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Efficacy of Integrated Nutrient Management in mango (*Mangifera indica*) cv. Kesar under semi-arid conditions of central Gujarat

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ABSTRACT

An experiment was carried out at KVK-Panchmahal, ICAR-CIAH, Godhra, Gujarat during 2014 and 2015 at five farmer's orchards to find out the impact of RDF, biofertilizers and mulching on yield and qualitative attributes of mango (*Mangifera indica* L.) cv. Kesar in semi-arid conditions. Among the four treatments combinations, the maximum plant height (68%), stem girth (14.20%) and plant spread E-W (11.14%) and N-S (11.16%), yield (33.67 kg/plant and 52.52 q/ha), TSS (16.29^0 brix), reducing (5.56 %), non-reducing (10.34 %) and total sugar (15.89%) was recorded when the plant treated with 75 % RDF + *Azotobactor* + PSB, each 250 g/plant) + mulching with grasses/ straw @15 kg dry grass/sq m (T_3) followed by RDF + mulching with grasses /straw @15 kg dry grass/sqm (T_4), RDF (Recommended dose of manure (70 kg) and fertilizers @ N 1000g, P 750g and K 750 g /plant (T_2) and control (T_1). The maximum acidity (1.28 %) was recorded in T_1 followed by T_2 (1.19%) and T4 (0.75 %) and it was minimum in T_3 (0.65%). The maximum cost of cultivation (₹ 13 154/ha) was recorded in T_2 and T_4 followed by ₹ 12 686/ha in T_3 and the same was minimum in T_1 (₹ 10 346/ha). The highest net returns (₹ 41 831/ha) and cost benefit ratio (4.91) was computed in T_3 followed by T_4 (₹ 39 831.40/ha and 3.33), T_2 (₹ 25 736.80/ha and 2.96) and T_1 (₹ 12 999.40/ha and 2.26). Results of the study revealed that the application of RDF (75%) + *Azotobactor* (250 g/plant) + PSB (250 g/plant)+mulching with grasses /straw (15 kg dry grass/sq m) were found to be more effective and can be applied to improve the vegetative growth, yield and quality of Kesar mango fruits. However, the application of RDF with grass mulching was also found to be better than bare RDF.

Key words: Biofertilizer, INM, Mango, Mulching, OFT, RDF

The importance of balance nutrition and soil moisture under semi-arid conditions is more important to increase the production of quality mango (*Mangifera indica* L.) fruits. Indiscriminate (imbalance use of nutrients) use of inorganic chemical fertilizers resulted in high amount of chemical residues in soil as well as in the crop produces leading to various environmental and health hazards along with socio-economic problem. Again the increasing cost of fertilizer and global concern of ground water pollution through leaching from the soil are discounting the use of fertilizers. So, it is necessary, to maintain the soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in integrated manner (Chundawat 2001). It is very difficult to manage nutrients, through organic manures only. In order to maintain soil health and to obtain higher yield with better quality fruits, it is importance to adopt balance nutrition approach. It can be achieved by adopting some practices such as application of organic manures like FYM, vermicompost, vermiwash, use of bio-fertilizers, organic mulches in addition to inorganic fertilizers (60-75%) ensures high yields and to sustain the available nutrients in the soil at optimum level. Biofertilizers are the living organism which add, conserve and mobilize the plant nutrients in the soil. Biofertilizer based on renewable energy source are cost effective supplement to chemical fertilizers and can help to economize the high investment needed for fertilizer use (Motsara *et al.* 1995). The beneficial effect of bio-fertilizers is now well established in fruit crops like papaya (Sukhade *et al.* 1995) and banana (Gogoi *et al.* 2004). However, very scanty work has been done on the use of biofetilizers in mango. Mulches, viz. soil, grasses, plastic etc. are not only conserve soil moisture but also impart manifold beneficial effect, like suppression of extreme fluctuation of soil temperature, reduced water loss through evaporation, resulting more stored soil moisture (Shirgure *et al*. 2003), maintenance of soil fertility (Thakur *et al.* 1997), suppression of weed growth (Bhutani *et al.* 1994), improvement in growth and yield (Shukla *et al*. 2000). Continuous use of organic mulches are helpful in

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improving the soil physico-chemical properties, microbial population and soil aeration which ultimately resulted into better growth and yield of plant (Rao and Pathak 1998). With these backgrounds the present experiment was designed with the objective to increase yield and quality of fruits by reducing the use of costly chemical fertilizers and incorporation of biofertilizers and organic mulch that could ensure eco-friendly environment.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* seasons of 2013-14 and 2014-15 at five farmers' mango orchards of different villages of the Panchmahal district of central Gujarat under semi-arid conditions. The soil type of all the study area was clay-to-clay loam with low organic carbon (0.28-0.33%). The soil depth ranges from 0.75-1.25 m derived from mixed alluvial basalt, quartzite, granite and layers of limestone. The climatic condition of the study area falls under semi-arid hot climate. The basic climatic parameters were observed during study period. The mean maximum and minimum temperature ranges from 28.4 to 41.5°C and 12.70° to 26.70°C respectively. During 2013-14, total annual rainfall (1053.54 mm during June to October), rainy days (56) and minimum (10.24-25.99°C) and maximum (27.66-41.86°C) temperature was recorded and no rainfall was observed during rest of the years. Whereas, during 2014-15, total annual rainfall (642.79 mm during June to September), rainy days (35) and minimum (12.36-26.34°C.) and maximum (28.42-40.78°C) temperature was recorded and no rainfall was observed during rest of the years. The experiment consisted four treatments, five replications and was laid out in randomized block design. The ten trees were taken in each treatment. The trees were eight years old and planted at 8×8m distance. All the four treatments were imposed in each orchard uniformly and one replication was taken for analyzing the experimental data. The treatments were T_1= control (farmers practices – application of imbalance fertilizers), T_2= RDF [Recommended dose of manure (70 kg) and fertilizers (N-1000g, P-750g and K-750 g/plant], T_3= 75 % RDF + *Azatobactor* + PSB (phosphorus solubilising bacteria) (each 250 g/plant)+mulching with grasses/straw (15 kg dry grass/sq m) and T_4- RDF + mulching with grasses/straw (15 kg dry grass/sq m). The treatments were applied to the concerned plants in two splits - once after onset of monsoon (June) and another at pea stage of fruit (February-March). However, full dose of FYM, phosphorous and potassium and 50 % of nitrogen were given after harvest and remaining 50 % of nitrogen was given at pea stage. Biofertilizers each @ 250g was incorporated to the concerned plant during July-August by thoroughly mixing with 5 kg of FYM. The treatments were applied in a ring 2 m away from the trunk and at a depth of 30 cm which were mixed in soil and covered. The whole shaded area of plant was mulched with grasses /straw during the last week of August and first week of September. The increase in tree height, stem girth and spread were measured at an interval of one year and averages of these parameters were presented. The number of panicles/plant was recorded at flowering stage**.** The harvesting of mango was done at maturity stage during first half of June and yield parameters such as number of fruits/ panicle, number of fruits/tree and fruit yield on weight basis and physical parameters of fruit, viz. length, width, weight, peel, pulp, stone and pulp to stone ratio were estimated after harvesting the fruits. The physico-chemical parameters, viz. TSS, acidity, TSS acid ratio, total, reducing and non-reducing sugars was estimated by following the standard method (Boland 1990). The data on cost of cultivation, gross returns, net returns and cost benefit ratio was analyzed by using standard method (Snedecer and Cochran 1989).

RESULTS AND DISCUSSION

Plant growth parameters

Among the four treatments, the combinations of organic, inorganic fertilizers, biofertilizers and grass mulching exhibited profound effect on plant growth. The results of the study clearly indicated that the efficiency of inorganic fertilizer was more when supplemented with biofertilizers (Table 1). The maximum increase in plant height (9.68%), stem girth (14.20%) and tree spread in east-west (11.14%) and north-south (11.16%) directions were recorded when plants were treated with 75% of recommended dose of manure and fertilizers + *Azotobacter* + PSB + grass mulching (T_3). The application of grass mulching with RDF was also found better for plant growth parameters plant height

Table 1 Efficacy of Integrated Nutrient Management on annual growth of mango cv. Kesar

Treatment	Plant height (% increase)			Stem girth (% increase)			Plant spread (% increase)					
							East-West			North-South		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
T_1	8.12	8.10	8.11	8.18	8.16	8.17	4.30	4.25	4.28	4.23	4.12	4.18
T_2	8.60	8.35	8.48	13.22	13.18	13.20	7.26	7.24	7.25	7.13	7.16	7.15
T_3	9.80	9.55	9.68	14.21	14.18	14.20	11.17	11.15	11.16	11.15	11.12	11.14
T_4	9.60	9.45	9.53	14.13	14.14	14.14	9.36	9.32	9.34	8.93	8.85	8.89
SEm±	0.033	0.025	0.014	0.015	0.020	0.007	0.022	0.023	0.009	0.097	0.025	0.009
CV	0.827	0.641	0.043	0.284	0.371	0.023	0.629	0.659	0.030	2.705	0.717	0.029
CD (P = 0.05)	0.102	0.078	0.350	0.048	0.063	0.139	0.069	0.909	0.276	3.725	0.988	0.276

(9.53%), stem girth (14.14%) and tree spread in east-west (9.34%) and north-south (8.89%) as compared to without mulch (T_2) because is weight added organic matter in soil, conserve soil moisture and provide better environment to micro fauna and flora. The improved growth may be resulted by the supplementation of biofertilizer due to better absorption and mobilization of nutrients by the action of microbes. The results of the study are in agreement with the findings of Kundu *et al.* (2011) in mango cv. Amrapali and reported that the 100% NPK + *Azotobacter* + VAM and 75% NPK + *Azotobacter* + VAM were effective to improve the vegetative growth and productivity with quality fruits. The similar findings are also reported by Singh and Singh (2003) and Singh *et al.* (2007) in aonla.

Yield attributing characteristics

The peak period of flowering in mango under central Gujarat conditions is December-January in all the treatments. On the basis of pooled data presented in Table 1, the maximum number of panicles/plant 207.93 was recorded in T_3 followed by T_4 (202.13), T_2 (191.60) and it was minimum in control (180.40). The number of fruit/panicle at the time of harvesting is main contributing factor of yield. There is great difference among the treatments, the maximum (0.93) was recorded in T_3 followed by T_4 (0.89), T_2 (0.87) and minimum (0.42) in T_1 (control). The number of fruits/panicle at harvest was recorded the minimum (0.42) in control (T_1), whereas in remaining treatments very less difference was recorded 0.87 in T_2, 0 89 in T_4 and 0.93 in T_3 (Table 2). This might be due to excessive fruit drop and low fruit retention due to drought or scarcity of water and nutrient imbalance in soil associated with poor fruit set and retention per panicle. Under such conditions, favourable effect of recommended dose of manure and fertilizers in uptake of various nutrients from soil by the plant and also solubilization effect of plant nutrients by addition of biofertilizers and grass mulching which helped in fulfilling the nutrient requirement of plant and create more conducive environment near the rhizosphere zone either by conserving soil moisture or increasing population of beneficial micro organism which directly or indirectly help in growth, flowering and fruiting of plants. The results of the study are in close agreement with Kumar *et al.* (2013) in mango cv. Kesar and reported number of fruit per panicle (0.95) at harvest and Singh *et al.* (2014) in aonla. The number of fruit on the plant at the time of harvesting is main yield contributing factor. There is great difference among the treatments. It ranged from 89.65 to 153.90 being maximum in T_3 followed by T_4 (134.15) and T_2 (127.40) and it was minimum in control (89.65). The results clearly indicate that the treatment T_3 (75 % RDF + *Azotobactor* (250 g/plant) + PSB (250 g/plant)+mulching with grasses/ straw (15 kg dry grass/sq m) was found to be superior as it was indicated by higher number of fruits/tree followed by T_4 (RDF + mulching with grasses/straw (15 kg dry grass/ sq m), T_3 RDF [recommended dose of manure (70 kg) and fertilizers (N-1000g, P-750g and K-750 g/plant] and minimum (89.65) in T_1. The findings are in line of Patil *et al*. (2005) in mango cv. Alphonso and reported 193.60 fruits/ plant with application of 75% RDF +25 kg FYM + 5 kg vermicompost and T_4-50% RDF+ *Azospirillum brasilense* (100g/tree)+'P' solubilizer- *Pseudomonas striata* (100 g/ tree)+5 kg vermicompost. The more or less similar findings are also reported by Kumar *et al*. (2013) mango cv. Kesar. The results of the study are in agreement with the previous workers like Musmade *et al.* (2009) in acid lime, Singh *et al*. (2003) in aonla, Rao *et al*. (1998) in aonla and reported integrated nutrient management has profound influence on fruit yield and other related charactes. This may be due to favourable effect of INM in extracting the various nutrients from soil by the crop and also solubilization effect of plant nutrients by addition of FYM and vermicompost leading to increase uptake of NPK.

Fruit qualitative attributes

The data presented in Table 3 show that the maximum fruit weight (201.10g), length (9.26cm) and width (6.02 cm) were recorded in T_3 followed by T_4 (196.70g 9.24 cm, 5.91 cm), T_2 (180.77g 9.20 cm, 5.85 cm) and T_1 (171.20g, 9.05cm and 5.63 cm). This may be due to recommended dose of manure and fertilizers in uptake of various nutrients from soil by the plant and also solubilization effect of plant nutrients by addition of biofertilizers and grasses mulching which help in fulfilling the nutrient requirement of plant and conserving soil moisture and aid in improving fruit quality. The similar findings are also reported by Kunda *et al.* (2011)

Table 2 Efficacy of Integrated Nutrient Management on yield attributes of mango cv. Kesar

Treatment	No. of panicles/ plant			No. of fruits/panicle at harvest			No. of fruits/ plant			Yield /plant (kg)			Yield/ha (q)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
T_1	187.30	173.50	180.40	0.43	0.41	0.42	91.5	87.8	89.65	15.76	14.17	14.97	24.59	22.11	23.35
T_2	195.65	187.55	191.60	0.90	0.85	0.87	129.25	125.55	127.40	26.06	23.80	24.93	40.65	37.13	38.89
T_3	207.25	208.60	207.93	0.96	0.91	0.93	155.20	152.60	153.90	35.19	32.14	33.67	54.90	50.14	52.52
T_4	205.45	198.80	202.13	0.92	0.86	0.89	132.65	135.65	134.15	29.64	26.59	28.12	46.24	41.48	43.86
SEm±	0.618	0.496	0.538	0.008	0.011	0.048	0.718	0.430	0.511	0.009	0.541	0.026	0.489	1.136	0.196
CV	0.698	0.581	0.615	2.460	2.460	17.50	1.271	0.768	1.575	2.754	0.753	0.083	2.652	6.718	0.604
CD (P=0.05)	1.907	1.528	1.660	0.026	0.026	0.149	2.214	1.326	0.938	0.028	1.670	0.237	3.654	3.503	1.103

Table 3 Efficacy of Integrated Nutrient Management on fruit qualitative attributes of mango cv. Kesar

Treatment	Fruit weight (g)			Length of fruit (cm)			Fruit width (cm)			Peel (%)			Pulp (%)			Stone (%)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
T_1	168.75	173.65	171.20	9.13	8.97	9.05	5.63	5.62	5.63	15.68	15.75	15.72	64.44	63.42	63.93	16.84	16.85	16.85
T_2	182.65	178.90	180.77	9.23	9.17	9.20	5.88	5.82	5.85	15.93	15.86	15.90	67.81	65.77	66.79	17.13	17.08	17.11
T_3	203.45	198.75	201.10	9.27	9.24	9.26	6.08	5.96	6.02	16.13	16.08	16.11	70.95	68.88	69.91	17.28	17.13	17.21
T_4	187.25	186.15	186.70	9.26	9.21	9.24	5.93	5.88	5.91	15.83	15.76	15.80	69.88	68.82	69.35	16.98	16.95	16.97
SEm±	0.574	1.323	0.467	0.021	0.087	0.017	0.052	0.025	0.017	0.15	0.018	0.015	0.423	0.687	0.363	0.086	0.069	0.024
CV	0.696	1.614	1.439	0.530	2.086	0.052	2.013	0.999	0.054	0.213	0.253	0.047	1.388	2.297	1.119	1.140	0.921	0.076
CD (P = 0.05)	1.770	4.077	0.564	0.067	0.268	0.417	0.161	0.079	0.676	0.046	0.055	0.218	0.599	2.119	1.235	0.266	0.214	0.328

Table 4 Efficacy of Integrated Nutrient Management on physic-chemical attributes of Mango cv. Kesar

Treatment	TSS			Reducing sugar (%)			Non-reducing sugar (%)			Total sugar (%)			Acidity (%)			TSS acid ratio		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
T_1	15.26	15.22	15.24	5.22	5.23	5.23	9.78	9.73	9.76	15.00	14.96	14.98	1.29	1.27	1.28	11.83	11.98	11.91
T_2	16.13	16.08	16.10	5.51	5.47	5.49	10.16	10.21	10.19	15.67	15.68	15.68	1.21	1.17	1.19	13.33	13.74	13.53
T_3	16.33	16.25	16.29	5.58	5.53	5.56	10.35	10.32	10.34	15.93	15.85	15.89	0.64	0.66	0.65	22.07	21.38	21.72
T_4	16.05	15.97	16.01	5.58	5.47	5.53	10.12	10.05	10.09	15.70	15.52	15.61	0.74	0.76	0.75	25.08	24.20	24.63
SEm±	0.076	0.057	0.021	0.014	0.020	0.016	0.012	0.040	0.025	0.030	0.037	0.005	0.012	0.007	0.005	0.134	0.161	0.040
CV	1.072	0.808	0.066	0.574	0.859	0.049	0.271	0.887	0.077	0.441	0.534	0.016	2.913	1.839	0.015	1.658	2.003	0.125
CD (P = 0.05)	0.236	0.177	0.301	0.043	0.064	0.657	0.037	0.123	0.558	0.094	0.114	0.074	0.038	0.024	1.160	0.414	0.498	0.507

Table 5 Efficacy of Integrated Nutrient Management on economics of mango cv. Kesar cultivation

Treatment	Cost of cultivation (₹/ha)			Gross return (₹/ha)			Net profit (₹/ha)			Cost benefit ratio		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
T_1	10112	10580	10346	22105.20	24585.60	23345.40	11993.20	14005.60	12999.40	2.19	2.32	2.26
T_2	12608	13700	13154	37128.00	40653.60	38890.80	24520.00	26953.60	25736.80	2.94	2.97	2.96
T_3	12296	13076	12686	50138.40	54896.40	52517.40	37842.40	41820.40	39831.40	4.08	4.20	4.14
T_4	12608	13700	13154	41480.40	46238.40	43859.40	28872.40	32538.40	30705.40	3.29	3.38	3.33
SEm±	4.320	11.952	4.150	2.433	3.969	25.760	2.013	2.817	33.657	0.024	0.018	0.013
CV	0.081	0.209	12.78	0.014	0.021	79.406	0.017	0.021	103.71	1.799	1.308	0.042
CD (P = 0.05)	13.315	36.831	0.090	7.498	12.233	0.145	6.205	8.682	0.256	0.076	0.057	0.806

in mango cv. Amrapali and Kumar *et al.* (2013) in mango cv. Kesar and Singh *et al.* (2012), Singh *et al.* (2008) in aonla. The maximum peel per cent (16.11) was recorded in T_3 followed by 15.90% in T_2, 15.80% in T_4 and minimum in control (15.72). The pulp per cent ranged between 63.93-69.91 it was being the maximum in T_3 followed by 69.35 in T_4, 66.79 in T_2 and minimum in T_1 (control). This may be due to application of manure, biofertilizers and grass mulching which helped in conserving soil moisture and increment in pulp per cent. The maximum stone per cent (17.21) was recorded in T_3 followed by 17.11% in T_2, 16.97% in T_4 and the same was minimum in control (16.85%). The higher fruit yield 33.67 kg/plant and 52.52 q/ha was obtained when the plants were treated with 75% RDF + *Azotobactor* (250 g/plant) + PSB (250 g/plant) +mulching with grasses/straw (15 kg dry grass/sq m) followed by 28.12 kg/plant and 43.86 q./ha with RDF (100%) + mulching with grasses/straw (15 kg dry grass/sq m), 24.93 kg/plant and 38.89 q/ha with RDF (100%) and minimum 14.97 kg/plant and 23.25 q/ha with control. This may be due to the application of biofertilizers along with inorganic fertilizers which might have increased the total chlorophyll content which in turn increased the photosynthesis and ultimately improved fruit yield and higher number of fruits, fruit weight was also recorded in the same treatment. The results of the study are in accordance with Rao *et al*. (1998), Singh *et al*. (2003), Singh *et al*. (2010), Kunda *et al.* (2011), in aonla. The results of the present studies was also supported by the findings of Ahmad *et al.* (2003) who obtained optimum yield when nitrogen was applied in combination with *A. chroococcum* CBD-15 in mango cv. Amrapali under high-density planting. The use of both biofertilizers at a time (VAM + *Azotobacter)* in combination with NPK (100%) responded the maximum increase in fruit weight (318.3 g).

Physico-chemical attributes

Among four treatments RDF (75%) + PSB + *Azotobacter* + grasses/straw mulch treated plants exhibited the highest TSS (16.29° brix), reducing sugar (5.56 %), non-reducing sugar (10.34 %) and total sugar (15.89 %) and lowest in control (Table 4). The lowest acidity (0.65 %) was recorded in T_3 followed by T_4 (0.75 %), T_2 (1.19%) and the maximum in plants treated with imbalance fertilizers with control plants (T_1). The range of TSS to acid ratio varied from 11.91 to being 24.63, maximum in T_3 and minimum in T_1 (Table 3). The results of present study are in concurrence with the finding by Patel *et al.* (2005) also noted higher quality fruits with combined application of biofertilizers in mango cv. Amrapali. These findings are in agreement with results of Kunda *et al.* (2011) in mango cv. Amrapali.

Economics of mango cultivation

Results of the study on the economics of mango cultivation as influenced by various treatments, the cost of cultivation (₹13 154 /ha) was recorded highest in the treatment T_2 and T_4 followed by ₹ 12 686 in T_3, and minimum (₹ 10 346) in T_1 (Table 5). The higher cost of cultivation in T_2 and T_4 is due to all the required materials especially fertilizers needs to be purchased from market and need to pay higher, whereas in T_3, 75% of T_2 was, purchased from the market and additional grasses were harvested from local resources and there was no need to pay. The maximum gross returns (₹ 52 517.40/ha), net returns (₹ 41 831.40/ha) and highest B: C ratio (4.14) was recorded in the treatment T_3 (75 % RDF + *Azotobactor* (250 g/plant) + PSB (250 g/plant) + mulching with grasses/straw (15 kg dry grass/sq m). The maximum gross returns may be due to increased yield and good quality of fruits with the application of bio-fertilizers and grass mulching thereby increased marketable yield. Similar results were reported by Patel *et al*. (2009a) in acid lime. Whereas, the highest net returns may be due to moderate cost of cultivation and high gross returns in these treatments. The highest B: C ratio was obtained due to more net returns and moderate cost of production. The beneficial effects of organic manures can be substantiated with the findings of Ingle *et al.* (2003) in Nagpur mandarin, Dalal *et al.* (2005) in mango and Musmade *et al.* (2009) and Patel *et al.* (2005) in acid lime. It was concluded from the present studies that the treatments RDF (75%), *Azotobactor* (250 g/plant) + PSB (250 g/plant) + mulching with grasses/straw (15 kg dry grass/sq m) were found to be effective to improve the vegetative growth and productivity with quality fruits in Kesar mango. It was also

concluded that the application of RDF along with grasses mulching also better than bare RDF.

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