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Research Paper

Yield and yield attributes, system productivity and economics of mango (*Mangifera indica*)-based intercropping systems as influenced by mango cultivars and nutrient levels

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ABSTRACT

A field experiment was conducted during the rainy, winter and summer seasons of 2011–12 and 2012–13 at New Delhi, to evaluate performance of 3 cropping systems, viz. cowpea [*Vigna unguiculata* (L.) Walp] (for green pods)–Indian mustard [*Brassica juncea* (L.) Czernj &Cosson], greengram [*Vigna radiata* (L.) Wilczek]–Indian mustard and blackgram [*Vigna mungo* (L.) Hepper]–Indian mustard, in intercropping association with 4 mango (*Mangifera indica* L.) cultivars, viz. 'Pusa Surya', 'Amrapali', 'Mallika' and 'Dashehari' grown under 3 fertility levels, viz. control, 50% recommended dose (RD) of NPK through inorganic + 50% recommended dose (RD) of FYM and RD of NPK through inorganic + RD of FYM to mango. The experiment was carried out on 3-year-old existing mango orchard, planted with spacing of 6 m × 6 m. Before the commencement of study no intercrops were grown in the interspaces of mango. Stover of each intercrop was incorporated after harvesting/threshing along with natural incorporation of mango-litter-fall. Effect of mango cultivars were not significant on the yield and yield attributes of the rainy-season intercrops, viz. cowpea, greengram and blackgram. Application of 50% RDF + 50% RD of FYM to mango induced marked increase in yield and yield attributes of cowpea over the control during both the years except number of grains/pod and stover yield/ha during the first year, while in case of greengram and blackgram significant effect of this fertility level were observed only during the second year except 1,000-seed of greengram. Indian mustard recorded statistically similar yield and yield attributes in association with different cultivars of mango during the first year, while during the second year siliquae/plant, seeds/siliqua and seed yield/ha were the highest with 'Amarpali' mango. Indian mustard showed marked variations after the rainy-season crops. On an average, increase in the seed yield of Indian mustard after cowpea was 3.14 and 8.80% when compared to yield recorded after greengram and blackgram respectively. System productivity of intercrops in terms of Indian mustard seed-equivalent yield, gross returns, net returns and benefit: cost ratio recorded significant variation due to effect of mango cultivars during the second year and the highest values of these parameters were recorded with 'Amrapali' and the lowest with 'Mallika' mango. Among the intercropping systems, cowpea–Indian mustard record significantly highest values of system productivity, gross returns, net returns and benefit: cost ratio during both the crop seasons, followed by greengram–Indian mustard. Recommended dose of organic and inorganic nutrients and their 50% revealed statistically similar values of system productivity and economics of intercrops but both were statistically superior to the control.

Key words : Agri-horticulture system, Blackgram, Cowpea, Fertility levels, Greengram, Indian mustard, Intercropping, Mango cultivars

Diversification of present cropping pattern coupled with development of suitable technology packages is the need of the day to cope with the ever-increasing demand for diversified products and assured income. In recent years, agri-horticulture systems (i.e. integration of fruit trees with the agricultural crops) are recognized as an important agro-forestry systems for improving the productivity, reducing the risk in agriculture with additional employment and sustainable use of resources.

Among horticultural crops, fruits trees occupy an area of about 7.23 million ha, of which 34.9% area (2.52 Mha) is occupied by mango alone and accounts for 20.7% (18.43 Mt) of the total fruit production (88.98 Mt). In In-

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dia, it is being grown in almost all the fruit-growing states. On global basis too, India is premium mango- producing country and share about 65% of total world's production (IHD, 2014).

Most of the commercial cultivars of mango of north India exhibit lower orchard efficiency as compared to many other fruit crops due to limiting factors like high establishment cost, long juvenile period, alternate bearing, lack of flower induction, malformation, flowers and fruits drop, adverse climate and occurrence of insect-pests and diseases. Among these, the long juvenile period of mango plant can be efficiently utilized by growing of different intercrops. Mango, a huge-size woody perennial tree, is usually grown on wider spacing and also at juvenile phase the sparse foliage permits required light for the under-storey intercrops that makes the microclimate compatible for inter-cultivation (Musvoto and Campbell, 1995).

Most of the soils of mango-producing states are poor in fertility and suffer mainly from fertility and moisture-related constraints. The nutrient use in mango is either below optimum or in unbalanced proportion. Application of inorganic fertilizers alone would not supply the total nutrient needs of crops (Satapathy and Banik, 2002). Intercropping of pulses fixes the atmospheric nitrogen which helps in building up of soil fertility and recycling the nutrients from lower soil layer to surface soil (Gangwar *et al*., 2004) and also the residues of pulses are nutritionally more important than that of cereals because of high nitrogen concentration in their dry matter and low C : N ratio, resulting in long-term improvement in soil quality and productivity of crops besides saving of fertilizers for associated and succeeding crops (Wilhelm *et al*., 2004).

The integration of ground-storey crops in orchard is usually done without any consideration of possible adverse effects on the components and the growing sites. Though large numbers of intercrops are grown in mango orchard, very meager information is available on to comparative performance of legume crops in mango orchard. Therefore, the present experiment was conducted to study the suitability and performance of different intercrops in young mango orchard during rainy and winter seasons.

MATERIALS AND METHODS

A field experiment was conducted during the rainy, winter and summer seasons of 2011–12 and 2012–13 at Todapur Research Orchard of Horticulture Division, Indian Agricultural Research Institute, New Delhi (28°35' N, 77°12' E and 228.6 m above mean sea-level). The climate is humid subtropical, with an average annual rainfall of 680 mm. The mean maximum temperature in June, which is the hottest month of the year, ranges from 40° to 45°C, while the mean minimum temperature in the coldest month of January is as low as 1.9°C. A composite representative soil sample was collected from the experimental field before start of study and analysed for physico-chemical properties. The soil was sandy clay loam, having *p*H 7.8. Soil had 157.2 kg/ha available N, 12.4 kg/ha available P, 252 kg/ha available K, 0.38% organic carbon and electrical conductivity of 0.36 dS/m.

The experiment was carried out on 3-year-old existing mango orchard planted with spacing of 6 m × 6 m, which gives ample space in between mango plants for growing intercrops. Before the commencement of study, this inter-space was not used for growing crops. The experiment was laid out in 3 times replicated split-split-plot design. Main plots treatments consisted of 4 mango cultivars, viz. 'Pusa Surya' (V_1), 'Amrapali' (V_2), 'Mallika' (V_3) and 'Dashehari' (V_4), subplots consisted of 4 cropping systems, viz. mango + cowpea for green pods–Indian mustard (CS_1), mango + greengram for grain–Indian mustard (CS_2), mango + blackgram for grain–Indian mustard (CS_3) and sole mango (no intercrop) (CS_4), while sub-subplots treatments comprised 3 levels of nutrient management in mango, viz. control (F_0), 50% recommended dose (RD) of NPK through inorganic + 50% RD of FYM (F_1) and RD of NPK through inorganic + RD of FYM (F_2). Besides this, residue/stover/stalks of all the intercrops were incorporated uniformly in the soil after picking of pods/threshing. Natural incorporation of litter fall of mango was also occurred during the experimentation.

The intercrops were sown 0.50 m away from all the sides of mango trunk; thus leaving an area of 0.787 m^2 around each tree. Spacing of 50 cm was left between 2 subplots, so that only 8,184.5 m^2 was available for cultivation of intercrops in each hectare of orchard. The data thus presented for green pod yield, grain/seed, stover and biological yields of intercrops are from 8,184.5 m^2 rather than 100% area as available under monocropping. The experimental area was divided into 48 main plots of 17.5 m × 5.5 m and each plots consisted of 3 bearing mango plants, thus accommodating 144 mango plants in an experimental area of 0.52 ha.

After preparation of seedbed, cowpea (cv. 'Pusa Komal'), greengram (cv. 'Pusa Vishal') and blackgram (cv. 'Azad urd 1') were sown on 17 and 18 July in 2011 and 2012 respectively. Indian mustard (cv. 'Pusa Vijay') sowing was done on 6 November in 2011 and on 5 November in 2012. Seed rate of 25, 15, 15 and 5 kg/ha were used for cowpea, greengram, blackgram and Indian mustard respectively. Basal dose of 20 kg N, 50 kg P_2O_5 and 40 kg K_2O/ha was given to all the rainy-season crops, while the fertilizer dose for Indian mustard comprised 80 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha. Spacing of 30 cm × 10 cm was maintained for all the rainy season crops.

Recommended dose of fertilizer for mango consists of 300 g N, 150 g P_2O_5, 300 g K_2O and 20 kg FYM/plant during the first year of investigation and 400 g N, 200 g P_2O_5, 400 g K_2O and 30 kg FYM/plant in the succeeding year. Half of FYM and fertilizer in the form of urea, diammonium phosphate and muriate of potash was thoroughly mixed with soil around plant basin after flowering and the remaining was applied after harvesting of the crop (in July).

All the crops including mango were raised under irrigated condition. Drip system was installed for irrigating the mango plants; irrigation water was delivered to the plants as and when required depending on the rainfall and soil-moisture availability, while intercrops were irrigated through surface irrigation as per their requirement. Irrigation was stopped before flowering and 10 days before harvesting of the mango. Regular cultural operation and plant-protection measures were carried out during the entire period of study.

The recommended package of practices including irrigation was followed for sole crops as well as intercrops grown in the orchard and plant-protection measures were taken depending on the requirement. After the final picking of green pods of cowpea and mature pods of greengram and blackgram, the crops were harvested with the sickle and left in plots for 3–4 days for sun drying. Grains/seeds were threshed by beating with sticks, winnowing was carried out and grains were separated. After threshing, crop residues were chopped into small pieces and incorporated in the respective plots. Observation for yield attributes in different intercrops were taken from 5 selected plants of each plot; marked at close to mango canopy, at intermediate distance and far from the canopy to acquaint better representative data.

Observation on growth and yield parameters of main and intercrops were recorded following the standard procedure. System productivity (in terms of Indian mustard-seed equivalent) and economics of intercropping systems were worked out based on prices of output and input in the respective crop season. The data were subjected to standard analysis of variance technique (Gomez and Gomez, 1984). The mean effect of treatments were compared at $P<$ 0.05 level of significance.

RESULTS AND DISCUSSION

Yield and yield attributes of rainy-season intercrops

Effect of mango cultivars: All the rainy-season crops recorded statistically similar yield and yield-attributing characters when grown in association with different mango cultivars (Tables 1, 2 and 3). Non-significant effect of mango cultivars on the yield and yield attributes of intercrops may be ascribed to their almost similar plant height and spread and small size of plants at initial growth stage, which failed to induce marked and variable shading effect on the intercrops. Contrary to this, in a similar study, Gill and Ajit (2006) recorded higher grain yield (8.08 q/ha) of intercropped oat in association with 'Langra' variety of mango followed by 'Amrapali' (7.92 q/ha) and 'Dashehari' (7.89 q/ha) and least in 'Mallika' variety (6.89 q/ha). The reasons for these variations could be distinctly dwarf stature of 'Amrapali' enabling the better light transmission for intercrops compared to 'Mallika' which is relatively vigorous causing more shading effect and thus light interception. Harmful effects of trees on agricultural crops have also been observed with increase in size and age of

Table 1. Effect of mango cultivar and nutrient management on yield attributes and yield of cowpea

Treatment	Green pods/plant		Pod length (cm)		Grains/pod		Green pod yield (t/ha)		Stover yield (t/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Mango cultivar										
'Pusa Surya'	19.8	21.2	15.6	16.2	11.8	12.3	8.71	9.29	3.40	3.59
'Amrapali'	20.1	21.7	15.8	16.6	12.2	12.6	8.90	9.49	3.45	3.64
'Mallika'	19.3	20.7	15.3	15.8	11.7	12.2	8.67	9.26	3.39	3.58
'Dashehari'	19.9	21.4	15.7	16.4	11.9	12.4	8.84	9.40	3.43	3.60
SEm±	0.6	0.5	0.4	0.4	0.3	0.3	0.17	0.22	0.10	0.07
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management in mango										
Control	19.0	20.3	14.9	15.4	11.7	11.8	8.51	8.96	3.32	3.46
50% RD of NPK + 50% RD of FYM	19.9	21.6	15.7	16.5	11.9	12.6	8.83	9.52	3.43	3.65
RD of NPK + RD of FYM	20.4	21.9	16.1	16.8	12.2	12.8	9.00	9.61	3.49	3.69
SEm±	0.4	0.4	0.3	0.4	0.3	0.3	0.16	0.18	0.06	0.06
CD (P=0.05)	1.1	1.3	0.9	1.1	NS	0.7	0.47	0.54	NS	0.18

RD, Recommended dose

trees (Harsh and Tiwari, 1993).

Effect of nutrient management: Application of recommended dose (RD) of NPK and RD of FYM (F_2) proved effective in bringing significant changes in number of green pods/plant, pod length, and green pod yield during 2011 over the control in cowpea. During 2012, both F_1 and F_2 showed significant difference from the control for green pods/plant, pod length, and green pod and stover yields. The highest green pod yield of cowpea, viz. was recorded in 2011 and 2012, respectively, where mango plants were treated with RD of NPK and RD of FYM. The yield increase in this treatment in comparison to the control was 5.76% and 7.25% during 2011 and 2012 respectively (Table 1). In case of greengram, application of RD of NPK and RD of FYM were effective in realizing significantly higher number of pods/plant, pod length, number of grains/pod, grain yield and stover yield than the control only during the second year. Application of 50% RD of NPK + 50% RD of FYM (F_1) to mango plant also showed supremacy over the control by realizing statistically higher number of pods/plant, number of grains/pod, grain yield and stover yield (Table 2). Effect of application of NPK and FYM to mango was not observed on the yield and yield-attributing characters of blackgram during the first year of experimentation; however, during the succeeding year, all these parameters were significantly higher than the control with F_2 (RD of NPK +RD of FYM) (Table 3).

The reasons for significant difference in yield and yield attributes of intercrops due to nutrient levels applied to mango may be attributed to cultivation of intercrops in very close proximity with mango and horizontal movement of nutrients from the place of high concentration to low concentration. Besides this, root proliferation enabled the intercrop to tap nutrients from adjoining areas. In general, the performance of cowpea in terms of yield in present study was relatively superior to other rainy-season (*kharif*) crops, as it has affinity to tolerate higher shades (Quin, 1997; Osman *et al*., 2011) and can grow well even in poor soil (Buck, 1986). This is in conformity with findings of Swain *et al*. (2013) and Baghel *et al*. (2004) who documented supremacy of cowpea in terms of yield to rest of the intercrops.

Yield and yield attributes of Indian mustard

Effect of mango cultivars: Mango cultivar failed to bring any significant deviation in yield attributes and yield, viz. siliqua/plant, number of seeds/siliqua, 1,000-seed, seed yield and stover yield of Indian mustard during 2011–12. Though the higher values of these parameters were recorded under 'Amrapali' and least under 'Mallika' variety of mango (Table 4). During 2012–13, Indian mustard crop in association with 'Amrapali' mango recorded significantly more siliqua/plant, seeds/siliqua and seed yield, being respectively 5.14, 6.15 and 4.09% higher over 'Mallika' variety. The difference in the yield attributing characters of Indian mustard between these 2 varieties may be due to distinctly dwarfness of Amrapali enabling the better light transmission for intercrops compared to the 'Mallika' which is relatively vigorous causing increased light interception. The results are in conformity with the findings of Saroj *et al*. (1999) and Sharma *et al*. (2000), who reported reduced number of siliqua/plant and yield with the increase in height of mango plant.

Effect of cropping system: Except for seeds/siliqua in

Table 2. Effect of mango cultivar and nutrient management on yield attributes and yield of greengram

Treatment	Pods/plant		Grains/pod		1,000-grain weight (g)		Grain yield (kg/ha)		Stover yield (kg/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Mango cultivar										
'Pusa Surya'	15.5	16.9	9.45	9.53	45.5	46.0	918	977	2395	2499
'Amrapali'	15.9	17.1	9.46	9.60	45.5	46.2	943	994	2443	2528
'Mallika'	15.3	16.5	9.27	9.43	44.9	45.6	906	956	2363	2450
'Dashehari'	15.7	16.9	9.41	9.55	45.4	45.7	926	985	2410	2511
SEm±	0.3	0.4	0.25	0.21	0.8	0.8	27	27	51	54
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management in mango										
Control	15.1	15.9	9.17	9.12	44.6	45.1	904	929	2364	2389
50% RD of NPK + 50% RD of FYM	15.7	17.2	9.44	9.68	45.5	46.1	925	996	2395	2536
RD of NPK + RD of FYM	16.0	17.4	9.59	9.78	45.9	46.4	941	1009	2449	2566
SEm±	0.4	0.4	0.17	0.18	0.8	0.7	21	22	52	49
CD (P=0.05)	NS	1.1	NS	0.53	NS	NS	NS	65	NS	145

RD, Recommended dose

2011–12, all the yield-attributing and yield parameters were significantly influenced by the cropping systems in both the years (Table 4). During 2011–12 mango + cowpea–Indian mustard sequence was superior to rest of the cropping system treatment in terms of siliqua/plant and 1,000-seed. In second year of experimentation, mango + cowpea–Indian mustard and mango + greengram–Indian mustard proved significantly better to mango + blackgram–Indian mustard in all the growth and yield attributes. The results are in conformity with the findings of Lal *et al*. (2005), who reported that *toria* crops under mango + cowpea–*toria* followed by mango + blackgram–*toria* gave the highest seed yield the during 5 and 6 years of mango age compared to the other system, where *toria* was succeeded by sesame, clusterbean and okra in association with mango. Similar finding was reported by Rathore *et al*. (2014), who, based on 7 years of study, stated that mango + cowpea–*toria* was most economically viable system compared to mango + sesame–*toria,* mango + blackgram–*toria*, mango + okra–*toria* and mango + pigeonpea, which gave the mean cowpea equivalent yield of 1.84 t/ha. Better yield attributes and yield of Indian mustard in mango + cowpea–Indian mustard sequential cropping might be due to more N-fixing ability and more dry-matter incorporation from the cowpea plants; which might be helpful in substantial increase in nitrogen content of the soil as well as other physico-chemical properties of soil resulting in better growth and development of Indian mustard.

Effect of nutrient management: Nutrient management in mango failed to bring any significant difference in yield and yield attributes of Indian mustard during the first year. During 2012-13, both F_2 and F_1 treatments recorded significantly higher siliqua/plant, seeds/siliqua and seed and stover yields over the control. The reasons for variation in these parameters may be because of better utilization of FYM and inorganic fertilizers by Indian mustard which was applied to mango (Table 4).

System productivity of intercrops

Effect of mango cultivars: In the first year of experimentation, system productivity of intercrops was recorded of the same statistical order in association with different cultivars of mango (Table 5). In the second year, the highest system productivity of intercrops was recorded with 'Amrapali', which was at par with the system productivity recorded with 'Pusa surya' and 'Dashehari' but significantly superior to the system productivity of intercrops recoded with 'Mallika'. This variation in system productivity of intercrops due to the effect of mango cultivar may be attributed to their variable height and spread, resulting in variable competition for light and other sources with the intercrops. In general 'Amrapali' has distinctly dwarf stature enabling better light transmission to intercrops compared to 'Mallika' which is relatively vigorous causing more shading effect and thus less light interception. Harmful effects of trees on agricultural crops have also been observed with increase in size and age of trees (Harsh and Tiwari, 1993).

Effect of cropping system: Among the cropping systems, cowpea–Indian mustard recorded significantly highest productivity, followed by greengram–Indian mustard (Table 5). On an average, system productivity of cowpea–Indian mustard cropping system was 71.6% and 88.3%

Table 3. Effect of mango cultivar and nutrient management on yield attributes and yield of blackgram

Treatment	Pods/plant		Grains/pod		1,000-grain weight (g)		Grain yield (kg/ha)		Stover yield (kg/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Mango cultivar										
'Pusa Surya'	30.5	31.9	5.83	6.07	40.4	41.0	829	882	2323	2375
'Amrapali'	30.9	32.3	5.92	6.25	40.8	42.0	836	893	2328	2396
'Mallika'	29.8	31.7	5.75	5.95	40.2	40.7	824	868	2314	2342
'Dashehari'	30.7	32.2	5.95	6.26	40.6	42.0	831	889	2320	2387
SEm±	0.9	0.8	0.13	0.12	0.7	0.7	28	25	72	50
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management in mango										
Control	29.7	30.8	5.60	5.77	39.7	39.9	813	843	2294	2278
50% RD of NPK + 50% RD of FYM	30.6	32.5	5.90	6.23	40.7	42.0	832	898	2321	2414
RD of NPK + RD of FYM	31.2	32.9	6.10	6.40	41.2	42.3	845	908	2349	2432
SEm±	0.6	0.6	0.18	0.15	0.6	0.7	19	17	39	44
CD (P=0.05)	NS	1.7	NS	0.45	NS	2.2	NS	50	NS	130

RD, Recommended dose

higher than the system productivity of greengram–Indian mustard and blackgram–Indian mustard respectively. This behaviour of system productivity may be ascribed to higher green pod yield of cowpea, which was sold in the market for vegetable purpose. In addition, Indian mustard produced significantly higher seed yield after cowpea than greengram and blakgram, which also contributed for higher productivity of cowpea–Indian mustard cropping system. The results are in conformity with the findings of Rathore *et al*. (2014), who observed mean maximum cowpea-equivalent yield from cowpea followed by okra, blackgram, sesame and mean minimum with pigeonpea in a mango-based agri-horticulture system.

Effect of nutrient management: In the first year, the highest productivity was recorded with recommended dose of nutrients (NPK and FYM) which was at par with 50% of recommended dose but significantly superior to the control, while control and 50% recommended dose recorded statistically similar system productivity (Table 5). In the second year, 50% recommended dose was found at par with recommended dose of NPK and FYM, but both were significantly superior to the control. The reasons for significant difference in system productivity of intercrops due to nutrient levels applied to mango may be attributed to cultivation of intercrops in very close proximity with mango; leaving a uniform space of only 0.5 m all along the mango trunk and horizontal movement of nutrients from the place of high concentration to low concentration, resulting in spread of nutrients beyond the area of its application. Besides this, root proliferation enabled the intercrop to tap nutrients from adjoining areas.

System economics

Effect of mango cultivars: Economics of production of intercrops remained unaffected due to mango cultivars during 2011–12, while during 2012–13 gross returns, net returns and benefit: cost ratio were recorded the highest in companionship with 'Amrapali', which were significantly superior to 'Mallika'. This behaviour of system economics can be traced to the trend of system productivity of intercrops in association with different mango cultivars (Table 5).

Effect of cropping system: During both the years, cowpea–Indian mustard system exhibited the highest system economics in terms of gross returns, net returns and benefit: cost ratio, which was significantly higher than the other 2 cropping systems (Table 5). This behaviour of system economics of cropping systems may be attributed to variation in system productivity. The results are in conformity with the findings of Saroj *et al*. (1999) and Rathore *et al*. (2014). Saroj *et al*. (1999) observed mango + blckgram–*toria* as the best combination followed by

Table 4. Effect of mango cultivar, cropping system and nutrient management on yield attributes and yield of mustard

Treatment	Siliqua/plant		Seeds/siliqua		1,000-seed weight (g)		Seed yield (kg/ha)		Stover yield (kg/ha)	
	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13
Mango cultivar										
'Pusa Surya'	291	336	12.8	13.5	4.75	4.96	1,601	1,682	5,165	5,367
'Amrapali'	298	348	13.3	13.8	4.92	5.15	1,622	1,705	5,235	5,441
'Mallika'	289	331	12.8	13.0	4.79	5.04	1,586	1,638	5,124	5,305
'Dashehari'	293	341	13.1	13.6	4.86	5.09	1,615	1,692	5,207	5,397
SEm±	3	4	0.1	0.2	0.07	0.06	22	17	54	60
CD (P=0.05)	NS	14	NS	0.6	NS	NS	NS	60	NS	NS
Cropping system										
Mango: cowpea-mustard	300	349	13.3	13.8	4.95	5.23	1,657	1,755	5,341	5,596
Mango: greengram-mustard	294	341	13.1	13.6	4.85	5.08	1,609	1,700	5,191	5,424
Mango: blackgram-mustard	285	327	12.7	13.0	4.70	4.88	1,553	1,584	5,016	5,112
SEm±	4	4	0.1	0.1	0.05	0.07	18	20	59	60
CD (P=0.05)	11	13	NS	0.4	0.16	0.19	53	59	177	179
Nutrient management in mango										
Control	289	330	12.9	13.0	4.76	4.99	1,582	1,626	5,107	5,213
50 % RD of NPK + 50% RD of FYM	293	342	13.0	13.6	4.84	5.09	1,609	1,701	5,196	5,435
RD of NPK + RD of FYM	296	345	13.2	13.7	4.89	5.11	1,627	1,712	5,245	5,483
SEm±	4	4	0.1	0.2	0.05	0.06	23	16	59	44
CD (P=0.05)	NS	11	NS	0.4	NS	NS	NS	44	NS	126

RD, Recommended dose

Table 5. Effect of mango cultivar, cropping system and nutrient management on system productivity in terms of mustard-seed equivalant and economics of production

Treatment	System productivity (Tonnes/ha)		System costs of cultivation (×10³₹/ha)		System gross returns (×10³₹/ha)		System net returns (×10³₹/ha)		System benefit: cost ratio	
	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13	2011–12	2012–13
Mango cultivar										
'Pusa Surya'	3.67	3.82	37.8	45.7	91.8	114.6	54.0	68.9	1.39	1.47
'Amrapali'	3.74	3.88	37.8	45.7	93.4	116.5	55.5	70.8	1.43	1.51
'Mallika'	3.64	3.76	37.8	45.7	91.1	112.6	53.2	66.9	1.37	1.43
'Dashehari'	3.71	3.85	37.8	45.7	92.7	115.5	54.8	69.8	1.42	1.49
SEm±	0.026	0.032	-	-	0.64	0.96	0.64	0.96	0.02	0.02
CD (P=0.05)	NS	0.111	-	-	NS	3.32	NS	3.32	NS	0.07
Cropping system										
Mango: cowpea-mustard	5.17	5.50	41.3	49.6	129.2	164.9	87.9	115.3	2.13	2.32
Mango: greengram-mustard	3.09	3.13	36.0	43.6	77.1	94.0	41.1	50.4	1.14	1.16
Mango: blackgram-mustard	2.82	2.85	36.2	43.7	70.3	85.5	34.1	41.7	0.94	0.95
SEm±	0.029	0.048	-	-	0.72	1.45	0.72	1.45	0.02	0.03
CD (P=0.05)	0.086	0.145	-	-	2.15	4.36	2.15	4.36	0.06	0.09
Nutrient management in mango										
Control	3.61	3.68	37.8	45.7	90.3	110.3	52.4	64.6	1.35	1.38
50% RD of NPK + 50% RD of FYM	3.70	3.89	37.8	45.7	92.5	116.5	54.7	70.9	1.41	1.52
RD of NPK + RD of FYM	3.76	3.92	37.8	45.7	93.9	117.6	56.1	71.9	1.45	1.54
SEm±	0.035	0.031	-	-	0.87	0.93	0.87	0.93	0.02	0.02
CD (P=0.05)	0.099	0.088	-	-	2.47	2.64	2.47	2.64	0.06	0.06

RD, Recommended dose

mango + cowpea–*toria* and mango + sesame–*toria* which showed benefit: cost ratio of 3.89, 2.69 and 2.50 respectively. Pawar and Sarwade (2006) conducted study in farmer's field in the 5–6 year-old bearing mango orchard and recorded the maximum net monetary returns (₹9,313/ha) and benefit: cost ratio (2.56) from the mango + soybean– Indian mustard cropping system compared to mango + cowpea– chickpea and mango + sesame– fallow. In another similar field study, the maximum gross monetary returns (₹21,089/ha) and net monetary returns (₹14,813/ha) were recorded from mango + soybean– Indian mustard cropping sequence (Pawar *et al*., 2009).

Effect of nutrient management: In the first year, recommended dose of nutrients recorded gross returns, net returns and benefit: cost ratio at par with 50% of recommended dose, but significantly superior to the control. Control and 50% RD were also at par with respect to these parameters. During the second season, recommended and 50% of recommended dose of nutrients recorded statistically similar values of gross returns, net returns and benefit: cost ratio, but both were significantly superior to the control (Table 5). These results are the outcome of effect of nutrient management on yield of intercrops.

Based on 2 years study, it is concluded that cowpea, greengram and blackgram during the rainy season and Indian mustard during the winter season can be intercropped in the inter-row space of mango orchard during establishment phase without any harmful effect to base crop. From this practice, farmers can earn on an average net returns around 70,000 from the intercropping based on the market prices for inputs and outputs during 2011–13.

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