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Development of Region Specific Horticulture based Integrated Farming System Models with Crop Diversification for Sustainable Livelihoods and Nutritional Security of Tribal of Sirohi District of Rajasthan: A Case Study

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Abstract

The study was conducted in two tribal dominated blocks *i.e.* Aburoad and Pindwara of district Sirohi during 2008-09 to 2012-13. The KVK developed region specific integrated farming system models with crop diversification for poverty alleviation, sustainable development in agriculture, generate on and off farm employment. Target group was tribals, who have very small land holding size with limited resources and marketing facility. Among different region specific integrated farming system models for 2.0 hectare arable land, the model 7 (Crop + cash crop + vegetable + fruit + flower production with retail marketing of fruit and vegetables) was more beneficial for the farmers than other models. Adaptor farmers earn highest net return (₹ 5.30 lakh year^{-1}) with maximum B: C ratio (4.38) and generate more (1800 mandays year^{-1}) employment opportunities at farmers field. Significant difference between non adaptors and adaptors respondents of modern agro-technologies and crop diversification was reported as adopters started earning up to ₹ 2.85 lakh annum^{-1}, their working hours increased (375%), made pukka houses (38%), purchased utility items (83%), have good bank balance up to ₹ 10,000 (92%), provided good education to children (63%), purchased agricultural inputs (66%), increase interaction with extension workers (72%), purchased personal transport conveyance (53%), telephone or mobile facilities (87%), women participation in decision making (39%) and purchasing power significantly increased. Thus, adoption of region specific integrated farming system models with modern agro-technologies proved a milestone in tribals empowerment by providing sustainable financial and nutritional security.

Keywords: Tribal, crop diversification, socio-economic, nutritional security, purchasing power

Sirohi falls under the disadvantaged district identified by the Planning Commission. The agriculture in this district is characterized by recurrent droughts, dominance of low value and low demand crops, inadequate infrastructure, small size of land holding, poor irrigation sources, lack of off farm employment opportunities, poor market support, non-availability of credit and high rate of illiteracy. Farmers of the district are growing traditional crops like wheat, mustard, gram, cumin and fennel in *rabi* season and maize, pulses, pearl millet, cotton, castor in *kharif* season and getting low farm income. Maize-wheat rotation is prevalent cropping system in the district. Maize is a major crop of the district under rainfed cultivation. Among oil seeds, mustard and castor occupied maximum area with irrigated cultivation. The crop sequences followed by cultivators are maize/pearl millet-fallow, *kharif* pulses-fallow, *kharif* pulses-mustard under rainfed condition whereas fallow-mustard/gram, cotton-fallow, castor-fallow, fennel-fallow and maize/pearl millet-mustard/wheat/gram under irrigated conditions. The productivity of castor, cotton and fennel are higher in comparison to state average. The productivity of the crops in tribal villages is very low as compared to district and state average.

Farmers generally grow maize-wheat for fulfilling dietary requirement and sell surplus in market for additional income. There is no cultivation of systematic vegetables and fruit crop in adopted tribal villages. During *kharif* season, farmers broadcast seeds of okra, ridge gourd and bottle gourd in between rows of cereal crops for their personal consumption. Due to poor socio-economic condition, lack of risk taking capacity, illiteracy, poor communication network and poor extension reach, use of improved technologies is very meager in the district. Therefore, agriculture is declining

towards low profit job leading to increasing migration of farmers to adjoining (Gujarat) urban areas in search of job. To increase farm profitability by refinement in existing technologies and farmers advised to adopt developed "*Region specific integrated farming system models*" based on horticultural crops, popularization of fruit (papaya, lime, pomegranate), flowers (marigold, roses) and vegetables (tomato, chilli, okra, cucurbits etc.) cultivation, primary processing (proper harvesting, grading and packing of produce) for increasing shelf-life and retail marketing of produce for maximizing net profit. By the help of agriculture scientists, progressive farmers and fruit-vegetables merchants develops a suitable IFS model consisting of three layers (lime + papaya + marigold or pomegranate + papaya + marigold) orchard, vegetables and off-season vegetables for regular and sustainable income generation from the farm. A bouquet of 7-10 modern agro-technologies were provided to farm households with horticulture based IFS models options. Horticulture based farming system emerged as economically viable system for small and marginal farmers and income of farm families doubled within a short span of 4 years (2008-09 to 2012-13). Papaya + lime based nutrition garden also improved nutritional status of the tribal families. Vegetable cultivation not only improved economy of the families but also empowered women as they were also engaged in retail marketing of vegetables themselves in nearby vegetable markets and in urban areas. Today (2012-13) the tribal farmers adopted maximum technologies and producing good quality vegetables, papaya, flowers, lime, pomegranate with highest productivity. This IFS model secured farmers from the unseen losses by weather vagaries also enhancing farm income manifold and farmers earned ₹ 5.30 lakh from 2.0 hectare land by adopting crop production + cash crop + vegetable + fruit + flower production with improved technologies in contrast to only ₹ 1.22 lakh from same piece of land by crop production.

MATERIALS AND METHODS

The study was conducted in ten villages of two tribal dominated blocks *i.e.* Aburoad (Moongthala, Jhamar, Chandella, Fatehpura and Dhamsara) and Pindwara (Moori, Kerlapadar, Amli, Talabfali and Rajpura) of district Sirohi during 2008-09 to 2012-13. Diagnostic survey was conducted in villages especially for improvement in farming system. Special emphasis has been given on formulation with proper planning and execution of the extension and research works. The goal of attaining social equity and inclusive growth cannot be achieved without providing livelihood and nutritional security to most vulnerable sections of the population which consist mostly of scheduled tribes and scheduled castes of district. Because of lack of access to knowledge and technology poor resource base has been developed and limited capacity to take risk is prevalent in the masses. On the basis of available resources, incorporate following horticulture based farming system models for emerged as economically viable system for small and marginal farmers.

Table 1. Horticulture based farming system model

Sl.No.	Models	Type of model
1	Models-1	Crop production
2	Models-2	Cash crop production
3	Models-3	Vegetable production
4	Models-4	Crop + cash crop+ vegetable production
5	Models-5	Crop + cash crop+ vegetable + fruit production
6	Models-6	Crop + cash crop+ vegetable + flower + fruit production
7	Models-7	Crop + cash crop+ vegetable + flower + fruit production with retail marketing

Other than above mention models a bouquet of 7-10 modern agro-technologies like use of hybrid seeds, micro-irrigation, custom hiring of machineries, pair row planting, staking in vegetables, off-season vegetable cultivation, nutrient management, primary processing, mixed cropping, grading, packing and retail marketing of the produce were provided to farm households with horticulture based IFS models options. After four year completion of interference for evaluation the effect of the farming system model and modern agro-technology was conducted a field survey during the year 2012-13. From each village 20 farmers (10 adopters and 10 non-adopters) and total 200 tribal farmers were selected through equal allocation using purposive sampling technique with the hope of representing the whole area.

Adoption and effect of vegetable cultivation, establishment of orchard, papaya cultivation, primary processing of fennel, change in input use and effect of modern agro-technologies on enhancement in productivity of major horticultural crops in tribal area of district Sirohi was determined by a team of five experts from the field of horticulture, economics, revenue and agriculture along with a progressive tribal farmer by direct mathematical calculation by using different revenue calculation methods, which standardized by department of statistics and economics. The horizontal expansion of the technologies was measured by complete village survey methods, those standardized

by Vyas *et al.*, (2014) and data generated by face-to-face interview with respondents. Further, the relevant information regarding retail marketing of fruit and vegetables, additional income from retail marketing and nutritional security through kitchen gardens was obtained from one hundred middle aged (30-50 years) housewives through direct interview method.

Socio-economic impact on tribals through crop diversification and adoption of modern agro-technologies was also observed by using standardized interview schedules with help of one hundres middle aged (30-50 years) tribal farmers. For this study a well designed questionnaire was developed and pre-tested with help of persistently standardized effect measuring scales by Vyas *et al.* (2014). Primary data was collected with the help of a questionnaire. Two hundred tribal farmers of the selected ten villages were interviewed in the year of 2012-13. The respondents were interviewed in their houses, farm and at gram panchayat. These places were selected for the convenience of respondents and for creating congenial situation, where both sides (researcher and respondent) exchanged their views frankly and informally by the help of local personnel (village level workers). The questionnaire mostly contained closed end questions and it was designed in English but the questions were asked in Hindi and local language (Marwari) in order to avoid confusion.

During interview every effort was made to explain the questions and its purpose, to collect correct and reliable information. For supporting the results of primary data, the secondary information was used being collected from published and unpublished sources. After collection of data, a tally sheet was prepared which facilitated the enumeration of answer of each question. By using descriptive statistics the data was analyzed by calculating simple percentages. The data was arranged in tables in very simple manner for clarity.

Socio-economic profile of tribal dominated area of district Sirohi

Most of the farmers were living in isolation and having poor health and socio economic status. They were

Table 2. Socio-economic profile and salient features of tribal dominated villages of district Sirohi

Name of cluster	Name of tribal dominated villages	Salient features of tribal dominated villages
Agro-climatic Zone IVa i.e. "Sub humid southern plain and Aravali Hills		
Aburoad cluster	Moongthala, Jhamar, Fatehpura, Chandella, Dhamsara	Total population: 184610; Geographical area: 86087 ha. Agricultural land : 15168 ha; Irrigated land: 7020 ha Unirrigated land : 8148 ha (56%); Average rainfall: 634mm Livestock population: 127396 (Cattle: 40580, Buffalo: 17076, Sheep: 6242, Goat: 63498). ***Prevailing crop*** • Kharif : Maize, castor, fennel, green gram • Rabi : Wheat, mustard, gram Number of families: 1434 (ST = 85 %) Seed Replacement Rate : Maize 14%, wheat- 9% and gram 12% Milk productivity: Cow 1.25 litre and buffalo1.85 litre day^{-1} animal^{-1} Few farmers growing vegetables with very less productivity **Average income of farm family ₹ 17235 annum^{-1}**
Pindwara Cluster	Moori, Kerlapadar, Amli, Talabfali, Rajpura	Total population: 205568; Geographical area 113609 ha. Agricultural land: 32988 ha. Irrigated land: 11617 ha. Un-irrigated land: 21371 ha. (80%); Average rainfall : 560mm Livestock population: 197944 (Cattle: 51354, Buffalo: 28418, Sheep: 35788, Goat: 82384). ***Major crop*** • Kharif : Maize, green gram and castor • Rabi : Wheat, mustard and gram Number of families: 1188 (ST= 82 %) Seed Replacement Rate: Maize 11%, wheat- 15% and gram 7% Milk productivity: Cow 1.4 litre and buffalo 2.5 litre day^{-1} animal^{-1} Few farmers growing vegetables at homestead levels **Average income of farm family ₹ 14250 annum^{-1}**

devoid of basic facilities like hygienic house, means of recreation and education. Hence, there were no means of securing nutritional status and allocating resources for the economic and nutritional upliftment of rural and tribal masses (Table 2).

RESULTS AND DISCUSSION

Development of region specific integrated farming system models

Introducing crop diversification in prevailing farming system as the district has vast potential for cash crops, vegetables, flowers and fruit crops. The agro-ecological conditions of the areas are suitable for diversification of traditional agriculture to more remunerative farming. The date presented in Table 3 those farmers adopt model 7 (Crop + cash crop + vegetable + flower + fruit production with retail marketing of fruit and vegetables) were earn ₹ 5.30 lakh year^{-1} with maximum B: C ratio (4.38) and generate 1800 mandays year^{-1} employment opportunities at farmers field from 2 hectare cultivable land, whereas under model-1 (crop production) the farmers earn annually ₹ 1.22 lakh with lowest benefit cost ratio (2.03) and minimum employment opportunities generated (480 mandays). Bhardwaj *et al.*, (2015) reported that the horticulture based integrated farming system is more remunerative and maximum utilization of available resource for generate on farm employment opportunity. Bhardwaj, (2011); Bhardwaj and Kumar (2012) also observed similar results. For promoting adoption of new technologies in operational area organized different activities like awareness camps, on and off farm trainings on vegetable production and exposure visits in different vegetable growing areas.

Table 3. Region specific integrated farming system models for partially irrigated arid condition in 2.0 hectare through crop diversification

Models	Major component	Cost of cultivation (₹ in lakh)	Gross return (₹ in lakh)	Net return (₹ in lakh)	Benefit: cost ratio	Generate employment
Models-1	*Rabi*- wheat, mustard, barley, gram etc. *Kharif*- Maize, bajra, green gram, cluster bean etc.	0.60	1.82	1.22	2.03	480 Mandays
Models-2	Fennel- 0.5 ha Castor -0.5 ha Cotton- 0.5 ha Other crop- 0.5 ha	0.78	2.85	2.06	2.64	780 Mandays
Models-3	*Rabi*-Tomato, brinjal, colecrop, pea etc. *Kharif*- Okra, cucurbits *Zaid*- Okra, chilli, cucurbits	1.68	6.80	4.12	3.04	1250 Mandays
Models-4	Crop-0.6 ha Cash crop-0.7 ha Vegetable -0.7 ha	1.02	2.85	2.91	2.86	850 Mandays
Models-5	Crop-0.5 ha Cash crop-0.5 ha Vegetable -0.5 ha Fruit plants-0.5ha	0.90	4.32	3.33	3.75	1170 Mandays
Models-6	Crop-0.4 ha Cash crop-0.4 ha Vegetable -0.4 ha Fruit plants-0.4ha Flower -0.4 ha	1.05	5.07	4.01	3.80	1500 Mandays
Models-7	Crop-0.4 ha Cash crop-0.4 ha Vegetable -0.4 ha Fruit production-0.4ha Flower -0.4 ha with retail marketing	1.20	6.50	5.29	4.38	1800 Mandays
S.Em ±		**0.075**	**0.037**	**0.026**	**0.250**	**13.56**
P<0.05		**0.224**	**0.111**	**0.079**	**1.010**	**54.77**

Introduction of Vegetables Cultivation

Maximum farmers have small land holding with meagre irrigation facility. Introduction of vegetable cultivation for maximum utilization of available water and land recourse. Farmers fetched very high returns from hybrid okra, tomato, brinjal, chilli, and bottle gourd cultivation with retail marketing in local market of their produce. The tomato and okra cultivation revolutionaries the socio-economic conditions of farming community. Presently (2012-13) farmers are earning ₹ 40000 to 100000 from just 0.25 ha area and earlier they hardly earned ₹ 5000 to 8000 from the same piece of land. It is reported that (Table 4) before intervention in the year of 2008 only 7.0% farmers in *rabi* and 11.0% farmers in *zaid* season grow vegetables, there is no vegetable production in *kharif* season. Whereas, at the time last observation (2012-13) the maximum farmers were grow vegetables in different season *e.i. rabi* (37.80%), *kharif* (28.90%) and *zaid* (48.50%) at commercial levels. Similar results were also observation by Bhardwaj *et al.*, 2014a and Bhardwaj *et al.*, 2015.

Establishment of Small Orchards

Establishment of large fruit orchards is impossible because of limited resources and small land holding size in the area, whereas the fruit production and establishment of orchard is a beneficial sustainable development in agriculture. So establishing small pomegranate orchards (50 plants orchard^{-1}) harnessing available resources and climatic conditions with drip irrigation method. Upto now (2012-13) total 92 orchards of lime were established in the district. This intervention alone has made major sustainable impact on livelihood improvement of the farmers and 50 farmers earn ₹ 22.0 lakh from pomegranate orchard, 127 farmers earn ₹ 105.0 lakh from lime orchard in district Sirohi with nutritional security of the farm family members (Table 5) through papaya- lime based kitchen gardening. Similar results were also reported by Bhardwaj *et al.*, (2013a) and Bhardwaj *et al.*, (2014a).

Popularization of Papaya Cultivation: Made Farmers Economically Empowered

For early return from fruit crops, popularize papaya-lime inter cropping system for sustainable earning from fruit cultivation. Farmers showed keen interest in papaya cultivation due to favourable climatic and soil condition. Looking into their interest, KVK, Sirohi formed a core group of scientists for taking care of farmers from soil testing to establishment of orchards. As an outcome, more than 220 orchards of papaya have been established in the district. Further, for quality-planting KVK raised 174080 saplings of papaya cv. Red Lady 786 in intensive supervision and provided to farmers @ ₹ 10 plant^{-1} upto

Table 4. Adoption per cent of vegetable cultivation in tribal area of district Sirohi

Season	Cumulative increase in adoption per cent of vegetable cultivation				
	2008-09	2009-10	2010-11	2011-12	2012-13
Rabi	7.0	13.25	17.26	26.40	37.80
Kharif	—	5.35	9.12	15.60	28.90
Zaid	11.0	17.6	23.45	28.50	48.50

Table 5. Crop diversification by establishment of fruit orchards in tribal dominated areas

S.N.	Fruit plants	Name of variety	Purpose	No. of beneficiaries	Monitoring return (₹)	Horizontal expansion %
In Pindwara and Aburoad cluster						
1	Pomegranate (50 orchards with 50 plants = 2500 plants)	Sinduri and Arkita	Nutritional and economical security	50	22.0 lakh	7.5
2	Lime (2 plant in each family = 1250 plant)	Kagzi	Nutritional security of tribal's	625	5.0 lakh	11.0
In district Sirohi						
3	Lime (10,000 plants)	Barhamasi	Commercial production	127	105.0 lakh	15.0

2013 and from 2014 @ ₹ 15 plant^{-1} and ₹ 17.69 lakh revenue generated for Revaluing Fund of KVK. The average revenue generated by the farmers is ₹ 469.35 lakh in last four years from 2009-10 to 2012-13 through papaya cultivation in district Sirohi (Table 6). Sanyang *et al.,* (2009) reported that the production of fruits and vegetables by tribals plays significant role in the socio-economic development of the country as provider of food, foreign exchange earner, employer and income generator.Similarly, growing of papaya in tribal dominated area significantly increase fruit intake and annual income of the farmers (Bhardwaj, 2014; Bhardwaj and Nandal, 2015).

Introduction of Primary Processing of Fennel

Fennel is a leading spice crop of the district as well as tribal dominated villages. KVK scientists worked as a team on primary processing of spices and organized training programmes for tribal women with an aim to develop their skills regarding harvesting of umbel at premature stage, grading of produce (A, B and C grades), drying of fennel in modified shade house made up of local indigenous material to obtain desired green color and flavor, threshing and packaging in polythene lined bags for retaining colour and texture. The technologies have spread in the district and 52 per cent farmers have adopted primary processing. This has resulted into an epoch of additional earning of ₹ 29.0 crores in the district (Table 7). Bhardwaj *et al.*, (2014b) observed that those farmers adopt primary processing of fennel earn 100 to 150 per cent more remuneration, generate on farm employment opportunities and significantly reduce hidden unemployment condition and also improve in living standard of farmers. Bhardwaj *et al.*, (2013b), also reported similar results.

Retail Marketing of Vegetables by Tribal Women for Continuous Earning

At the time of field survey it is also observed that the retail marketer tribal women earn more than ₹ 850 to 1459 day^{-1} whereas the vegetable growers earned ₹ 250 to 650 on day^{-1} basis (Table 8). It is observed that the average whole sale market rate of vegetable is ₹ 10.67 kg^{-1}, whereas retail rate is just double ₹ 21.40 kg^{-1}. Average daily sale of different vegetable is 204 kg and retailer generated ₹ 1984.0 day^{-1} out of which the average expenditure on raw material and transpiration cost is ₹ 500.0 to 550.0 day^{-1} basis. Similar results were also observed by Nandal and Bhardwaj (2012).

Table 6. Preparation of quality planting material of papaya for plantation at farmers

Years	Papaya varieties				Total revenue generated for R.F. of KVK (₹ in lakh)	Number of beneficiaries	Revenue generated by farmers (₹ in lakh)
	Red lady	Market rate / plant (₹)	Coorg honey dew	Market rate / plant			
2009-10	22967	10.00	5773	5.00	2.58	35	70.27
2010-11	22085	10.00			2.20	39	67.58
2011-12	67001	10.00			6.70	72	204.38
2012-13	38346	10.00			3.83	42	127.12
2013-14	23681	10.00			2.36	32	—
Total	**1,74,080**		**5,773**		**17.69**	**220**	**469.35**

Table 7. Monetary return of primary processing of fennel in district Sirohi

S.N.	Grade	Rate ₹ per kg	Percent produce	Earning per ha (Lac.)
1	A	130-170	59-65	2.04
	B	115-135	19-25	0.60
	C	55-75	13-19	0.22
		Total		2.88
2	Graded	131.0	22	2.88
3	Ungraded	65.0	22	1.65
Difference in income due to secondary agriculture per ha.				1.23
Total area under adoption of primary processing				2354 ha
Total additional income due to primary processing in district Sirohi (1.23 × 2354 ha.= 2895)				29.0 crores

The average annual income of selected farmers irrespective of their categories increased upto 103.0 per cent (₹ 1.32 lakh annum^{-1}) by vegetable growing, 43.0 per cent (₹ 0.93 lakh annum^{-1}) by retail marketing of vegetables and 323.0 per cent (₹ 2.75 lakh annum^{-1}) by adoption of vegetable growing with retail marketing of graded produce in local markets as compared to returns from other crops cultivated by farmers. Similarly a significant increase in generate employment opportunity at village level was also reported (Table 9). There is significant change in average annual income, employment generation and farmers build cemented house and purchase utility facilities like radio, TV, CD player, bed, store bin, etc. maintain bank balance upto ₹ 25000 round the year by adoption of retail marketing of fruit and vegetables in local market (Nandal and Bhardwaj, 2012). Similar results were also observed by Bhardwaj (2011).

Change in input Use and Increase in SRR for Higher Production

Farmers realized the importance of using HYVs/ hybrids and following integrated nutrient management clubbed with plant protection measures, which are the basic requirements for increasing quality yield to fetch good market price. The Seed Replacement Rate and fertilizers used in major horticultural crops like tomato, brinjal, cucurbits, cole crops, okra, fennel and papaya is drastically increased. At time of observation (2012-13) maximum farmers are used hybrid seed of tomato (95%), brinjal (90%), chilli (89%), cucumber (88%), okra (92%), and cole crop (80%) whereas at time of baseline survey only 30-65 per cent farmers are used hybrid seed of vegetables (Table 10). It is also observed that the fertilizer application in different horticulture crop like fennel, cumin and vegetables also increased upto 20-50 per cent during last four years. Similar results were also reported by Bhardwaj *et al.*, 2014a and Bhardwaj *et al.*, 2015.

Modern Technologies for Enhancement in Productivity of Major Horticultural Crops

Tomato, brinjal, chilli, cucurbits, cole crops, okra, fennel, cumin, onion, papaya, pomegranate and lime are the major horticultural crops of the district. The productivity of these crops were less in the tribal villages as well as district prior to intervention of the KVK due to non-use of improved seeds, poor nutrient management, ignorance about plant protection measures, poor knowledge and negative attitude about adoption of modern agro-technologies. Data depicted in Table 11, at time of last observation (2012-13) maximum farmers adopt the modern agro-technologies (used hybrid seed, adopt pair row plantation method, raised bed plantation, staking of plants, adopt INM, IPM, drip irrigation, use PGRs, virus free plant and grow off season vegetable in small poly-houses) and comparative increase in

Table 8. Additional income through retail marketing of vegetables in local market

Vegetables	Av. whole sale market rate (₹/kg)	Av. retail market rate (₹/kg)	Av. daily sale of vegetable in local market (Kg)	Additional income by retail marketing (₹/day)	Per cent increase in income
Tomato	8.0	20.0	25.0	300.0	150.00
Chilli	12.0	26.0	17.0	238.0	116.60
Brinjal	7.0	18.0	15.0	165.0	157.10
Cucurbits	11.0	18.0	35.0	245.0	63.60
Cauliflower	13.0	25.0	20.0	240.0	92.30
Cabbage	7.0	18.0	20.0	220.0	157.10
Pea	15.0	23.0	30.0	240.0	53.30
Okra	17.0	35.0	12.0	216.0	105.90
Radish	6.0	10.0	30.0	120.0	66.70
Total/Average	**10.67**	**21.40**	**204**	**1984.0**	**100.50**
Average additional cost of retail marketing = ₹ 500-550 day^{-1}; Average net earning = ₹ 1459 day^{-1}					

Table 9. Effect of retail marketing on income and employment opportunity

Essential facilities	Respondents N = 80 (20 from each group)			
	Field crop growers	Vegetable growers	Vegetable retail marketers	Vegetable growers with retail marketers
Average annual income	65000	132000 (103%)	93000 (43%)	275000 (323%)
Increase in working hours hectare^{-1}	324	421 (30%)	470 (45%)	525 (62%)

productivity of major crops are as in tomato (71.1%), okra (32.0%), brinjal (53.21%), cucurbits (22.70%), cauliflower (17.14%), cabbage (14.44%), green chilli (34.34%), onion (17.20%), papaya (92.30%), lime (55.41%), fennel (125.0%) and cumin (30.77%). Bhardwaj and Agrawal (2014) reported that the modern agro-technologies like pair row plantation, raise bed plantation, use of PGRs, INM and IPM were major tools for significant increase in yield and quality of fennel and vegetables. Similar results were also reported by Bhardwaj *et al.*, (2014a); Bhardwaj *et al.*, (2015).

Horizontal Expansion of Technologies

During initial stage (2008-09) the area under horticulture crops was less than 675 hectare in Sirohi with very low productivity of all the crops. After introducing crop diversification with vegetable and papaya cultivation and adopting improved production technology, the total area under fruits and vegetables has reached upto 1850 hectare in 2012-13 with major area covered by tomato, chilli and okra in vegetables and papaya and lime in fruits. The productivity of the vegetables and papaya has increased nearly 100 to 250 per cent more during reporting years (2008-09 to 2012-13). Tomato, okra, bottle gourd cultivation is gaining popularity and farmers have adopt improved practices and cultivating crop in pair row trench method on raised bed with stacking. Due to farmers friendly nature for increasing production, productivity and quality of fruits and vegetables, the numbers of technologies are largely spread among farmer community.

Use of hybrid seeds (79.25%), raise bed plantation of tomato (43.50%), staking in tomato (35.60%), change crop geometry in papaya (95.50%), integrated nutrient management in vegetables (11.0%), primary processing of fennel (52.0%), off-season vegetable cultivation in open field (2.5%), marigold-papaya-lime cultivation (5.0%), pomegranate orchard plantation (5.5%), papaya cultivation (33.3%), grading and packing of fruits (12.5%), micro-irrigation (5.5%) and retail marketing of vegetables (6.5%) was accepted and adopted by the farmers as per their need (Table 12). Similar results were also reported by Bhardwaj *et al.*, (2013a); Bhardwaj *et al.*, (2014a) in tribal dominated area of district Sirohi.

Nutritional Security through Establishment of Lime-papaya based Nutrition Garden

The tribal people especially women and children of operational areas were severely malnourished along with multiple nutrient deficiency disorders due to ignorance about importance of fruits and vegetables in their diets. Only some tribal families were broadcasting seeds of okra, ridge gourd, bottle gourd, muskmelon, watermelon in between rows of cereal crops during *kharif* season for their home consumption. The concept of nutrition-garden was popularized along with cultivation of horticultural crops among the poor tribal farmers by integrating production of required seasonal vegetables for continuous supply round the year. For better nutritional security planted papaya + lime plants (5 + 2) at near source of irrigation or backside of their house for establishing nutrition gardens as an initiative to improve

Table 10. Change in input use in agriculture in tribal dominated areas of district Sirohi

S. No.	Items	Seed Replacement Rate (%)					
		2008-09			2012-13		
1.	Use of HYV/Hybrid varieties						
	i. Tomato	65			95		
	ii. Brinjal	45			90		
	iii. Chilli	30			89		
	iv. Cucurbits	35			88		
	v. Cole crops	36			80		
	vi. Okra	45			92		
	vii. Fennel	42			97 Local cultivar (Abu Saunf)		
	viii. Cumin	15			38		
	ix. Papaya (Red lady)	NIL			95		
2.	Use of fertilizers (NPK) (nutrient)	Fertilizer use (kg/ha)					
		N	P	K	N	P	K
	i. Fennel	30	40	00	60	30	20
	ii. Cumin	25	20	10	40	20	20
	iii. Vegetables	130	95	30	145	120	30

Table 11. Modern agro-technologies for enhancement in productivity of important horticultural crops in district Sirohi

Name of crop	Productivity in 2008-09 (Qt. ha^{-1})	Productivity in 2012-13 (Qt. ha^{-1})	Per cent increase	Adopted modern agro-technologies
VEGETABLES				
Tomato	263.0	450.0	71.10	• Used hybrid, high yielding varieties • Adopted pair-row plantation method • Raised bed and staking of plants • Off-season cultivation in poly-houses • Adopted INM and IPM methods • Use of PGRs and timely harvesting of fruits
Okra	86.0	113.5	32.00	
Brinjal	163.5	250.5	53.21	
Cucurbits	185.0	227.0	22.70	• Adopted INM and IPM methods • Used hybrid varieties • Off-season cultivation in poly-houses • Trench method of plantation • Used PGRs for high yield
Cauliflower	175.0	205.0	17.14	• Used hybrid varieties • Pair-row plantation on raise beds • Adopted INM and IPM methods • Improved nursery management • Drip irrigation method
Cabbage	190.5	218.0	14.44	
Green chilli	83.0	111.5	34.34	
Onion	220.5	260.0	17.20	• Seed replaced by high yielding varieties • Plantation on raise beds • Adopted INM and IPM methods • Timely transplanting • Introduce *kharif* onion production
FRUIT PLANTS				
Papaya	390.0	750.0	92.30	• Plantation on raise beds • Used hermaphrodite, high yielding, long self-life verities (Red lady-786) • Changed crop geometry for reducing cost of cultivation • Intercropping with lime-papaya-marigold • Adopted INM and IPM methods
Lime	120.0	186.5	55.41	• Used virus free, high yielding planting material • Adopted INM and IPM methods • Adopted bahar treatment for off-season production • Used PGRs for increasing fruit set
Pomegranate	New introduction	75.0	-	
SPICES				
Fennel	1000	2250	125.00	• Used high yielding local cultivar • Adopted pair-row plantation method • Adopted INM and IPM methods • Adopted primary processing for quality production
Cumin	390	510	30.77	• Used improved high yielding wilt resistant verities (GC-4) • Adopted line sowing method • Adopted INM and IPM methods • Use of herbicide for weed control • Adopted primary processing for quality production

their nutrition. Each household was provided with a kit of vegetable seeds of cucumber, okra, ridge gourd, bottle gourd, cluster bean, tomato, chilli, spinach, pea, radish, cabbage, cauliflower, carrot and fruit plants like papaya etc. by the KVK once and then after that they were asked to follow in a similar way. These families consumed their organically grown vegetables and fruits which helped to improve their nutrition and further surplus produce was sold in the village market fetching small income (₹ 1200-1500 annum^{-1}). Papaya based nutrition garden significantly improve nutritional status of the rural population and it also provide means of recreation in life style of tribals (Bhardwaj and Nandal, 2015). Similar results were also reported by Bhardwaj *et al.*, (2013a); Bhardwaj *et al.*, (2014a) in KVK adopted villages of district Sirohi.

Socio-economic impact on tribals through crop diversification and adoption of modern agro-technologies

The overall economic profile of selected households in the tribal villages revealed that sources of income of marginal farmers were from agricultural produce, vegetables, flowers, fruits, labour and subsidiary occupations. During 2008-09 the average income of farm household was ₹ 14235.0 annum^{-1} in Pindwara cluster, ₹ 17235.0 annum^{-1} in Aburoad cluster and ₹ 18500 annum^{-1} in district Sirohi. So the average income of marginal farm household comes out to be ₹ 16656.70 annum^{-1} (Table 14). Based on analysis of realistic agricultural scenario in these villages it was observed that crop diversification based on horticulture crop model with modern agro-technologies the income of the farmers are increase manifolds. Consequently at the time of last observation (2012-13) the average annual income of farm household is ₹ 35750.0 annum^{-1} in Pindwara cluster, ₹ 47500.0 annum^{-1} in Aburoad cluster and ₹ 36,300.0 annum^{-1} in district Sirohi. So the average income of marginal farm household comes out to be ₹ 39850.0 annum^{-1} (Table 14). A significant increase in income and living standard by adoption of horticulture based IFS models and crop diversification (Bhardwaj, 2011; Bhardwaj *et al.*, 2013a).

Results revealed that refinement in technologies through extension, demonstration, adoption and popularization of "Region specific Integrated Farming System models" based on horticulture crops in tribal dominated villages of district Sirohi by vegetable and papaya cultivation gave lucrative returns in comparison to field crops. Farmers fetched ₹ 1.57 to 2.85 lakh ha^{-1} from vegetables cultivation, ₹ 2.89 lakh ha^{-1} from marigold production and ₹ 7.50 lakh ha^{-1} in two years from papaya cultivation, whereas field crop gave only ₹

Table 12. Different modern agro-technologies are disseminated in district Sirohi

S.N.	Name of the technologies	Horizontal expansion (%)	Area covered under technology*	Per cent increase in yield
1	Use of hybrid seed/HYV	79.25	1129.3 ha (1425 ha)	53.0
2	Raise bed plantation of tomato	43.50	339.30 ha (780 ha)	10.23
3	Stacking in tomato	35.60	277.70 ha (780 ha)	32.40
4	Change crop geometry in papaya (2.5 × 1.6 m)	95.50	360.0 ha (375 ha)	17.50
5	Integrated nutrient management in vegetables	11.00	156.75 ha (1425 ha)	7.35
6	Primary processing in fennel (Sirohi district)	52.00	2354 ha (4708 ha)	₹ 29 crores
7	Off-season vegetable cultivation in open field	2.50	35.60 ha (1425 ha)	- 11.80
8	Marigold-papaya-lime cultivation technology	5.00	10.0 (37 ha)	—
10	Pomegranate orchard plantation	5.50	20.62 ha (375 ha)	7.50
11	Lime plantation	4.50	16.87 ha (375 ha)	5.50
12	Papaya cultivation	33.30	125 ha (375 ha)	14.70
13	Grading and packing of fruits	12.50	—	—
14	Micro-irrigation	5.50	105 ha	12.50
15	Retail marketing of vegetables	6.50	92.60 ha (1425 ha)	₹ 135 lac.

19,000 to 30,000 ha^{-1} year^{-1}. Similar results were also reported by Bhardwaj *et al.*, (2015) in tribal dominated area of district Sirohi.

In last five years (2008 to 2013) have shown that the farmers adopt modern technologies based on vegetable and fruit crop growing and retail marketing of vegetables have constructed pucca houses (38), purchased utility facilities (83), dugged wells (57), purchased improved farm equipments and machineries (66), improved hygiene and sanitation of their houses (36), started

Table 13. Establishment of nutrition garden in tribal dominated area

Season	Name of vegetables	Average production of vegetables (kg family^{-1})	Market value of vegetables (₹)	Average consumption of vegetables (kg family^{-1})	Average consumption of vegetables (kg family^{-1}) prior to nutrition garden	Nutritional status of family/ additional consumption (kg year^{-1})
Rabi	Radish, cole crops, bean, pea, spinach, carrot, tomato, brinjal	85.00	923.0	75.0	18.50	Improved (56.5)
Kharif	Cucurbits, okra, tomato, cluster bean, chilli	68.50	785.0	65.0	15.50	Improved (49.5)
Zaid	Cucurbits, okra, tomato, cluster bean, chilli	55.50	620.0	63.0	23.5	Improved (49.5)
Papaya	5 plants round the year	150.0	1500.0	125.0 (25.0 kg sold in market)	Nil	Improved (100.0)
Lime	2 plants round the year	80.0	1200.0	20.0 (60.0 kg sold in market)	Nil	Improved (20.0)

Table 14. Increase in average income of farm family

Name of cluster	Average income (₹ annum^{-1} 2008-09)	Average income (₹ annum^{-1} 2012-13)	Per cent increase
Pindwara	14235.0	35750.0	151.0
Aburoad	17235.0	47500.0	175.6
District Sirohi	18500.0	36300.0	96.20
Average	**16656.70**	**39850.0**	**140.90**

Table 15. Socio-economic impact of adoption of modern agro-technologies and crop diversification on respondent groups from 2008-09 to 2012-13 (One hectare cultivable land)

Essential components	Respondents (n=200)	
	No adoption of modern agro-technologies (n=100)	Adopt of modern agro-technologies (n=100)
Average annual income (₹)	62500.0	285000.0
Employment generation (mandays/ha)	240	900
Construction of pucca house	12.0	38.0
Utility facilities (Radio, TV, CD player, bed, storage bin etc.	17	83
Bank account with more than ₹ 10000 balance	25	92
Children education in good school	17	63
Improved agricultural implements	23	66
Interaction with extension workers for different field problems	42	72
Personal transportation facilities (cycle, motorcycle, car)	18	53
Irrigation facility (Dugged wells)	22	57
Understanding about urban society	13	32
Awareness about health and hygiene	19	36
Participation in social works	19	49
Change in behaviour and thought	11	22
Telephone and Mobile facilities	33	87
Women participation in decision-making	17	39

sending their wards to good school (63), purchased motor bikes (53) and television sets (87) with improved income vis-a-vis social status. These families have become examples for others who are eager to follow them (Table 15). Significant change in socio-economic condition of tribal farmers through adoption of modern agro-technologies by way of increase production and quality of different crops (Nandal and Bhardwaj, 2012). Similar results were also reported by Bhardwaj *et al*., 2015).

CONCLUSION

Remarkable change in agriculture production due to dissemination of horticulture based modern technologies to the rural and tribal farming community of district Sirohi. Diversification in agriculture has been achieved with accelerated vegetables and fruit cultivation and proved economically viable intervention in tribal dominated areas. It has not only enhanced household income but also provided on and off-farm employment opportunities for small and marginal farmers, thereby reducing migration. It was observed that due to adoption of modern agro-technologies based on horticulture (cultivation of vegetables, flowers and fruits with other crops) with livestock and other subsidiary enterprises income of the landless, marginal and small farmers increased 100 to 250 per cent more. Prior to adoption of the horticulture based model, income from vegetable cultivation was nil as small and marginal farmers were earning average income of ₹ 19000 to 30000 from agricultural activities only, whereas after adoption of modern agro technologies based on horticulture farmers started earning more than ₹ 1.5 lakh to 2.85 lakh annum^{-1} ha^{-1}. The tribal farmers have constructed pucca houses, dig wells, ensure better cleanliness in house, started giving good education for kids, purchased motor bikes, mobil phone other luxury items, and to enjoy more quality in their day to day life, improved income vis-a-vis social status with modern horticultural technological interventions.

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