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Influence of cultivars, cropping systems and nutrient levels on yield and quality of mango in north India

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ABSTRACT

A field experiment was carried-out on 3-year-old mango trees (6 m × 6 m) during 2011-12 and 2012-13 at New Delhi to study the effect of cultivar, cropping system and nutrient level on yield and quality parameters. The experiment was laid out in a split-split-plot design with three replications. The main plots comprised of four cultivars, *viz*., Pusa Surya, Amrapali, Mallika and Dashehari, sub-plots consisted of four cropping systems, *viz*., vegetable cowpea-Indian mustard, green gram-Indian mustard, blackgram-Indian mustard and sole mango. Sub-sub plots included three fertility levels *viz*., control, 50% recommended dose of NPK fertilizers (RDF) + 50% recommended dose of FYM (RD-FYM), and 100% RDF + 100% RD-FYM to mango. A marked variation in fruit yield and fruit quality was observed among mango cultivars. 'Amrapali' exhibited supremacy over rest of the cultivars for yield and quality parameters. Under vegetable cowpea-mustard system, the mango fruit yield and yield parameters were comparatively higher. However, the physical and biochemical fruit quality parameters showed a non-significant variation among cropping systems. Application of 100% RDF + 100% RD-FYM remaining at par with 50% RDF + 50% RD-FYM produced significantly higher number of fruits/plant (16.5 and 24.3), fruit weight (212 and 223 g) and pulp: stone ratio (5.01 and 5.02) during 2011-12 and 2012-13, respectively over control. Application of 100% RDF + 100% RD-FYM exhibited higher biochemical quality parameters *viz*., TSS, vitamin C, total carotenoids and total sugars during both years over other treatments. Overall, 'Amrapali', vegetable cowpea-mustard cropping system and application of 100% RDF + 100% RD-FYM were the best performing treatments in terms of fruit yield and quality parameters in the current study.

Key words: *Magnifera indica*, cropping systems, fruit quality, intercropping.

INTRODUCTION

Mango (*Mangifera indica* L.) is regarded as national fruit of the country because of its wide edaphic and climatic adaptability, high nutritive value, attractive appearance and popularity among growers. It is 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 (Swain, 14). Thus, long juvenile period of mango plant can be efficiently utilized for different intercrops. Intercropping enables efficient utilization of resources in vertical (space and light) and horizontal dimensions (land, nutrient and moisture). This additional intercropping component provides additional production and farm income by utilizing natural resources and inputs efficiently especially in the initial years of orchard establishment (Swain *et al*., 15). Pulses are preferred intercrops over cereals in fruit based agri-horticultural systems as they have biological N_2 fixation ability vis-à-vis higher N turnover in the soils (Kumar *et al*., 6). Similarly, the application of chemical fertilizers alongwith organic manures in mango orchards may improve the plant growth, fruit yield and quality owing to improved soil physico-chemical and biological properties (Patil *et al*., 8). Thus, a field experiment was conducted to assess the influence of cultivars, legume based cropping systems and nutrient levels on mango yield and quality parameters.

MATERIALS AND METHODS

A field experiment was conducted during 2011-12 and 2012-13 at Todapur Research Orchard, Division of Fruits & Hort. Tech., ICAR-ARI, New Delhi [28°35' N, 77°12' E, 228.61 m amsl, humid subtropical climate]. The soil of experimental site was sandy clay loam, having pH 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 (6 m × 6 m), which gave ample space for growing intercrops. The experiment was laid out in a split-split-plot design with three replications. Main-plots treatments consisted of four mango cultivars, *viz*., Pusa Surya, Amrapali, Mallika and Dashehari. Sub-plots consisted of four

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cropping systems, *viz*., CS_1: mango + cowpea (cv. Pusa Komal) for green pods -Indian mustard (cv. Pusa Vijay); CS_2: mango + greengram (cv. Pusa Vishal) for grains - Indian mustard (cv. Pusa Vijay), CS_3: mango + blackgram (cv. Azad Urd 1) for grains - Indian mustard (cv. Pusa Vijay) and CS_4: sole mango (Fig. 1). The sub-sub-plot treatments comprised three nutrient levels in mango, *viz*., F_0: Control; F_1: 50% recommended dose of NPK fertilisers (RDF) + 50% recommended dose of FYM (RD-FYM); and F_2: 100% RDF + 100% RD-FYM (Fig. 1). Natural litter fall of mango and intercrop residues were incorporated uniformly in the soil after threshing/pod picking.

During first year, the recommended dose of FYM and NPK fertilizers consisted of 20 kg FYM, 300 g N, 150 g P_2O_5, 300 g K_2O/plant, while in the succeeding year we gave 30 kg FYM, 400 g N, 200 g P_2O_5, 400 g K_2O/plant. Half of fertilizers (urea, DAP and MOP) were broadcasted under the canopy after mango harvesting (in July) and incorporated upto 15 cm soil depth followed by irrigation when no rain. Remaining doses were applied at flowering. Intercrops were sown 0.50 m away from either side of the trunk; thus, leaving an area of 0.787 m^2 around each tree. Uniform spacing of 0.50 m was left between all the plots, thus; only 8,184.5 m^2 orchard area was available for cultivation on hectare basis. The experimental area was divided into 12 main-plots of 23.5 m × 17.5 m and each plot consisted of 12 mango bearing plants (Fig. 1). Sub-plot and sub-sub-plot treatments were duly randomized, however randomization could not be done for main-plot treatments (cultivars), because same cultivars were already planted in common strip. Drip irrigation was stopped before 21 days to flowering and 10 days before harvest of mango to reduce flower drop and produce larger fruits. Cultural practices were uniformly followed except nutrient management.

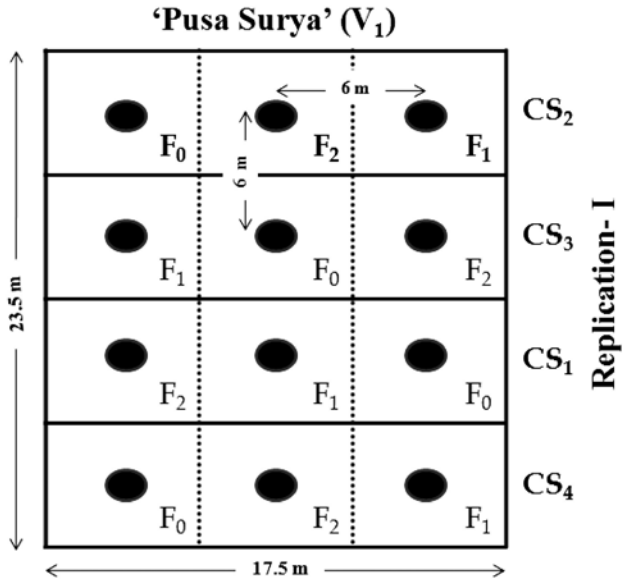

Fig. 1. Layout of one main plot (Mango cultivar), indicating 12 mango plants in a main plant. Sub-plot consists of cropping system (CS_1: Mango + cowpea - Indian mustard, CS_2: Mango + greengram - Indian mustard, CS_3: Mango + blackgram - Indian mustard and CS_4: Sole mango), Sub-sub-plot consists of nutrient management in mango (F_0: Control, F_1: 50% RD of NPK + 50% RD of FYM and F_2: RD of NPK + RD of FYM)

Cowpea, greengram and blackgram were sown in the seed-beds on 17th and 18th July in 2011 and 2012, respectively. Indian mustard was sown on 6th Nov., 2011 and 5th Nov., 2012. 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. The recommended package of practices was followed for all intercrops (Rana *et al*., 10). Harvesting of mango was done at full maturity stage. Physico-chemical analysis was done on five randomly selected mature fruits from each plant. Biochemical quality parameters, *viz*., TSS, sugars, total titratable acidity, ascorbic acid and total carotenoides were determined using standard procedures. The data was statistically analysed at 5% level of significance following standard procedures (Rana *et al*., 10).

RESULTS AND DISCUSSION

A marked variation in yield attributes, yield and physical quality parameters of mango fruits was observed among cultivars (Table 1). 'Pusa Surya', 'Amrapali' and 'Dashehari' yielded significantly higher number of fruits/plant over 'Mallika'. Maximum number of fruits/plant were harvested from 'Dashehari' (20.8 and 29.8) followed by 'Amrapali' and 'Pusa Surya' and lowest in 'Mallika' during 2011-12 and 2012-13, respectively. Significantly higher fruit weight was obtained from 'Mallika' over rest of the cultivars. Owing to heavier fruit weight, 'Mallika' produced significantly highest pulp: stone ratio. Average fruit yield per plant and fruit yield ha was significantly influenced amongst mango cultivars. 'Amrapali' with fruit yield/plant of 3.35 and 5.07 kg and fruit yield/ha of 929 and 1407 kg during 2011-12 and 2012-13, respectively showed supremacy over 'Dashehari' and 'Mallika'. 'Amrapali' gave 18.6 and 9.0% higher fruit yield compared to 'Mallika' in 2011-12 and 2012-13, respectively. Though the individual fruit weight of 'Mallika' was higher, but because of significantly lower number of fruits/plant, it registered lowest yield amongst cultivars. The variation amongst cultivars for physical quality and yield parameters of fruit might be

Table 1. Effect of mango cultivars, cropping systems and nutrient levels on yield attributing characters and physical quality parameter.

Treatment	No. of fruits/ plant		Fruit wt. (g)		Fruit yield/ plant (kg)		Estimated fruit yield/ ha (kg)		Pulp: stone ratio	
	2011-12	2012-13	2011-12	2011-12	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Cultivar										
Pusa Surya	14.0	20.8	235	240	3.29	5.00	913	1388	5.40	5.35
Amrapali	18.7	27.2	179	186	3.35	5.07	929	1407	4.02	4.12
Mallika	11.0	17.0	256	274	2.82	4.65	783	1291	6.57	6.36
Dashehari	20.8	29.8	149	163	3.10	4.86	860	1350	3.35	3.48
CD (P = 0.05)	0.41	0.76	7.7	7.3	0.20	0.16	56.4	43.2	0.27	0.24
Cropping system										
Mango + cowpea - mustard	16.2	24.1	207	220	3.18	5.08	882	1412	4.94	4.99
Mango + greengram - mustard	16.2	23.9	206	218	3.16	4.97	878	1382	4.83	4.87
Mango + blackgram - mustard	16.1	23.8	205	215	3.14	4.88	872	1356	4.87	4.81
Sole mango	16.0	23.1	202	210	3.07	4.63	853	1286	4.70	4.65
CD (P = 0.05)	NS	0.57	NS	7.4	NS	0.16	NS	44.1	NS	0.21
Nutrient level										
Control	15.7	22.9	195	204	2.91	4.44	808	1232	4.63	4.58
50% RDF + 50% RD - FYM	16.2	23.9	207	220	3.19	5.04	886	1400	4.86	4.88
100% RDF + 100% RD - FYM	16.5	24.3	212	223	3.31	5.20	920	1445	5.01	5.02
CD (P = 0.05)	0.4	0.5	5.0	5.4	0.12	0.13	33.7	36.5	0.25	0.19

due to variable response of applied inputs, variation in genetic constitution and interaction of various genotypes with the agro-climatic conditions (Singh *et al*., 13; Das, 3).

There were no significant effects of agri-horticultural systems on yield and physical quality parameters of mango fruits during 2011-12, though highest number of fruits/plant, fruit weight, and pulp: stone ratio was recorded from mango + cowpea-mustard system (Table 1). During 2012-13, cowpea-mustard system recorded significantly maximum cumulative number of fruits/plant (24.1), average fruit weight (220 g) and pulp: stone ratio (4.99) over sole mango closely followed by greengram-mustard system. Cropping systems showed non-significant differences in mango yield during 2011-12. During 2012-13, mango yield/ plant was maximum in mango + cowpea-mustard system followed by mango + green gram-mustard and mango + black gram-mustard system and least in sole crop of mango (Table 1). Similar effects of intercropping with legume crops on physical fruit quality and fruit yield of base crop mango has also been advocated by several workers (Singh *et al*., 12; Swain, 14). Better performance of intercropped mango over sole mango may be ascribed to substantial N turnover in the soil *vis-a-vis* improved soil health due to legume intercrops (Bai *et al*., 1). Legume based intercropping systems in mango orchard also efficiently utilized the natural resources like solar radiation, soil moisture and nutrients, thus, adding larger biomass and nutrient recycling which led to better yield and quality of mango fruits (Negi *et al*., 7; Swain *et al*., 15).

Application of 100% RDF + 100% RD-FYM demonstrated significantly higher number of fruits/ plant, fruit weight, fruit yield/plant, fruit yield/ha and pulp: stone ratio during both years over control (Table 1). The 50% RDF + 50% RD-FYM was found to be the second best treatment and statistically as good as 100% RDF + 100% RD-FYM for all the above parameters. There was an increasing trend in yield with successive increase in nutrient levels. This variation may be ascribed to variation in nutrient availability, which differently influenced the growth and yield. Addition of FYM alongwith NPK fertilizers might have helped in improving the soil physico-chemical and biological properties (Paul *et al*., 9), which ultimately improved the plant growth and yield in terms of number of fruits, fruit weight and yield (Singh and Banik, 11).

Biochemical quality parameters were significantly influenced by the mango cultivars (Table 2 and 3). 'Amrapali' was observed as superior cultivar for most of the biochemical quality parameters of fruits exhibiting highest values for total soluble solids (TSS), total carotenoids as well as non-reducing sugars. Significantly least acidity was again recorded in the fruits of 'Amrapali'. However, ascorbic acid (vitamin C) content was significantly lower during both years in the 'Amrapali' fruits. Mallika possessed significantly higher ascorbic acid and reducing sugars among all mango cultivars. It also registered significantly higher total sugars content except 'Amrapali' during second year of study. Significantly higher acidity during respective season was recorded from the fruits of 'Mallika'. Variation in biochemical quality of fruits among cultivars implies intrinsic genetic variability and their interaction with environment (Das, 3; Dixit and Yadav, 4).

The intercrops did not bring significant differences with respect to biochemical fruit quality parameters of mango during both the years of study (Tables 2 & 3). However, mango + cowpea-mustard system recorded superior values of biochemical quality parameters. Improvement in soil fertility due to nitrogen fixation by legumes might have been the reason for improved physical and biochemical quality of fruits (Kumar *et al*., 5; Swain, 14).

Mango plants supplied with 100% RDF + 100% RD-FYM, and 50 % RDF + 50% RD-FYM exhibited significantly better fruit quality parameters over control. Application of 100% RDF + 100% RD-FYM showed marginal supremacy over 50 % RDF + 50% RD-FYM and both the treatments were marked as statistically identical for most of the quality parameters, except for total carotenoids during 2012-13. Application of 100% RDF + 100% RD-FYM resulted in an increase of about 10.5 and 9.8% in TSS, 6.5 and 6.1% in vitamin C, 9.3 and 9.1% in total carotenoids and 12.8 and 13.4% in total sugars during 2011-12 and 2012-13, respectively over control. This variation in quality parameters may be ascribed to variation in nutrient availability and uptake which differently influenced the growth and quality traits (Bai *et al*., 1; Kumar *et al*., 5; Swain *et al*., 15). The acidity was reduced by 3.3 and 3.5% with the application of 100% RDF + 100% RD-FYM, and by 1.4 and 2.0% with 50 % RDF + 50% RD-FYM compared to control during 2011-12 and 2012-13, respectively. Balanced fertilization and organic manures increase the nutrient use efficiency which led to improved fruit quality (Bhargava, 2; Paul *et al*., 9).

Current study inferred that integration of legumes and their biomass incorporation in juvenile phase

Table 2. Effect of mango cultivars, cropping system and nutrient levels on fruit biochemical parameters.

Treatment	TSS (ºBrix)		Acidity (%)		Ascorbic acid (mg/100 g pulp)		Total carotenoids (µg/100 g pulp)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Cultivar								
Pusa Surya	18.6	18.8	0.218	0.195	40.8	41.8	14215	14139
Amrapali	20.5	20.9	0.168	0.168	36.8	39.0	15355	15858
Mallika	19.3	19.5	0.259	0.236	46.2	46.9	9347	9603
Dashehari	18.5	18.9	0.185	0.182	42.3	42.9	7449	8027
CD (*P* = 0.05)	0.53	0.63	0.007	0.007	1.7	1.3	449	330
Cropping system								
Mango + cowpea - mustard	19.5	19.8	0.204	0.192	41.9	43.1	11701	12030
Mango + greengram - mustard	19.3	19.5	0.208	0.195	41.7	42.7	11596	11985
Mango + blackgram - mustard	19.1	19.5	0.209	0.197	41.5	42.6	11562	11906
Sole mango	19.0	19.3	0.210	0.197	41.0	42.2	11508	11706
CD (*P* = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient level								
Control	18.1	18.4	0.211	0.199	40.1	41.2	10996	11291
50% RDF + 50% RD - FYM	19.6	20.0	0.208	0.195	41.8	43.1	11763	12105
100% RDF + 100% RD - FYM	20.0	20.2	0.204	0.192	42.7	43.7	12016	12324
CD (*P* = 0.05)	0.46	0.39	0.004	0.005	0.9	0.7	274	215

Table 3. Effect of mango cultivars, cropping systems and nutrient levels on fruit biochemical parameters.

Treatment	Total sugars (%)		Reducing sugar (%)		Non-reducing sugars (%)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Cultivar						
Pusa Surya	15.6	15.7	4.24	4.33	11.4	11.4
Amrapali	16.7	17.0	4.71	4.76	12.0	12.2
Mallika	17.4	17.3	5.84	5.93	11.6	11.4
Dashehari	14.4	14.7	4.64	4.68	9.8	10.1
CD (P = 0.05)	0.42	0.45	0.11	0.14	0.35	0.35
Cropping system						
Mango + cowpea - mustard	16.3	16.4	4.94	5.00	11.3	11.4
Mango + green gram - mustard	16.1	16.2	4.86	4.95	11.2	11.3
Mango + black gram - mustard	16.0	16.1	4.83	4.91	11.1	11.2
Sole mango	15.9	16.0	4.79	4.84	11.1	11.1
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Nutrient level						
Control	14.9	14.9	4.48	4.55	10.4	10.4
50% RDF + 50% RD - FYM	16.5	16.7	4.99	5.05	11.5	11.6
100% RDF + 100% RD - FYM	16.8	16.9	5.09	5.18	11.7	11.8
CD (P = 0.05)	0.54	0.44	0.16	0.14	0.39	0.32

of mango orchard appreciably improved the mango productivity and quality owing to modified soil physico-chemical and biological properties. Overall, 'Amrapali', cowpea-mustard cropping system, and application of 100% RDF + 100% RD-FYM were the best performing treatments with respect to mango yield attributes, fruit yield and quality parameters in the current study.

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