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Research Paper

Effect of mixed farming on farm productivity and income in *Kandi* areas of North-Western plains

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ABSTRACT

An on-farm study was carried out during the rainy season (*kharif*) of 2015 to the winter season (*rabi*) of 2017–18 at Samba District of Jammu region to assess the effect of mixed farming production systems on the farm productivity and income. The study indicated enhanced growth of citrus (*Citrus* sp.) along with wheat (*Triticum aestivum* L.) and Indian mustard (*Brassica juncea* L.) grown as intercrops. The increase in fruit yield of citrus after interventions was recorded to the tune of 22, 23 and 24% during first, second and third year of study, respectively, over that before the study. Among all the production systems, fruit yield increased significantly owing to intercrops and it was the maximum (4.92 t/ha) with the citrus associated with the intercropping of wheat and Indian mustard during *rabi* 2017–18. The highest benefit: cost ratio (6.04) was obtained with citrus trees. Maize (*Zea mays* L.)–wheat–fruit–goat was noticed highly profitable production system which fetched highest net returns of ₹210,327.0 and system profitability of ₹576/ha/day followed by pearlmillet (*Cenchrus americanus*)–wheat–fruit–goat system. The maximum employment generation (146 days) was recorded with maize–wheat–fruit–goat followed by pearlmillet–wheat–fruit–goat (125 days) production systems.

Key words *:* Mixed farming system, Citrus, Indian mustard, Wheat, Goat, Productivity, Farm income, Soil fertility

Under gradual shrinking of land holding, it is necessary to integrate land-based enterprizes like fishery, poultry, duckery, apiary, field and horticultural crops, within the biophysical and socio-economic environment of the farmers to make farming more profitable. In this context, mixed farming has great potential to utilize and conserve rainfed area for betterment of poor farmers. Horticulture and small ruminants (sheep and goats) production systems play a vital role in sustenance of livelihoods of rural poor of rainfed agro-ecosystem (Ramana *et al.*, 2011). Cultivation of agricultural crops with fruit trees provides an opportunity for maximum use of land surface and helps it to distribute the risk due to adverse climatic conditions. Intercropping not only generates an extra income, but also helps to check soil erosion through ground coverage and improves the soil physico-chemical condition. Intercropping may be an alternate practice for surmounting low productivity in case of low input low output and small-scale farming systems (Dadabhau, 2014).

Citrus has vast potential in Jammu region of Jammu and Kashmir, as it comprises the highest area under its cultivation, i.e. 8,320 ha, with production of 17.62 million tonnes (DACFW, 2017). Traditionally, intercropping in fruit orchard was practiced under irrigated situation, but with the harvesting of rainwater it was possible to utilize the land unit efficiently by putting it under cultivation of crops, which helped in increasing both production and productivity. In general, farmers develop orchards for fresh fruit production and not consider it as grazing resource. However, small ruminants are primarily maintained on natural pasture lands/wastelands with *in-situ* grazing and the productivity is constrained by the low quality of native grasses as well as the shortage of good-quality forage, especially during the dry season. Hence, it is suggested to develop mixed farming including horticultural and small ruminant systems/models by introducing pasture or foliage component under trees so as to provide nutritious green forage and foliage to small ruminants for getting higher production from unit of land in rainfed areas. Besides, the multipurpose forest trees planted on the borders of the field helped to save land and increase cropping area.

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In Jammu and Kashmir, about 58.0% of the area is rainfed, which is locally called '*Kandi belt*'. It is characterized by water scarcity during the crop-growing season and undulated topography. Economically, the farmers of this area are poor with small holdings. Moreover, the adoption of scientific technologies in the crop production is low because of low literacy, lack of awareness regarding the adoption of modern technologies resulting in low and unstable income besides occasional crop failure. Since, most of the agricultural land is rain dependent, the use of inputs is very important to make farming economically viable in these areas. The focus of agriculture research has to be field oriented, so as to ensure efficient use of resources along with introduction of new varieties and improved production technologies (Singh *et al*., 2018). The present study was, therefore, conducted to assess the effect of mixed farming systems (including fruit crops and small ruminants) with rainwater harvesting on farm productivity and farmer's income in rainfed agro-ecosystems of *Kandi belt* of Jammu region. Such a production system can provide continuity through conservation and improvement of natural resources in the rainfed ecosystem, as well as regular income to meet the diverse needs of the farming family.

MATERIALS AND METHODS

The investigation was undertaken during the rainy season (*kharif*) of 2015 to the winter season (*rabi*) of 2017–18, under rainfed conditions at farmers' field in village Satuah (32°39' N and 74°53' E 332 m above mean sea-level) of Samba district of Jammu region. The experiment was conducted on an existing orchard with citrus as the main crop with maize and pearlmillet followed by wheat and Indian mustard grown as intercrop in the rainy season and winter season, respectively, during the period of experimentation. The soil was sandy loam, with alkaline soil *p*H (8.2) and low in organic carbon (0.20%). The soil was low in available nitrogen (152 kg/ha) and potassium (84.0 kg/ha) and medium in available phosphorus (9.6 kg/ha). The Samba district of Jammu region has a subtropical climate with hot summer, and cold winter seasons. The soil and climate are well suited for the cultivation of fruits and field crops under irrigated and rainfed conditions. During the citrus-growing period (October to March), the experimental site recorded average monthly maximum temperature between 13.0 and 34.3°C and minimum temperature in the range of 2.9 to 20.7°C. The climate of this region is influenced by south-west monsoon in the rainy season and western disturbances in the winter season. An important feature of the rainfall is high variability. The mean annual rainfall of the region is about 1,150 mm, out of which 77.3% of the total annual rainfall is received during the south-west monsoon, from the first week of July to the middle of September and 22.7% is received during winters through western disturbances. Monthly rainfall during the 3 years of study is depicted in Fig. 1.

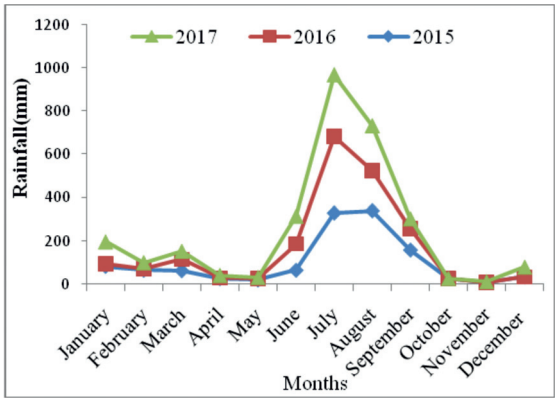

Fig. 1. Rainfall pattern of Samba district during study period

The selected orchard comprised 4-year old citrus trees, planted in an area of about 1.0 ha field, at a distance of 4 m × 4 m. Crops like pearlmillet and maize were taken in the rainy season, whereas wheat and Indian mustard in the winter season were sown in the inter-row spaces of the orchard to meet the food and fodder requirement of the family. The intercrops were sown 1 m away from the fruit trees on either side of the trunk. Pearlmillet and maize sowing was done with the onset of monsoon (in June/July), whereas Indian mustard and wheat crops were sown subsequently with residual soil moisture during the succeeding winter season. The care and management was done using standard package and practices for the components crops and fruit trees.The calculations of system productivity and system profitability were done as per Devasenapathy *et al*. (2008). The economic returns were calculated using standard statistical tools as per the prevailing market rates of the grain, seeds, straw, small ruminants and fruits in the respective years.

The system productivity of various components of farming systems either alone or in conjunction with fruits and small ruminants grown and reared during the year (kg/ha/day) were calculated in term of maize-equivalent yield (MEY) as:

$$MEY = \frac{\Sigma\, Yi \times Pi}{P\,(p)}$$

where: MEY, maize equivalent yield; Yi, yield of different crops/components;

Pi, Price of respective crops/components; P(p), Price of Maize crop

Similarly, system profitability (₹/ha/day) was calculated as:

$$\text{System Profitability} = \frac{\text{Net returns/ha/year}}{365}$$

A rainwater-harvesting structure was prepared by digging at the farmer's field using excavating JCB machine in a trapezoidal shape and was lined with polylining material subsequently. The pipes were fitted for collection of the run off in the pond. The rainwater collected in the pond, during the rainy season was utilized for providing life-saving irrigation to field crops and fruit trees as and when required to save the crop from failure (Fig. 2).

Fig. 2. Water harvested in the pond

Benchmark survey was undertaken to understand the existing farming practice, cropping systems, yield of crops, animal reared and various production constraints. Based on the production constraints identified from benchmark survey, suitable interventions for fruit crop, field crops and goat were undertaken. Interventions taken at the farm included use of certified seed of varieties recommended for the region, complete package and practices like fertilizer doses and plant-protection measures were adopted. Crops were sown in lines in the inter-row spaces of trees (Fig. 3). The bio-fertilizers and fungicides were used before sowing of crops following standard procedures. Application of recommended dose of fertilizers and manures to the fruit trees as per recommendations as per age besides the foliar application by micronutrients was done during the study period.

Two numbers of goats were also raised at the farm (Fig. 4). Generally, goats thrived by grazing on natural pastures. Tree foliage as nutritious green fodder and foliage were provided along with concentrates for getting higher goat production. Besides this, deworming and vaccination was also done once in 3 months.

RESULTS AND DISCUSSION

Crop yield and system productivity

The interventions in the existing orchard were started from winter season of 2015–16. Therefore, crop data from the winter season of 2015–16 to 2017–18 were presented in this study. Grain yield data presented in Table 2, clearly

Fig. 3. Wheat crop raised in the interspaces of orchard

show the effect of agronomic interventions on crops, viz., wheat, Indian mustard, maize, pearlmillet and maize + moong [*Vigna radiata* (L.) R. Wilczek] yield. Average grain yield of different crops with interventions recorded increase of 34.0 (wheat), 32.0 (Indian mustard), 50.0 (maize) and 48.0 (pearlmillet) per cent, respectively, over plots without interventions. This increase in yield of field crops may be attributed to irrigations given with harvested rainwater collected as run-off in the pond at the farmer's field. Also, interventions like use of hybrid seeds, recommended dose of fertilizers, timely pest management played a key role in enhancing the farm yields of different crops. This enhancement in the crop yields provided additional income (over the income obtained just by selling fruits from the orchard) to farm family as depicted as net returns besides providing additional days of employment to them (Table 3). The additional benefits from the cultivation of these crops helped farmer to meet his small revenue demands. Ramana *et al*. (2011) and Dadabhau (2014) reported similar benefits of intercropping in fruit trees which

Fig. 4. Goats reared at the farm

provided additional income to the small and marginal farmers. Among the different production systems, the maximum system productivity was recorded in maize–wheat–fruit–goat system where highest system productivity (15.21 in terms of maize-equivalent yield) was recorded after the imposition of scientific interventions in comparison to before scientific interventions where the system productivity was found to be lower (9.61 t/ha) and was followed by maize–Indian mustard–fruit–goat system with corresponding values of 15.02 and 9.42 t/ha respectively. This increase in the system productivity may be attributed to adoption of the scientific interventions like use of certified seed of varieties recommended for the region, supply of life-saving irrigation through rainwater harvesting, adoption of complete package and practices namely recommended fertilizer doses, plant-protection measures, line sowing, use of biofertilizers, application of recommended dose of fertilizers and manures to the fruit trees as per age of tree and foliar application by micro-nutrients besides deworming and vaccination of small ruminants which resulted in increased productivity of the components of the production systems as compared to the systems where no interventions were adopted (Table 2).

Income benefits from citrus fruit trees and small ruminants

The data presented in Table 1 showed increase in fruit yield after adoption of agronomic interventions, being of 22, 23 and 24% during the first, second and third year of experimentation, respectively. Similarly, the extent of increase in terms of benefit: cost ratio was 5.5, 6.2 and 6.4 in the first, second and third year, respectively, as compared to lower benefit : cost ratio of 4.68, 5.32 and 5.60, respectively, in plots when no interventions were taken. However, after 3 years of study, the fruit yield showed an increase of 36.0% with cultivation of crops as intercrops with interventions than the yield obtained in the first year in comparison. Fruit production was markedly improved by growing intercrops. The production of the citrus fruits increased as result of growing of intercrops which might have improved the fertility status of the soils owing as the manure and fertilizers applied to intercrops were also utilized by citrus trees, as there was no physical barrier between the root-systems of intercrops and trees. The increase in the fruit yield was the maximum during the winter of 2017–18. The reason for increase in fruit production under mixed farming can also be attributed to synergistic effect of the good crop husbandry during the crop-growing season which may have resulted in lower insect and disease incidence in the citrus plants.

The farm income was augmented by rearing of goats in conjunction with the component crops and fruit trees. Goat rearing involved meager resources and expenses on their vaccination, de-worming and concentrate (Table 4). The

Table 1. Comparison of crop yield and economics in the mixed farming before and after interventions

	Before intervention					After intervention					
Cropping season and crops	Grain/fruit yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio	Grain Yield (t/ha)	Straw yield (t/ha)	Irrigations given with collected rain water	Input cost/ cost of cultivation (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Winter season 2015-16											
Wheat	2.05	3.25	17,510	29,096	1.66	2.78	4.55	-	22,305	41,538	1.86
Indian mustard	0.82	2.46	11,432	18,088	1.58	1.11	2.94	-	14,712	25,248	1.71
Fruit trees	2.95	-	12,990	60,810	4.68	3.61	-	-	13,846	76,354	5.5
Rainy season 2016											
Maize	2.25	5.06	17,700	31,445	1.77	3.26	7.18	1	23,771	46,995	1.97
Maize + greengam	-	-				2.77+ 0.24	6.04	1	27,641	47,186	1.71
pearlmillet	1.34	3.75	12,605	20,352	1.61	2.04	6.73	-	17,466	36,281	2.09
Winter season 2016-17											
Wheat	1.85	3.05	17,510	25,075	1.43	2.42	4.15	1	22,305	34,122	1.58
Indian mustard	0.76	1.96	11,432	15,540	1.09	0.98	2.62	1	14,712	20,568	1.40
Fruit trees	3.60		14,256	75,944	5.32	4.43	-	1	15,236	95,464	6.2
Rainy season 2017											
Maize	2.37	5.18	17,700	33,627	1.89	3.68	7.34	2	23,771	53,817	2.26
Maize + greengram	-	-				2.82 + 0.26	6.2	1	27,641	49,661	1.79
pearlmillet	1.50	3.96	12,605	23,455	1.85	2.17	6.78	-	17,466	38,380	2.19
Winter season 2017-18											
Wheat	2.14	3.38	17,510	31,444	1.77	2.90	4.70	2	22,305	44,085	1.97
Indian mustard	0.88	2.63	11,432	20,248	1.78	1.18	3.14	1	14,712	27,768	1.88
Fruit trees	4.10	-	15,522	86,978	5.60	4.92	-	1	16,548	106,452	6.43

fodder requirement of the goats was met from the fodder trees (*Leucenea, Albezia*), which were present on the field boundaries. After one year, the body weight of goat increased to 40–50 kg and fetched ₹4,200 as additional farm income. The farm income after rearing of 2 goats at the start of first year increased to an extent of ₹34,500 in the third year after the sale of goats. Ramana *et al*. (2011) and Sharma (2012) reported similar results who observed additional income to the farmers through rearing of goats as compared to cow and buffalo rearing owing to their lower owning and maintenance costs. This advantage have helped the resource-poor farmers to resort to goat rearing for additional farm income especially in the *kandi* areas where the crop cultivation is somewhat tricky due to aberrant weather and is prone to crop failure. Goat rearing can even be practiced under prolonged drought where the local fodder trees like *Albizia lebbeck* (L.) Benth*., Zizipus mauritiana* (Lam.) and *Leucaena leucocephala* (Lam.) De Wit show tremendous resilience by giving green fodder in harsh summer months from ending April to July during which the rains are more or less scanty in the dryland areas. Therefore, the farmers can easily rear goats and get regular income through sale of goat milk as well as for meat purpose during festivals and other occasions.

System profitability and employment generation

Details of cost of production and net returns of various components integrated in orchards are given in Table 1. Choice of a crop or cropping system in an area is mainly guided by profitability of the farm. In general, the scientific interventions like balanced nutrition to crops and fruit trees, choice of latest high-yielding varieties, plant-protection measures, rearing of small ruminants resulted in increase in farm income. These interventions increased the net returns to the farmer household under all the crops/ cropping systems which were found to be higher than plots

Table 2. Average production and income from different production systems as influenced by interventions (2015-18)

Enterprise	System productivity on MEY basis (t/ha)		System cost of cultivation (₹/ha)		System net income (₹/ha)	
	BI	AI	BI	AI	BI	AI
Fruit trees	5.25	7.15	14,256	15,210	74,577	92,757
Goat	-	1.80	-	1,167	-	27,250
Maize-wheat-fruit-goat	9.61	15.21	49,466	62,453	135,651	210,327
Maize-Indian mustard-fruit-goat	9.46	15.02	43,388	54,860	125,072	194,941
pearlmillet-wheat-fruit-goat	8.69	13.80	44,371	56,148	125,018	197,253
pearlmillet-Indian mustard-fruit-goat	8.64	13.61	38,293	48,555	114,439	181,866

BI, before intervention; AI, after intervention

Table 3. System profitability (₹/ha/day) and employment generation (man-days) as affected by various enterprizes after 3rd year of experimentation

Cropping system	Before intervention		After intervention		Additional returns overbefore interventions	Employment generated (man-days)	
	Net returns	SP	Net returns	SP		BI	AI
Sole fruit	74,577	204	92,757	354	18,180	15	25
Maize–wheat	61,074	167	90,321	247	29,247	50	95
Maize–wheat–fruit	135,651	371	183,077	502	47,426	56	110
Maize–wheat–fruit–goat	–	–	210,327	576	–	68	146
Maize–Indian mustard	50,494	138	74,934	205	24,443	46	70
Maize–Indian mustard– fruit	125,071	343	167,690	459	42,619	52	85
Maize–Indian mustard–fruit–goat	–	–	194,940	534	–	64	121
Pearlmillet–wheat	50,441	138	77,245	211	26,804	42	74
Pearlmillet–wheat–fruit	125,018	342	170,001	466	44,983	48	89
Pearlmillet–wheat– fruit–goat	–	–	197,251	540	–	60	125
Pearlmillet–Indian mustard	39,861	109	61,858	169	21,997	38	49
Pearlmillet–Indian mustard–fruit	114,438	313	154,614	423	40,176	44	64
Pearlmillet–Indian mustard–fruit–goat	–	–	181,864	498	–	56	100

*Goat was not taken by the farmer before imposing of interventions so no data of goat
BI, before interventions; AI, after interventions; SP, system profitability

where no interventions were done. Among different field crops (Table 2) the highest mean net return of ₹50,406 was obtained with maize crop with a benefit: cost ratio of 2.13 followed by maize + greengram intercropping system and pearlmillet. Economic analysis of different farming systems (Table 3**)** showed that maize–wheat–fruit–goat showed the highest net returns of ₹210,327 and system profitability of ₹576/ha/day and were followed by pearlmillet–wheat–fruit–goat system and maize–Indian mustard–fruit–goat system. Kaushik *et al*. (2017) also reported highest net returns and system profitability through adoption of agri-silvi-horti system, whereas the lowest net returns were found through adoption of sole copping. Interventions undertaken at the farm, resulted in marked difference in the family income.The farmers family was able to get additional benefits (net returns) by growing field (both *kharif* and *rabi)* crops in the inter-spaces of the orchard. These findings are corrugous with those of Das (2015), who observed that low-cost interventions in crop, livestock and other optional enterprizes increased the gross returns of farmers. Additional returns over before interventions were also worked out and it was observed that by mixed farming in the orchard, the additional returns ranging from ₹40,176/ha to ₹47,426/ha were achieved by the farm family than without any interventions, thus, highlighting the importance of agronomic interventions which add to the farm income or profitability.

Adequate employment generation is crucial in the rural areas in order to check the migration of rural people to the urban frontiers. In this regard, mixed-farming systems have potential to generate gainful employment throughout the year. The study revealed that generation of employment was higher, when different enterprizes were integrated on the farm. Employment generation (Table 3) was also found to be maximum (146 days) in the maize–wheat–fruit–goat system followed by pearlmillet–wheat–fruit–goat and maize–Indian mustard–fruit–goat. Singh *et al.* (2011) concluded that, comparatively diversified and rather intensive nature of multifarious activities related to different enterprizes included in the integrated farming system model provide a lot of opportunities of employment and keeps farmers and their family members engaged throughout the year and as such can help in solving unemployment problem of the country mainly among the rural youths.

Based on 3 years of experimentation, it can be concluded that mixed farming did not exert adverse effect on the growth and productivity of citrus fruits. The field crops raised in the interspaces of the fruit trees in the orchard provided seasonal revenue to the farm family. Since income generated from the unit was inadequate to meet the family requirements, integrating trees with various enterprizes such as field crops as intercrops in conjunction with rearing of small ruminants, i.e. goat, besides adoption of scientific interventions like use of certified seed of varieties recommended for the region, supply of life-saving irrigation through rainwater harvesting, adoption of complete package and practices, namely recommended fertilizer doses, plant-protection measures, line sowing, use of biofertilizers, application of recommended dose of fertilizers and manures to the fruit trees as per age of tree and foliar application by micro-nutrients, besides deworming and vaccination of small ruminants resulted in increased productivity as compared to systems where no interventions were adopted. Also, the adoption of rainwater harvesting technology not only made life-saving irrigations possible to the fruit crops and field crops but increased the farm profits as well. Rearing of goat provides a great chance to the resource-poor farmers for increasing farm profits as it is affordable to buy and is low cost to keep as it feeds on tree foliage which provided nutritious green fodder and foliage for getting higher production. Thus, mixed farming model led to overall increase in farm productivity, profitability, sustainability and employment generation and hence can be recommended for *Kandi* belt rainfed areas of Jammu region.

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Table 4. Income benefits from goatry after intervention

Goat	No./ Unit	Production	Sale Rate (₹/kg)	Gross income	Input cost	Net income	MEY (t/ha)
			2015-16				
Goat	1	2 kids	-	-	1,000	-	-
			2016-17				
Goat	2	5 kids	₹4,200/kid	21,000	1,000	20,000	13.2
			2017-18				
Goat	4+2*	6 kids	₹5,000/kid 7500/kid	35,000	1,500	34,500	22.8

*4 female and 2 male kids

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