्रचार दिगम्बर एवं श्वेताम्बर दोनों सम्प्रदायों में समान रूप से पाया जाता है। इस मन्त्र में पांच पद, अठावन मात्रा और पैंतीस अक्षर है।

प्रथम तीर्थंकर भगवान ऋषभदेव के द्वारा अपने शिष्यों, पुत्र-पुत्रियों को दी गई शिक्षा, जैन-शिक्षा के मूल उद्देश्यों से ओत-प्रोत थी। जिसके मुख्य बिन्दु इस प्रकार है [2] :-

1.आत्मोथान के लिए प्रयत्नशील।
2.जगत और जीवन के सम्बन्धों का परिज्ञान करना।
3.आचार, दर्शन और विज्ञान के त्रिभुज की उपलब्धि।
4.प्रसुप्त शक्तियों का उद्बोधन।
5.सहिष्णुता की प्राप्ति।
6.शारीरिक, मानसिक और आत्मिक शक्तियों का विकास।
7.कलात्मक जीवन यापन करने की प्रेरण देना।
8.अनेकान्तात्मक दृष्टिकोण द्वारा भावत्मक अहिंसा को समझना।
9.व्यक्तित्व के विकास के लिए समुचित अवसरें की प्राप्ति करना।
10.कर्तव्य पालन के लिए जागरूकता का बोध कराना।
11.विवके दृष्टि की प्राप्ति करना।

जैन संस्कृति के विकास हेतु प्रदाय शिक्षा में भी अन्य संस्कृतियों की शिक्षा की भांति, शिक्षक व शिक्षार्थी ही मुख्य घटक

होते है। जैन संस्कृति के अनुसार ये कुछ विशेष विशेषताओं से युक्त होने चाहिए। जिसका विवरण इस प्रकार है :-

शिक्षक :- शिक्षार्थी को योग्य और अनुकूल बनाना शिक्षक का प्रमुख गुण है। शिक्षक का आदर्श जीवन विद्यार्थी के लिए प्रेरणा पुन्ज होता है। इसीलिए अनुकूल अनुशासन और स्वच्छ वातावरण के निर्माण के लिए यह आवश्यक है कि शिक्षक सदैव शिक्षार्थी बना रहे और शिक्षार्थी को शिक्षित करने की साधना करता रहे। शिष्य को अपने गुरू के समान माने और उसके लाभ की दृष्टि रखे। जो भी उपदेश दे वह कल्याणकारक, आत्मशान्ति एवं आत्मशुद्वि करने वाला होना चाहिए। [3] जैन धर्म में शिक्षक के आवश्यक गुणों को इस प्रकार दर्शाया है :- सदाचारिता, नित्यात्मकता, जितेन्द्रियता, अन्तरंग और बहिरंग की सौम्यता, व्याख्यान शक्ति की प्रवणता, सुबोध व्याख्या शैली, प्रत्युत्पन्न (मतैक्य) तार्किकता, दयालुता, पाण्डिय, शिष्य के अभिप्राय को अवगत करने की क्षमता, अध्ययन शीलता, विद्वता, वाड्मय के प्रतिपादन की क्षमता, गम्भीरता, स्नेहशीलता, उदारता और विचार समन्वय की शक्ति, सत्यवादिता, सत्कुलोत्पनन्ता, अप्रमन्नता, परहित साधन परता आदि।

ऐसे शिक्षकों में पूर्णाश्यप, मक्खलि, गोसाल, अजीतकसम्वलि, पकुधकच्चामन, संजयबेलदिपुत, निगण्ठनातपुत्र एवं सिद्वार्थ गौतम का नाम विशेष उल्लेखनीय है। ये सभी आचार्य एवं गणाचार्य सर्वज्ञ और सर्वदर्शी थे। इनके अतिरिक्त सारिपुत्र, मौदगल्यायन, आनन्द एवं चाप आदि भिक्षु-भिक्षुणियों का भी उल्लेख मिलता है। [4]

शिक्षार्थी :- शिक्षार्थी की सफलता इस बात पर निर्भर करती है कि उसकी स्वंय की वृति किस प्रकार की है। ज्ञान प्राप्त करने के लिए यह आवश्यक है कि शिक्षार्थी के साधन पवित्र और विनीत हो। [5] शिक्षा का फल विनय है और विनय का फल समस्त कल्याण है। जैन धर्म में विनयआदि गुणों को शिक्षार्थी के मूलभूत गुणों में सम्मिलित किया गया है। भगवान महावीर स्वामी ने जिस साधना पद्वति को अंगीकार किया था उसका एक अंग तपोयोग है। उसका एक प्रकार विनय है। जिसके सात रूप वर्णित है [6] :-

1. ज्ञान विनय, 2. दर्शनविनय, 3. चरित्रविनय

4. मनोविनय, 5. वचनविनय, 6. कामविनय

7. लोकोपचार विनय

विनय से अहंकार की मुक्ति और परस्परोगृह की भावना का विकास होता है। आचार्य जिनसेन ने आगम और आगमेतर ग्रन्थों का मनन-चिन्तन कर आदिपुराण में शिक्षार्थी के गुणों का व्याख्यान इस प्रकार किया है [7] :- जिज्ञासावृति, श्रद्धा-अध्ययन और अध्यापक दोनों के प्रति आस्था, विनय शीलता, शुश्रूषा-पाठ के प्रति सतर्कता एवं जागरूकता, ग्रहण-पाठ ग्रहण की अर्हता, धारण-पठित विषय का स्मरण करना, स्मरण-शक्ति, अपोह-अकरणीय का त्याग, तर्क-शक्ति, निर्णाति-संयुक्तिक विचार करने की क्षमता, संयम, प्रमाद का अभाव, सहज प्रतिभा एवं अध्यवसाय। शिक्षार्थी के ये सभी गुण उसकी समग्र सफलता को दर्शाते है। ऐहिक और पारलौकिक सुख साधना की दृष्टि से इन गुणों को सर्वोपरि कहा जा सकता है।

जैन धर्म में बालक की शिक्षा प्रारम्भ करने से पहले उसका संस्कार किया जाता है। शिक्षा सम्बन्धी (संस्कार) क्रियाओं का वर्णन निम्न प्रकार से है :-

(अ) लिपिक्रिया :- जैन धर्म में जब बालक पाँच वर्ष का हो जाता था, तब उसे अक्षर ज्ञान करवाना, लिपिक्रिया के नाम से जाना जाता था। इस क्रिया में बालक का पिता अपने वैभव के अनुरूप पूजन सामग्री लेकर श्रुत देवता का पूजन करता है। आदि तीर्थंकर ने स्वयं अपनी पुत्रियों के लिपिक्रिया के समय सुवर्ण पट्ट पर अ, आ, इ, ई, उ, ऊ आदि वर्णमाला लिखी और श्रुत देवता की स्थापना की थी। अक्षर ज्ञान के साथ-साथ अंको का ज्ञान भी आवश्यक था। शिक्षा-आरम्भ 'सिद्वं नमः' मंगला चरण मन्त्र से करते थे। [8]

(ब) उपनीत क्रिया :- जैन धर्म के अनुसार जन्म के आठवें वर्ष में बालक की उपनीत (यज्ञोपवीत) क्रिया होती है। इस क्रिया में सर्वप्रथम जिनालय में जाकर अर्हन्त की पूजा करने के बाद बालक को व्रत देकर उसका 'मौंजी बन्धन' (कमर में मूंज की रस्सी बांधना) किया जाता है। सर पर चोटी, सफेद धोती व दुपट्टा दिया जाता था। ऐसा बालक ब्रह्मचारी कहलाता था। उस समय केवल राजपुत्र को छोड़कर सबको भिक्षा-वृति से ही निर्वाह करना पड़ता था। राजपुत्र को भी अन्तःपुर में जाकर माता आदि से किसी पात्र मे भिक्षा मांगनी पड़ती थी। भिक्षा में जो कुछ भी प्राप्त होता, उसका अग्र भाग श्री अर्हन्तदेव को समर्पण कर, बाकी बचे हुए अन्त का स्वंय भोजन करता था। इस क्रिया के पश्चात बालक को गुरू के पास विद्याध्ययन के लिए भेजा जाता था। इस क्रिया के पश्चात ही बालक विधिवत शिक्षा ग्रहण करता था।

(स) व्रतचर्या :- इस क्रिया का अभिप्राय विद्याध्ययन के समय संयमित एवं कठोर जीवन व्यतीत करने से है। विद्यार्थी ऐसा कोई कार्य नहीं करता जो विद्याध्ययन में बाधक हो। उसका लक्ष्य केवल विद्याध्ययन ही होना चाहिए।

(द) व्रातावरण क्रिया :- यह क्रिया विद्याध्ययन की समाप्ति पर सम्पन्न होती थी। इस अवसर पर शिष्य, गुरू को दक्षिणा देकर, गुरू के आश्रम का परित्याग कर ग्रहस्थाश्रम में प्रवेश करते है। [9]

प्रायः बालक-बालिकाओं को बचपन में घर पर ही उनके माता-पिता द्वारा प्रारम्भिक शिक्षा प्रदान की जाती थी। उसके पश्चात विद्यालय या वन में गुरू के आश्रम के शिक्षा के लिए भेजा जाता था। विद्यार्थी अध्ययन के लिए गुरू के घर भी जाते थे। [10]

जैन शिक्षा केन्द्रो का विकास क्रम

भारत में सांसरिक चिन्तन की अपेक्षा तत्वधान तथा पारलोकिक चिन्तन की ओर अधिक प्रवृति थी। वानप्रस्थ और संन्यास आश्रमों की व्यवस्था में प्राचीन ऋषि मुनियों ने यह प्रयत्न किया था, कि जीवन का अधिकांश भाग उच्च तत्व ज्ञान के चिन्तन में व्यतीत हो। इस उद्देश्य की पूर्ति के लिए सांसारिक कोलाहल से दूर, प्रकृति के वन-उपवन चुने गये। इन स्थानों पर ऋषि-मुनियों के आश्रमों की स्थापना हुई। बाद में, आश्रमों की स्थापना नदियों तथा नगरों के निकट होने लगी। ये तपोवन तथा आश्रम धीरे-धीरे धर्म एवं शिक्षा के केन्द्र बने। वैदिक आश्रमों के अनुरूप जैनों ने विहार, मठ, स्थानक और मन्दिर में शिक्षा की व्यवस्था की। [11] इनके अतिरिक्त कुछ पाठशालाऐं वृक्षों के नीचे भी लगती थी। [12] इस प्रकार जैन समाज प्रारम्भ से ही विद्या प्रेमी रहा है। पहले आचार्यो के केन्द्रों से जैन शिक्षा का संचालन होता रहा। जिनमें आचार्य कुन्दकुन्द, धरसेन, समन्तभद्र, उमास्वामी, विद्यानन्दि, अंकलक नेमिचन्द एवं जिनसेन जिनमें प्रमुख रहे। [13] तेरहवीं

शताब्दी से भट्टारक भट्टारकों की गद्दियों में शिक्षण चलता रहा है।

शिक्षा का पाठ्यक्रम

पाँच वर्ष के बालक-बालिकाओं को लिपिज्ञान एवं सामान्य भाषा सिखने के पश्चात गणित का ज्ञान प्रदान किया जाता था। उपनयन संस्कार के पश्चात गुरू के पास शास्त्रीय ज्ञानार्जनार्थ हेतु जाते थे। जहाँ मुख्यतः चार वेद- (ऋग्वेद, यजुर्वेद, सामदेव एवं अथर्ववेद), वेदांग (शिक्षा, कल्प, व्याकरण, छन्द, ज्योतिष एवं निरूक्त), इतिहास, पुराण, मीमांसा, न्यायशास्त्र, काम शास्त्र, हस्ति एवं अश्वशास्त्र, तन्त्रशास्त्र, लक्षणाशास्त्र, नीतिशास्त्र, कला शास्त्र तथा धर्मशास्त्र विषय पटाये जाते थे। इनके अतिरिक्त नृत्य-गीत, भवन एवं मूर्ति निर्माण आदि कलाऐं भी सम्मिलित थी। शिक्षा प्रायः संस्कृत एवं प्राकृत भाषाओं के माध्यम से ही दी जाती थी। [14]

शिक्षण विधि

जैन शिक्षण प्रणाली में प्रशोत्तर शैली में मुख्य रूप से उपमाशैली एवं खण्डन-मण्डन शैली प्रचलित रही है। प्रश्नोत्तर शैली में भगवान महावीर स्वामी एवं उनके अनुयायी अपने प्रतिपक्षी विद्वानों से प्रश्न करते और उन्ही के माध्यम से उत्तर निकाल लेते थे। भगवती सूत्र, कथावत्थु एवं मिलिन्दपन्हों आदि ग्रन्थों में इस शैली के दर्शन होते है।

जैन शिक्षा में उत्तर देने की चार विधियों का उल्लेख है। [15]

1. एक संख्या करणीय - प्रश्न का एक भाग व्याकरणीय होता है।
2. विभज्ज व्याकरणीय - प्रश्न का विभाजन करके उत्तर देना।
3. पटिपुच्छा व्याकरणीय - प्रश्न का उत्तर प्रतिप्रश्न करके दिया जाता है।
4. ठापनीय- कुछ प्रश्न ऐसे भी होते है जिनके उत्तर छोड़ देने पड़ते है। इन चारों प्रकार के प्रश्नों को गम्भीर, अनाक्रमणीय, अर्थ अनर्थ का जानकार ही बड़ा पण्डित होता है।

शिक्षण संस्थान

अजमेर क्षेत्र में जैन धर्मावलम्बियों ने प्रारम्भ से ही शिक्षा का महत्व समझते हुए समाज के प्रत्येक व्यक्ति को शिक्षित करना चाहा। इसी भावना से प्रेरित होकर उन्होंने विभिन्न शिक्षण संस्थाओं का निर्माण करवाया था। इनमें से मुख्य शिक्षण संस्थाओं का वर्णन निम्नलिखित है :-

1. श्री ऐलक पन्नालाल दिगम्बर जैन विद्यालय, ब्यावर :- सन् 1895 में स्थापित यह विद्यालय स्थानीय दिगम्बर जैन समाज की एक प्रमुख संस्था है। यह शिक्षा के क्षेत्र में गौरवपूर्ण स्थान रखती है।
2. ओसवाल जैन उच्च विद्यालय, अजमेर :- धार्मिक शिक्षा प्रदान करने के उद्देश्य से सन् 1899 में ओसवाल जैन समाज के प्रयास से यह धार्मिक पाठशाला खोली गई थी। प्रारम्भ में यह एक प्राथमिक विद्यालय था जिसे सन् 1929 में उच्च विद्यालय में क्रमोन्नत किया गया था। इस संस्था की प्रबन्ध समिति का, विद्यालय की उन्नति में विशेष प्रयास रहा है। [16]
3. श्रीगुलाब कँवर ओसवाल उच्च प्राथमिक कन्या विद्यालय,अजमेर :- श्री धनराज कास्टिया के प्रयास से 8 सितम्बर, 1912 ईस्वी में इसकी स्थापना हुई थी। संस्था का संचालन कार्य ओसवाल फीमेल एज्युकेशन सोसायटी द्वारा सम्पादित होता है। यहाँ आठवीं कक्षा तक अध्ययन की व्यवस्था है। [17]
4. भूरीबाई दिगम्बर जैन पाठशाला, ब्यावर :- श्रीमती भूरी बाई की पुण्य स्मृति में मोतीलाल मोदी, द्वारा 1943 ईस्वी में बालिकाओं के शिक्षण हेतु यह पाठशाला बनवाई गई। [18]
5. टीकमचन्द जैन विद्यालय, अजमेर :- इस विद्यालय का निर्माण, अजमेर में शिक्षा की आवश्यकता को पूर्ण करने के लिए सेठ भागचन्द सोनी ने अपने पिता टीकचन्द की याद में 1944 ईस्वी में बनाया था। 1956 ईस्वी में यह उच्च प्राथमिक विद्यालय में क्रमोन्नत कर दी गई। [19]
6. श्री कुन्थुसागर दिगम्बर जैन उच्चतर माध्यमिक विद्यालय, किशनगढ़ :- इस विद्यालय की स्थापना सेठ भागचन्द सोनी हीरालाल पाटनी एवं मगनलाल पाटनी के प्रयासों से 1951 ईस्वी में हुई। 1956 ईस्वी में यह उच्च माध्यमिक विद्यालय में क्रमोन्नत हुआ। इस विद्यालय के दो निजी भवन है। पुराना भवन मदनगंज चौराहा के पास है जिसका नाम भागचन्द विद्याभवन रखा गया है। इस विद्यालय में बाल मंदिर तथा प्राथमिक पाठशाला है। इसमें लगभग 1200 छात्र-छात्रायें अध्ययनरत है। दूसरा नवीन भवन जो (पी.टी.एस. के पास) छोटी सी पहाड़ी पर स्थित है। इस भवन का निर्माण सरकार की सहायता, अध्यापकों एव छात्र-छात्रओं के अविस्मरणीय श्रम द्वारा हुआ था। विद्यालय में बाहर के गांवों से जाने वाले छात्रों की सुविधा के लिए छात्रावास एवं एक विशाल वाचनालय भी है। [20]
7. श्री भाग्य मातेश्वरी कन्या पाठशाला :- यह पाठशाला समाज के नन्हें बालक-बालिकाओं को पांचवी कक्षा तक शिक्षण प्रदान करने हेतु सेठ भागचन्द सोनी के संरक्षण मे गतिशील है। पाठशाला का समग्र व्यय भार सोनी परिवार द्वारा वहन किया जाता है। [21]
8. श्री दिगम्बर जैन विद्यालय, अजमेर :- 108 आचार्य शिवसागर महाराज के अजमेर में सम्पन्न हुए चातुर्मास के अवसर पर इस विद्यालय की स्थापना की गई थी। यहाँ समाज के बच्चों को रात्रि में धार्मिक शिक्षा भी प्रदान की जाती है।
9. आचार्य श्री धर्मसागर दिगम्बर जैन पाठशाला, अजमेर :- पाठशाला प्रधान पूनम चन्द लुहाड़िया के अनुसार श्री 108 आचार्य धर्मसागर महाराज के अजमेर चातुर्मास के अवसर पर बच्चो को धार्मिक शिक्षण प्रदान करने हेतु, इस पाठशाला की स्थापना की गई थी। [23]
10. दिगम्बर जैन पाठशाला, अजमेर :- यह पाठशाला स्थानीय महावीर मौहल्ले में संचालित है। यहाँ धार्मिक शिक्षा के अतिरिक्त आठवीं कक्षा तक के सभी विषय पढ़ाये जाते है। इनके अतिरिक्त मुनि श्री हजारीमल स्मृति जैन सिद्धान्त शाला, श्री साधुमार्गी जैन सिद्धान्तशाला, मेहता ज्ञानचन्द जैन सिद्धान्त शिक्षण शाला, ब्यावर, श्री बाहुवली जैन पाठशाला, नसीराबाद, श्री पार्श्वनाथ जैन

तत्वज्ञान विद्यापीठ, श्री श्रमणोपासक जैन फूलादेवी धार्मिक रात्रि पाठशाला, अजमेर इत्यादि है। इन शिक्षण संस्थाओ ं के अतिरिक्त सिद्धकूट चैत्यालय, महापूत जिनालय, बाबाजी की नसियाँ आदि प्रमुख मन्दिरों में रात्रि-कालीन शिक्षा का प्रावधान है जो निरन्तर जारी है।

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Form IV
(See Rule 8)

Statement about ownership and other particular of Journal of Progressive Agriculture

Place of publication	:	Ajmer, Rajasthan, India
Periodicity of publication	:	Half Yearly
Printer's Name	:	Shree Offset, Printing Press, Ajmer.
Nationality	:	Indian
Address Kesar Ganj, Ajmer (Raj.)	:	M/S Shree Offset, Printing Press,
Publisher's name	:	Sh. Ram Singh Bhati President of Samaj Kalyan Avam Samannvit Vikas Sanstha, Ajmer (Rajasthan)
Address	:	316/A, Christian Ganj, Ajmer (Raj.) India
Editor's name	:	Sh. Ram Singh Bhati President of Samaj Kalyan Avam Samannvit Vikas Sanstha, Ajmer (Rajasthan)
Nationality	:	Indian
Address	:	316/A, Christian Ganj, Ajmer (Raj.) India
Name and address of individual who own the newspapers/journal partners and shareholders holding more than 1% of the total capital		Samaj Kalyan Avam Samannvit Vikas Sanstha, Ajmer (Rajasthan) India

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Dated: 18th April, 2016 (Ram Singh Bhati)