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Nutrient Management in Mango Based Agri-Horti System under Marginal Lands

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ABSTRACT

In order to identify the appropriate land use system towards enhancing productivity of marginal lands, an effort was made to develop Agri- Horti system includes arable crops and fruit trees. A field experiment was carried out by growing maize under six year old mango orchards in red sandy loam soil with different management options viz., T_1- Farmer practice (FYM@ 12 t ha^{-1}), T_2-125% RDN, T_3-100 % RDF (200- 60-50 kg ha^{-1}), T_4-75% RDN + 25 % N through FYM, T_5-75 % RDN + 25 % N through poultry manure, T_6-75% RDN + Azotobacter + PSB @ 5 kg ha^{-1} each , T_7-100% RDF (Sole crop without trees). pH and EC of the soil at harvest of maize were not significantly influenced by the treatments and over initial values. Application of 75 % RDN + 25 % N through PM shows the significant increase in availability and uptake of N, P and K at knee high and harvest stage of maize. The SPAD values increased from knee high stage to tasselling stage and then decreased towards the maturity of the crop. At knee high stage and harvest, application of all the treatments improved dry biomass and significantly more than that of application of FYM @12 t ha^{-1}. All the treatments application resulted in significant increase in grain yield over the FYM @12 t ha^{-1}(5540.00 kg ha^{-1}).

Keywords Agri-Horti system, Marginal lands, Dry matter, Nutrient content, Yield.

INTRODUCTION

To meet the ever growing population, there is a need to increase food grain production in India. The per capita availability of land for agriculture is decreasing year over year. Therefore, the area not utilized under waste, marginal and degraded lands has to be brought under cultivation by many ways. Generally the productivity and fertility of such lands are low, hence not suitable for normal agriculture. But with land use management the productivity and fertility of such soils increased by adaptation of different agroforestry system (Pathak *et al*. 1996). Agri-horti agroforestry system is an alternative land use system that integrates the cultivation of agricultural crops and fruit trees. It has the inbuilt capacity to increase the productivity and at the same time maintain the nutrient balance as well as food and environmental

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security. Tree component increases production and income, besides imparting stability to the farming system. Fruit trees, apart from the above advantages also yield valuable products like fodder and fuel wood through their annual pruning, which are supposed to improve and maintain good health of human beings. The soil quality and its production capacity can be restored and improved by adopting agroforestry systems which provides a way to sustain agricultural production (Thakur and Kumar 2006). There is a great risk of growing food grains in marginal, degraded waste lands unless proper management is taken. Basically the fertility and nutrient status of marginal lands is very poor. Even under such situation, there is lot of scope to increase the productivity and sustainability in semi arid tropics of Telangana state by adopting different agroforestry models, among the systems, the important are agri-silvi, agri-horti, silvi-pastoral, horti-pastoral, silvi-medicinal, block plantations and boundary plantations (Roy 2016). Maize, a crop of worldwide economic importance together with rice and wheat provides approximately more than 30% of the food calories to more than 4.5 million people. In India, maize is considered as third most important crop among the cereals and used as staple food in many developing countries (Yakadri *et al*. 2015). Worldwide, maize is grown in an area of 197.20 m ha with production of 1148.49 Mt and productivity of 5824 kg ha^{-1} (FAOSTAT 2019-20) while 9.56 m ha with 28.77 Mt production and 3006 kg ha^{-1} productivity in our country. In Telangana, maize occupies an area of 0.56 m ha with production and productivity of 2.99 Mt and 5347 kg ha^{-1} respectively (CMIE 2019-20). Maize yields in India need to be increased significantly so as to meet food, feed and industrial needs.

Keeping above facts in view, a field experiment is undertaken to study the effect of organic, inorganic fertilizers and their combinations on soil nutrient status and maize growth in fruit based agroforestry system for marginal lands.

MATERIALS AND METHODS

A field experiment was carried out during *kharif* 2017 in 6 year old mango plantations in the Agroforestry Research Block, AICRP on Agroforestry, Professor Jayashankar Telanagana State Agricultural University, Rajendranagar, Hyderabad. The experimental soil was sandy loam in texture with pH (6.31), EC (0.135 dS m^{-1}) and OC (0.32 %). The soil was low in available nitrogen (230.6 kg ha^{-1}), medium in available P_2O_5 (28.31 kg ha^{-1}) and high in available K_2O (360.0 kg ha^{-1}). The experiment was laid out in a Randomized Block Design and replicated thrice, treatments comprised of T_1- Farmer practice (FYM@ 12 t ha^{-1}), T_2-125% RDN, T_3-100 % RDF (200- 60-50 kg ha^{-1}), T_4-75% RDN + 25 % N through FYM, T_5-75 % RDN + 25 % N through poultry manure, T_6-75% RDN + Azotobacter + PSB @ 5 kg ha^{-1} each , T_7-100% RDF (Sole crop without trees). Recommended dose of phosphorus and potassium was applied in treatments from T_2 to T_7.

Mango variety Baneshan was planted at a spacing of 8 m × 8 m with 156 trees ha^{-1}. No special management practices were followed for Mango, except application of organic manure and fertilizers and pruning during later stages. Maize was intercropped with mango during the first week of July 2017. Maize variety DHM-117 was planted according to the Telanagana state recommendations at spacing of 60 cm X 20 cm with seed rate of 20 kg ha^{-1}. The observations on physico-chemical properties of soil were recorded under agri-horticulture system during the course of investigation. The quantity of organic manures was applied as per the treatments.

The pH of the soil samples was determined in soil: water (1:2.5) suspension using a glass electrode pH meter (Jackson 1973). Electrical conductivity of the soil samples was determined in soil: water (1: 2) suspension with a conductivity meter (Jackson 1973). Organic carbon percentage in soil sample was determined by wet digestion method (Walkley and Black 1934). Bulk density (BD) of the experimental soil was estimated by core sampler method following the standard procedures (Klute 1986). Available nitrogen in soil sample was estimated by alkaline permanganate method (Subbiah and Asija 1956). Available phosphorus in soil sample was extracted with $NaHCO_3$ (0.5 M) as per the procedure outlined by Olsen *et al*. (1954) and the phosphorus in the extract was estimated by colorimetric method using ascorbic acid as the reductant; The intensity of blue color developed was read in spectrophotometer at 680 nm (Watanabe and Olsen 1968). Available potassium in the soils was extracted by employing Ammonium Acetate (NN) and determined by aspirating the extract to the flame photometer (Jackson 1973) and results were expressed were in kg ha^{-1}. The chlorophyll content was measured by SPAD (Soil-Plant Analysis Development) meter at knee high, tasselling and harvest. Five plants were up rooted from the destructive sampling area from each plot at knee high, tasselling and harvesting stage to measure the dry biomass production. These are cleaned and dried in hot air oven at 60°C till constant weight was obtained. Their weights were recorded and expressed in kg ha^{-1}. Grain yield was estimated by harvesting the matured cobs from net plot area and dried. After drying, shelling was done by maize sheller and again the grain was dried and weights were recorded as per the treatments and expressed in kg ha^{-1}. The plant samples were digested with H_2SO_4 and H_2O_2 and distilled by microkjeldhal distillation method to estimate the nitrogen content in plant sample (Jackson 1973). Phosphorus content in the diluted diacid digest was determined by vanadomolybdo phosphoric acid yellow color method on spectrophotometer at 420 nm (Jackson 1973). Potassium content in the diluted diacid digest was determined by flame emission spectroscopy using flame photometer (Muhr *et al*. 1965). The uptake of N, P and K by the crop was computed and expressed in kg ha^{-1} as follows.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) X Dry matter (kg ha}^{-1}\text{)}}{100}$$

Statistically significance was tested by F-value at 5 % level of probability and critical difference was worked out where ever the effect were significant.

RESULTS AND DISCUSSION

Soil properties

pH and EC of the soil at harvest of maize were not significantly influenced by the combined application of organic manures and chemical fertilizers and over initial values (Table 1). As the duration of the crop is less, the basic properties like pH and EC were not changed by application of low quantities of manures and fertilizers. With the application of 100 % RDF had maximum pH and electrical conductivity (6.33 and 0.25 ds m^{-1} respectively). These results are in line with the findings of Pallavi *et al*. (2015) and Jagadeesha *et al*. (2019). Whereas soil organic carbon was significantly influenced by type of manure applied. The lowest organic carbon was observed in 100% RDF-Sole crop without trees compared to other treatments (0-30 cm and 30-60 cm). It could be clearly attributed to the advantage of growing trees which contributed to the improvement of physical condition of soil over the years and might also be due to higher plant growth activity or root growth and production of more crop residues thus causing faster decomposition of residues leading to higher organic carbon content (Hala *et al*. 2014). There was no significant difference between OC content in sole crop and treatments in agri-horti system except in FYM @ 12 t ha^{-1} (0-30 cm and 30-60 cm). Among different nutrient sources, the organic carbon content

Table 1. Soil physico-chemical properties of maize as influenced by nutrient management in mango based Agri-Horti system.

Treatments	pH	EC (dSm^{-1})	Organic carbon (%) 0-30 cm	30-60 cm
T_1- FYM@12 t ha^{-1}	6.28	0.24	0.39	0.25
T_2-125% RDN	6.31	0.25	0.32	0.20
T_3- 100 % RDF	6.33	0.25	0.32	0.21
T_4-75% RDN+ 25% N through FYM	6.30	0.25	0.34	0.22
T_5-75% RDN+ 25 % N through PM	6.30	0.24	0.34	0.22
T_6- 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}	6.31	0.25	0.32	0.21
T_7- 100% RDF-Sole crop without trees	6.32	0.25	0.31	0.20
CD (P = 0.05)	0.62	0.05	0.04	0.02
SEm±	0.20	0.02	0.01	0.01
Initial values	6.31	0.135	0.32	0.21

registered higher with FYM @ 12 t ha^{-1} (0-30 cm and 30-60 cm). These results were in conformity with the findings of Chandana *et al*. (2018).

Available nutrients

The available NPK data at knee high stage and harvest is presented in the Table 2. The highest available nitrogen content at knee high stage of 225.16 kg ha^{-1} was observed with 75% RDN+ 25 % N- PM which is on par with 125% RDN (225.10 kg ha^{-1}), 100 % RDF (220.68 kg ha^{-1}), 100% RDF-Sole crop without trees (218.53 kg ha^{-1}), 75% RDN+ 25% N-FYM (218.12 kg ha^{-1}), 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1} (217.88 kg ha^{-1}). Application of 75% RDN+ 25 % N- PM (225.16 kg ha^{-1}) and 125% RDN (225.10 kg ha^{-1}) shows significantly higher nitrogen than application of FYM @12 t ha^{-1} (202.05 kg ha^{-1}). At harvest, Application of 125% RDN (218.23 kg ha^{-1}) and 75% RDN+ 25 % N- PM (218.01 kg ha^{-1}) was shows significantly higher nitrogen than application of FYM @12 t ha^{-1} (195.70 kg ha^{-1}). The higher available N in agroforestry system than sole crop is due to constant addition of leaf litter and nitrogen fixing ability over the years from uncut trees under intercropping situation. Among treatments, higher available N was observed with conjoint use of poultry manure with 75% N inorganic source. This might be attributed due to higher amount of N and OC content present which hastened the process of mineralization during crop growth period. Another reason for higher availability of N may be due to the addition of mineral fertilizer N along with organic sources which have contributed to the reduction of C:N ratio and thus increased the rate of decomposition resulting in faster availability of nutrients from manures. The results are in conformity to the findings of Roshani *et al*. (2005) and Priyanka *et al*. (2019).

The highest available phosphorus content in soil at knee high stage was observed with 75% RDN+ 25 % N- PM (24.85 kg ha^{-1}) on par with 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1} (24.25 kg ha^{-1}), 75% RDN+ 25% N-FYM (24.16 kg ha^{-1}), 100 % RDF (23.74 kg ha^{-1}), 125% RDN (23.68 kg ha^{-1}), 100% RDF-Sole crop without trees (23.62 kg ha^{-1}). The application of 75% RDN+ 25 % N- PM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}, 75% RDN+ 25% N-FYM shows significantly higher phosphorus than application of FYM @12 t ha^{-1} (21.23 kg ha^{-1}). The same pattern was observed at harvest stage also. At harvest, application of 75% RDN+ 25 % N- PM (23.04 kg ha^{-1}), 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1} (23.02 kg ha^{-1}), 75% RDN+ 25% N-FYM (22.98 kg ha^{-1}) shows significantly higher phosphorus than application of FYM @12 t ha^{-1} (19.98 kg ha^{-1}). The higher available P_2O_5 in integrated application of organic manures with chemical fertilizers might be due to more availability of nutrients coupled with favorable status of soil physically and chemically (Rajanikanth *et al*. 2016). Another reason might be due to the release of organic acids during microbial decomposition of organic matter which helped in the solubility of native phosphates thus increasing available phosphorus. Similar results were observed by Pallavi *et al*. (2015).

At knee high stage, available potassium status

Table 2. Available nutrient status (N, P_2O_5 and K_2O) influenced by nutrient management in mango based Agri-Horti system.

Treatments	Available nutrients (kg ha^{-1})					
	N		P_2O_5		K_2O	
	Knee high stage	Harvest	Knee high stage	Harvest	Knee high stage	Harvest
T_1- FYM@12 t ha^{-1}	202.05	195.70	21.23	19.98	327.21	236.77
T_2-125% RDN	225.10	218.23	23.68	21.94	346.20	252.10
T_3- 100 % RDF	220.68	215.85	23.74	22.00	353.80	251.98
T_4-75% RDN+ 25% N through FYM	218.12	214.25	24.16	22.98	353.68	256.98
T_5-75% RDN+ 25 % N through PM	225.16	218.01	24.85	23.04	355.92	257.10
T_6- 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}	217.88	215.00	24.25	23.02	346.39	251.10
T_7- 100% RDF-Sole crop without trees	218.53	214.58	23.62	21.70	346.09	250.10
CD (P = 0.05)	19.73	20.64	2.63	2.01	33.91	26.22
SEm±	6.43	6.72	0.86	0.65	11.05	8.54

was not significantly influenced by integrated application of organic and inorganic sources compared to FYM @12 t ha^{-1} (327.21 kg ha^{-1}). The highest available potassium was recorded with 75% RDN+ 25 % N- PM (355.92 kg ha^{-1}). Similar trend was observed at harvest in case of available potassium content. The highest available potassium at harvest was recorded with 75% RDN+ 25 % N- PM (257.10 kg ha^{-1}). The favorable effect of application of nitrogen through organic sources is an outcome of increased proliferation of roots and microbial activity, which in turn have released the organic acids causing lowering down the pH of the soil and releasing the native potash from the soil, apart from reduction in fixation of applied potassium (Sinha 2015).

Poultry manure increased N, P and K compared with other manures. This was due to the fact that poultry manure was low in C: N ratio and high in N, P and K compared with other manures. Due to high quality of this amendment, it decomposes quickly and release nutrients to the soil. Similar results were observed by Khan and Krishna (2017).

Nutrient uptake

The nitrogen uptake was calculated from nitrogen content and dry biomass at knee high stage and at harvest were presented in Table 3. The nitrogen uptake at knee high stage ranged from 15.50 kg ha^{-1} (FYM @12 t ha^{-1}) to 19.47 kg ha^{-1} (125% RDN). Application of treatments like 125% RDN, 75% RDN+ 25 % N- PM, 75% RDN+ 25% N-FYM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1},100 % RDF and 100% RDF-Sole crop without trees resulted in significant increase in uptake of nitrogen (19.47, 19.44, 19.35, 19.32, 19.30 and 19.27 kg ha^{-1}) than FYM @12 t ha^{-1}. The improvement in nitrogen uptake was due to multiplication effect of higher nutrient absorption i.e., nitrogen as well as high biomass production. The nitrogen uptake in stover at harvest ranged from 42.80 kg ha^{-1} (FYM @12 t ha^{-1}) to 60.15 kg ha^{-1} (125% RDN). Application of 125% RDN, 75% RDN+ 25 % N- PM, 75% RDN+ 25% N-FYM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}, 100 % RDF and 100% RDF-Sole crop without trees resulted in significant increase in uptake of nitrogen (60.15, 58.43, 58.12, 58.05, 57.52 and 56.97 kg ha^{-1}) than FYM @12 t ha^{-1}. The nitrogen uptake in grain at harvest was ranged from 61.79 kg ha^{-1} (FYM @12 t ha^{-1}) to 90.98 kg ha^{-1} (125% RDN). Application of 125% RDN, 75% RDN+ 25 % N- PM, 75% RDN+ 25% N-FYM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1},100 % RDF and 100% RDF-Sole crop without trees resulted in significant increase in uptake of nitrogen (90.98, 90.20, 89.93, 89.82, 88.98 and 88.58 kg ha^{-1}) than FYM @12 t ha^{-1}. Similar results were obtained by Fiyyaz *et al*. 2021.

The phosphorus uptake at knee high stage ranged from 1.08 kg ha^{-1} (FYM @12 t ha^{-1}) to 1.32 kg ha^{-1} (75% RDN+ 25 % N- PM). Application of 75% RDN+ 25 % N- PM, 75% RDN+ 25% N-FYM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1} resulted in significant increase in uptake of phosphorus (1.32, 1.30 and 1.29 kg ha^{-1}) than FYM @12 t ha^{-1}. The improvement in phosphorus uptake was due to mul-

Table 3. Nutrient uptake of maize as influenced by nutrient management in mango based Agri-Horti system.

Treatments	Nutreint uptake (kg ha^{-1})								
	Nitrogen			Phosphorus			Potassium		
	Knee high stage	Harvest		Knee high stage	Harvest		Knee high stage	Harvest	
		Stover	Grain		Stover	Grain		Stover	Grain
T_1- FYM@12 t ha^{-1}	15.50	42.80	61.79	1.08	3.88	8.41	35.79	66.10	24.68
T_2-125% RDN	19.47	60.15	90.98	1.17	4.19	9.14	38.77	72.58	28.90
T_3- 100 % RDF	19.30	57.52	88.98	1.18	4.18	9.15	38.50	72.50	28.88
T_4-75% RDN+ 25% N through FYM	19.35	58.12	89.93	1.30	4.32	9.28	40.38	77.31	29.73
T_5-75% RDN+ 25 % N through PM	19.44	58.43	90.20	1.32	4.42	9.31	42.40	78.25	30.50
T_6- 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}	19.32	58.05	89.82	1.29	4.35	9.28	38.82	72.75	29.01
T_7- 100% RDF-Sole crop without trees	19.27	56.97	88.58	1.18	4.17	9.12	38.15	71.85	28.82
CD (P = 0.05)	2.38	6.49	8.26	0.13	0.41	0.82	3.50	5.70	3.02
SEm±	0.78	2.11	2.69	0.04	0.13	0.27	1.14	1.86	0.99

tiplication effect of higher nutrient absorption i.e., phosphorus as well as high biomass production. The phosphorus uptake in stover at harvest was ranged from 3.88 kg ha^{-1} (FYM @12 t ha^{-1}) to 4.42 kg ha^{-1} (75% RDN+ 25 % N- PM). Application of 75% RDN+ 25 % N- PM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}, 75% RDN+ 25% N-FYM resulted in significant increase in uptake of phosphorus (4.42, 4.35 and 4.32 kg ha^{-1}) than FYM @12 t ha^{-1} but the application of 125% RDN, 100 % RDF and 100% RDF-Sole crop without trees resulted in increase in uptake of phosphorus (4.19, 4.18 and 4.17 kg ha^{-1}) which was on par with FYM @12 t ha^{-1}. The phosphorus uptake in grain at harvest was ranged from 8.41 kg ha^{-1} (FYM @12 t ha^{-1}) to 9.31 kg ha^{-1} (75% RDN+ 25 % N- PM). Application of treatments like 75% RDN+ 25 % N- PM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}, 75% RDN+ 25% N-FYM resulted in significant increase in uptake of phosphorus (9.31, 9.28 and 9.28 kg ha^{-1}) than FYM @12 t ha^{-1} but the application of 100 % RDF, 125% RDN and 100% RDF-Sole crop without trees resulted in increase in uptake of phosphorus (9.15, 9.14 and 9.12 kg ha^{-1}) which was on par with FYM @12 t ha^{-1}. Almaz *et al.* (2017) reported that integrated application of 50% NPK+50% poultry manure increased nutrient (N, P, and K) uptake of maize over sole poultry manure and sole inorganic fertilizer.

The potassium uptake at knee high stage ranged from 35.79 kg ha^{-1} (FYM @12 t ha^{-1}) to 42.40 kg ha^{-1} (75% RDN+ 25 % N- PM). Application of 75% RDN+ 25 % N- PM and 75% RDN+ 25% N-FYM resulted in significant increase in uptake of potassium (42.40 and 40.38 kg ha^{-1}) than FYM @12 t ha^{-1} but the application of 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}, 125% RDN, 100 % RDF and 100% RDF-Sole crop without trees resulted in increase in uptake of phosphorus (38.82, 38.77, 38.50 and 38.15 kg ha^{-1}) which was on par with FYM @12 t ha^{-1}. The improvement in potassium uptake was due to multiplication effect of higher nutrient absorption i.e., potassium as well as high biomass production. The potassium uptake in stover at harvest was ranged from 66.10 kg ha^{-1} (FYM @12 t ha^{-1}) to 78.25 kg ha^{-1} (75% RDN+ 25 % N- PM). Application of 75% RDN+ 25 % N- PM and 75% RDN+ 25% N-FYM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}, 125% RDN, 100 % RDF and 100% RDF-Sole crop without trees resulted in significant increase in uptake of potassium (78.25, 77.31, 72.75, 72.58, 72.50 and 71.85 kg ha^{-1}) than FYM @12 t ha^{-1}. The potassium uptake in grain at harvest was ranged from 24.68 kg ha^{-1} (FYM @12 t ha^{-1}) to 30.50 kg ha^{-1} (75% RDN+ 25 % N- PM). Application of 75% RDN+ 25 % N- PM and 75% RDN+ 25% N-FYM, 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}, 125% RDN, 100 % RDF and 100% RDF-Sole crop without trees resulted in significant increase in uptake of potassium (30.50, 29.73, 29.01, 28.90, 28.88 and 28.82 kg ha^{-1}) than FYM @12 t ha^{-1}. Similar results were obtained by Vidyavathi *et al*. 2012.

Among manurial combinations, the superiority of poultry manure over Azotobacter and FYM was well established in increasing the nutrient content may be due to its higher nutrient content and easy mineralization with low C:N ratio. Use of organic manures viz., poultry manure, FYM and Azotobacter has also been known to help in reducing the soil pH to some extent by producing organic acids while their decomposition, that may also be the reason for greater availability and mobility of nutrients. This could have also helped in additional uptake of the nutrients by plants (Prasad *et al*. 2010).

Dry matter production

A dry matter production was recorded at knee high stage and at harvest was presented in Table 4. The perusal of data of the dry matter production at knee high stage indicates that highest dry matter production was produced with the application of 75% RDN+ 25 % N- PM (1036.23 kg ha^{-1}) on par with 125% RDN (1030.52 kg ha^{-1}), 75% RDN+ 25% N-FYM (1023.48 kg ha^{-1}), 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1} (1012.48 kg ha^{-1}), 100 % RDF (1009.85 kg ha^{-1}), 100% RDF-Sole crop without trees (1009.45 kg ha^{-1}). Application of all the treatments improved dry biomass and significantly more than that of application of FYM @12 t ha^{-1} (897.12 kg ha^{-1}). Similar trend in dry biomass was sustained till harvest of the crop. The increase in dry matter production due to application of treatments may be attributed to the favourable soil physical and chemical environment. Interactive effect of FYM and fertilizer provided congenial soil environment for better plant growth

Table 4. SPAD reading, dry matter production and yield of maize influenced by nutrient management in mango based Agri-Horti systeml.

Treatments	SPAD reading			Dry matter (kg ha^{-1})		Yield (kg ha^{-1})
	Knee high stage	Tasselling	Harvest	Knee high stage	Harvest	
T_1- FYM@12 t ha^{-1}	45.13	45.70	10.11	897.12	10318.72	5540.00
T_2-125% RDN	50.42	52.58	12.78	1030.52	12290.42	6236.67
T_3- 100 % RDF	49.85	50.33	12.45	1009.85	12245.54	6200.00
T_4-75% RDN+ 25% N through FYM	49.75	49.75	11.37	1023.48	12286.54	6241.67
T_5-75% RDN+ 25 % N through PM	49.80	50.87	12.50	1036.23	12348.52	6244.00
T_6- 75% RDN+ Azotobacter+ PSB @ 5 kg ha^{-1}	49.10	49.41	11.30	1012.48	12222.58	6205.00
T_7- 100% RDF-Sole crop without trees	49.50	49.60	12.17	1009.45	12190.52	6199.33
CD (P = 0.05)	1.53	4.71	1.25	109.21	1156.13	580.68
SEm±	0.50	1.53	0.41	35.59	376.73	189.22

resulting into increased dry matter production of the crop (Joshi *et al*. 2013).

SPAD meter reading

SPAD values were recorded at knee high, tasselling stage and at harvest and were presented in Table 4. This SPAD values increased from knee high stage to tasselling stage and then decreased towards the maturity of the crop. The SPAD values of maize at knee high stage varied from 45.13 to 50.42. The perusal of data of the SPAD values at knee high stage indicates that highest SPAD reading was produced with the application of 125% RDN (50.42) followed by 100 % RDF application (49.85) which was statistically on par with other treatments except with FYM @ 12 t ha^{-1}. The perusal of data of the SPAD values at tasselling stage indicates that highest SPAD reading was produced with the application of 125% RDN (52.58) followed by 75% RDN+ 25 % N- PM application (50.87) which was statistically on par with other treatments except with FYM @ 12 t ha^{-1}. The perusal of data of the SPAD reading at harvest indicates that highest SPAD reading was produced with the application of 125% RDN (12.78) followed by 75% RDN+ 25 % N- PM application (12.50) which was on par with the application of 100% RDF, 100% RDF-Sole crop without trees (12.45 and 12.17). The application of 125% RDN, 75% RDN+ 25 % N- PM, 100% RDF, 100% RDF-Sole crop without trees, 75% RDN+ 25% N-FYM, 75% RDN+ Azotobacter+ PSB@ 5 kg ha^{-1} significantly increased the SPAD meter reading (12.78, 12.50, 12.45, 12.17, 11.37 and 11.30) respectively compared to the FYM @ 12 t ha^{-1} (10.11). Significant increase in SPAD values may be attributed to higher chlorophyll content because of more leaf nitrogen content as availability of nitrogen was increased due to application of treatments. Nitrogen being the major constituent of chlorophyll therefore increased in nitrogen availability leads to increase in chlorophyll content (Baharvand *et al*. 2014).

Yield

The grain yield of maize was presented in Table 4. The grain yield of maize ranged from 5540.00 kg ha^{-1} (FYM @ 12 t ha^{-1}) to 6244.00 kg ha^{-1} (75% RDN+ 25 % N- PM). Among the various treatments, the grain yield of maize followed the order of 75% RDN+ 25 % N- PM > 75% RDN+ 25% N-FYM > 125% RDN > 75% RDN+ Azotobacter+ PSB @5 kg ha^{-1} > 100 % RDF > 100% RDF-Sole crop without trees > FYM @12 t ha^{-1}. All the treatments application resulted in significant increase in grain yield over the FYM @12 t ha^{-1}. Application of treatments resulted in better soil physical environment and also increased availability of nutrients by improving biological activity and also supplied nutrients directly which was resulted in more plant growth and biomass production which inturn reflected in grain yield of maize. Increased grain yield might also be due to the increased photosynthetic activity which resulted in higher accumulation of photosynthates and translocation to sink due to better source and sink channel which resulted in higher grain yield. The conjunctive use of organic and inorganic sources has beneficial effect on physiological process of plant metabolism and growth, there by leading to higher grain yield. Aruna *et al*. (2020) revealed that maize yielded higher under chemical fertilizer integrated with poultry manure compared with their sole forms. Similar results were observed by Khaliq *et al*. (2004).

CONCLUSION

This study has shown that application of organic manures along with the chemical fertilizers not shown significantly influence on pH and EC of the soil at harvest of maize over initial values. Application of 75% RDN+ 25 % N- PM increased the available N, P, K content, nutrient uptake and dry matter production. SPAD values increased from knee high stage to tasselling stage and then decreased towards the maturity of the crop. Among manurial combinations, the superiority of poultry manure over Azotobacter and FYM was well established in increasing the nutrient content may be due to its higher nutrient content and easy mineralization with low C: N ratio. Application of all the treatments resulted in significant increase in grain yield over the FYM @12 t ha^{-1}.

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