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Nutrient uptake and soil available nutrients of drumstick as influenced by fertilizer levels and pruning techniques

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Abstract
The experiment was conducted for two consecutive years of 2016-17 and 2017-18 at Research Farm, Post Graduate Institute, MPKV, Rahuri Maharashtra to assess the "Nutrient uptake and soil available nutrients of drumstick as influenced by fertilizer levels and pruning techniques". The experiment was laid out in Factorial RBD design with three replications. The treatments comprised of three fertilizer levels *viz.*, 75% RDF plant^{-1}, 100% RDF plant^{-1} and 125% RDF plant^{-1} as main plot treatments and four pruning techniques *viz.*, No pruning of main shoot, pruning of main shoot at 30 cm from ground level, pruning of main shoot at 60 cm from ground level and pruning of main shoot at 90 cm from ground level at 90 days after transplanting. Application of 125 per cent RDF plant^{-1} recorded significantly higher plant dry matter production and pod dry matter production (4070.67 and 2981.63 kg ha^{-1}), (4148.00 and 3055.42 kg ha^{-1}) and (4109.33 and 3018.57 kg ha^{-1}), uptake of nitrogen (58.68, 89.29, 147.97 kg ha^{-1}, respectively), phosphorous (24.98, 14.04, 38.85 kg ha^{-1} respectively) and potassium (54.62, 64.10, 119.02 kg ha^{-1} respectively) by pod, plant and in total and soil available nitrogen (217.14, 227.56 and 222.35 kg ha^{-1}), phosphorous (27.53, 29.69 and 28.61 kg ha^{-1}) and potassium (307.79, 315.54 and 311.67 kg ha^{-1}) after harvest of drumstick crop during 2016-17, 2017-18 and on pooled mean, respectively than rest of the fertilizer levels. The pruning of main shoot of drumstick at a height of 60 cm from the ground level at 90 days after transplanting recorded significantly higher plant dry matter production and pod dry matter production (4268.44 and 3464.72 kg ha^{-1}), (4293.33 and 3605.28 kg ha^{-1}) and (4280.89 and 3534.99 kg ha^{-1}), uptake of nitrogen (67.82, 91.70, 159.52 kg ha^{-1}, respectively), phosphorus (28.60, 14.13, 42.50 kg ha^{-1}, respectively) and potassium (63.63, 65.16, 128.79 kg ha^{-1}, respectively) by pod, plant and in total and higher nitrogen (222.28, 229.21 and 225.75 kg ha^{-1}, respectively), phosphorous (27.78, 30.85 and 29.31 kg ha^{-1}, respectively) and potassium (311.94, 319.19 and 315.56 kg ha^{-1}, respectively) during 2016-17, 2017-18 and on pooled mean, respectively than rest of the pruning techniques. Significant interaction effect of fertilizer levels and pruning techniques on plant dry matter production and pod dry matter production (4629.33 and 4373.33 kg ha^{-1}), (4704 and 4531.15 kg ha^{-1}) and (4666.67 and 4452.24 kg ha^{-1}), uptake of nitrogen (186.20, 192.81 kg ha^{-1}, respectively), phosphorus (51.17, 57.32, 54.24 kg ha^{-1}, respectively) and potassium (150.91, 161.12 kg ha^{-1}, respectively) by pod and in total, respectively and it was obtained with the treatment combination, fertilizer levels of 125 per cent RDF plant^{-1} with pruning of main shoot at 60 cm from ground level at 90 days after transplanting and which was at par with fertilizer levels of 100 per cent RDF plant^{-1} with pruning of main shoot at 60 cm from ground level at 90 days after transplanting.

Keywords: Fertilizer, pruning, available nutrients, nutrient uptake and balance sheet etc.

Introduction
Drumstick (*Moringa oleifera* L.) is well known for its multi-purpose attributes, wide adaptability and ease of establishment. Moringa is popularly native to India. It is grown in tropical and sub-tropical areas. India is the largest producer of moringa with an area of 93,917 acres and production at 1,30,00,00 tons. Andhra Pradesh as the largest producer among the states, followed by Karnataka and Tamil Nadu in both area and production. Consequent to the release of PKM-1 annual moringa a bushy type amenable for seed propagation, the commercial cultivation has gained momentum in India. About 8,000 ha in Tamil Nadu, 6,000 ha in Andhra Pradesh and 2,000 ha in Maharashtra are under PKM-1 moringa. After first ratoon, the crop is removed and resown again for new crop.

Among the limiting factors of productivity, the nutrients application and their response in the growth and development of moringa largely decides the productivity and is a vital factor in as much as the soil, crop response which is always dynamic and vary extremely. The bulk production of pods (30 kg tree^{-1}) and leaves (100-120 kg tree^{-1}) depletes the soil nutrient status.

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India is the largest producer of moringa with an area of 93,917 acres and production at 1,30,00,00 tons. Moringa grows in sunny climates and wherever sufficient water and sunshine available. It grows in tropical and sub-tropical regions. It cannot sustain extreme cold and frost. Generally, it is cultivated in the months of July to October when there will be moderate weather conditions. Moringa grows well in loamy or sandy or combined loamy-sandy soil with pH value between 5 to 9. But best suited is at 7.5. Earlier perennial moringa occupied the major area and after the introduction of Periakulam-I cultivar a seed moringa type. It has become very popular due to factors like ease of propagation, convenience in transport and high yield potential.

Moringa is considered the most nutritious plant on this planet. Drumstick leaves, seeds, seed pods, flowers and roots are very nutritious, rich in vitamins A and C, iron and calcium, which help to (a) keep the skin healthy and smooth, (b) to make people strong and resistant to cold and infections and (c) to keep our bones strong. The drumstick tree is also grown as a homestead crop. According to the scientific records, moringa leaves contain twice the protein of yogurt, 7 times the vitamin C of oranges, 4 times the calcium of milk, 4 times the vitamin A found in carrots and 3 times the iron found in almonds, 3 times the potassium in banana and 2 times the protein in milk. Hence, moringa plant can be considered as a powerhouse of nutritional value (Moyo *et al*. 2011) [8].

Drumstick is a popular vegetable in South Indian states. Flowering in drumstick varies from place to place and is greatly influenced by rain, temperature, humidity, wind, soil temperature, soil moisture etc. Under South Indian condition, one or two distinct peak periods of flowering noticed. Peak period of flowering in central parts of Kerala is December-January while in southern part it is February-March and July-August with maximum flowering in February-March. Under Coimbatore and Bangalore conditions, flowering seasons are March-May and July-September respectively. PKM-1 propagated through seeds is developed at Horticultural Research Station, TNAU, Periyakulam. Plants grow to a height of 4 to 6 m and come to flower in 90 to 100 days after planting. The first harvest starts 160 to 170 days after planting and on an average each tree bears 200 to 225 fruits year^{-1}. Pods are 65 to 70 cm long with 6.3 cm girth and 150 g weight. Fruits are green coloured and highly pulpy. Drumstick is predominantly a crop of dry and arid tracts. However, intensive cultivation with good irrigation and systematic cultural practices will give good yield especially for annual type. The plant put forth luxuriant growth at 25 to 30 ºC. Higher temperature results in heavy flower shedding. Crop is also injured severely by frost.

For sowing in normal manner in prepared pits, about 1.250 kg seeds are required acre^{-1}, when two seeds are planted in a pit. The seeds after planting easily germinates in two weeks. However, if the seeds are kept in water overnight and planted next day, it will quicken germination. For enabling sowing, pits of size 45 cm x 45 cm x 45 cm in length x width x depth are to be prepared. Leave it for a few days exposed to sun rays to protect the plant from earthy pests. Apply farmyard manure at the rate of 15 kg pit^{-1} and mix it with top soil and fill the pits before sowing. The seeds are also sown in poly bags of size 20 cm height and 15 cm dia., duly filling the bag with mixture of soil 2/3rd and sand 1/3rd portion. Sow 2 to 3 seeds and water them the seed will germinate in about 10 days. Keep the polybags with the moringa plants in shade and after some time keep one healthy plant and remove other plants from the polybag. When the plants reach a height of 60 to 70 cm, transplant them in prepared pits for further growth.

Since the plants take time to grow and start yielding, inter cropping with short duration vegetables is beneficial. The cropping pattern for drumstick is annual as well as perennial. In annual pattern, the plants are re-cultivated after two yields, whereas in perennial cultivation such as in rain fed areas, the plant is kept for periods up to five or six years, following due pruning practices. Water requirement is less for this plant; hence this is capable of giving yield in drought condition also but to a lesser extent. But with following proper irrigation methods like drip irrigation and fertigation, it will give more yield. It is a must when annual cropping pattern is followed. For annual cropping pattern with normal irrigation, the plants are to be irrigated before sowing and a few days after sowing, to allow the seeds to germinate. Onward once in 15 to 20-day interval will do. It is a potential crop for dry land agriculture and can be successfully grown on marginal and cultivable wastes on borders along bunds and suits very well in agri-horti-silvi systems. Drumstick has been a neglected crop and very little has been done crop improvement and production technology. Considerable variation is seen from plant to plant and it has many cultural problems like shy hearing, tall growth and non-availability of technical knowhow on cultural or nutritional requirements. Hence, greater attention and research on the nutritional aspects needed to improve and meet the human needs.

The moringa growing areas are cropped nearly eight months in a year and varying quantities of fertilizers have been applied over the years. This practice has resulted in the soil health deterioration and makes the soil, crop response and uptake of nutrients more complex that leads to deficiency of one or two elements. The restoration of soil health and enhancing the quality of the produce are considered as prime factors in recent times thus, receives much attention in all the crops and moringa is no exception. Hence proper nutrient management practices will be required in moringa cultivation. In the past ten years. The demand of this crop in Maharashtra has increased considerably. The soil and climatic conditions of Maharashtra are better suited for its cultivation and would gain a successful establishment in all agroclimatic zones of Maharashtra. In near future, considering its increasing demand in our Maharashtrian diet. Its cultivation would fetch greater returns to our farmers. Keeping these views, it is decided to standardize the package of practices for this magic crop especially for Maharashtra with respect to nutrient management and pruning which will serve as the guideline to our farmers for commercial cultivation of this crop.

Materials and Methods

The experiment was conducted for two consecutive years of 2016-17 and 2017-18 at Research Farm, Post Graduate Institute, MPKV, Rahuri Maharashtra to assess the "Influence of fertilizer levels and pruning techniques on yield attributes, yield and economics of drumstick". The area falls under semi-arid tropical zone and receives and annual average rainfall of 520 mm.

The experiment was laid out in Factorial RBD design with three replications. The treatments comprised of three fertilizer levels *viz.*, 75% RDF plant^{-1}, 100% RDF plant^{-1} and 125% RDF plant^{-1} as main plot treatments and four pruning techniques *viz.*, No pruning of main shoot, pruning of main shoot at 30 cm from ground level, pruning of main shoot at 60 cm from ground level and pruning of main shoot at 90 cm from ground level. The pits of 30 cm x 30 cm x 30 cm at a distance of 2.5 m x 2.5 m were dug out fifteen days before transplanting and kept open in sunlight for 15 days. The pits were filled with topsoil along with well decomposed fine textured farmyard manure @ 0.5 kg pit^{-1}. The healthy seedlings having uniform girth and almost equal heights were selected and one seedling pit^{-1} was planted according to the plan of layout. Due care was taken to keep rhizosphere sufficiently moist in order to ensure proper establishment of plants up to 30 days. The treatments were imposed thereafter.

Recommended dose of fertilizers 250:125:125 N, P_2O_5 and K_2O g plant^{-1} were applied as per the treatments *i.e.* 75 per cent, 100 per cent and 125 per cent in 5 equal splits (20 per cent each split). Out of this, 20 per cent at the time of transplanting as a basal dose, 20 per cent at the time of pruning and remaining 60 per cent 3 equal splits at every two months interval from date of transplanting as a top dressing during both years of investigation to the drumstick (Table.1).

Table 1: Treatment wise schedule of fertilizer application to the drumstick

Fertilizer levels	No. of split	Each splits (g plant^{-1})			Total quantity (kg ha^{-1})			Each splits (kg ha^{-1})			Total quantity (kg ha^{-1})		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P*	K*	N	P*	K*
75% RDF	5	37.5	18.75	18.75	187.5	93.75	93.75	60	13.2	24.9	300	66	124.5
100% RDF	5	50	25	25	250	125	125	80	17.6	33.2	400	88	166
100% RDF	5	62.5	31.25	31.25	312.25	156.25	156.25	100	22	41.5	500	110	207.5

*P = 0.44 x P_2O_5, *K = 0.83 x K_2O

The treatment wise pruning of drumstick plant was done with the help of hand operated saw at 90 days after transplanting except P_1. After pruning bordo paste was applied to prevent fungal infection to drumstick plant.

Dry matter production (kg)

Two plants from each treatment were uprooted after last harvesting, then they were chopped into small pieces and were sundried till constant weight was obtained and recorded the dry matter of each plant and expressed in kg.

Soil analysis

Before layout of experiment soil samples were collected from five randomly selected spots at 0-30 cm depth and made a composite sample for initial analysis. After harvest of crop, soil samples at 0 to 30 cm depth were collected from each treatment plot. After air drying these samples were grinded in wooden mortar and pestle and sieved through 2 mm sieve and used for chemical analysis *viz.*, pH, EC, organic carbon, soil available N, P, K content in soil by using standard analytical methods during both the year of experimentation.

Nutrient uptake (kg ha^{-1})

On the basis of dry pod yield and N, P and K content in plant and pods of drumstick, the nutrient uptake kg ha^{-1} for each treatment were estimated by using following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{\% of nutrient concentration}}{100} \times \text{Total dry yield of drumstick (kg ha}^{-1}\text{)}$$

Statistical analysis of the data was carried out according to Factorial RBD. The experimental data were pooled and the mean data for two years are subjected to statistical scrutiny as per methods suggested by Panse and Sukhatme (1985) [10]. The 'F' test of significance was used for testing the null hypothesis and appropriate standard error of mean (S.E. mean) for each treatment effect was calculated. Where the treatment effects were significant, the critical difference (CD) at 5% probability level was worked out for testing the significance of treatment differences.

Results and Discussion

A. Plant and pod dry matter production (kg ha^{-1})

The plant dry matter production and pod dry matter production of drumstick as influenced by different fertilizer levels and pruning techniques are presented in Table 2.

The mean plant dry matter production and pod dry matter production of drumstick was (3894.37 and 2569.46 kg ha^{-1}), (3960.00 and 2693.86 and kg ha^{-1}) and (3927.33 and 2631.66 kg ha^{-1}) during first year, second year and pooled mean, respectively.

Fertilizer levels

Data presented in Table 2 revealed that the plant dry matter production and pod dry matter production of drumstick was influenced significantly due to different fertilizer levels during both the years of experimentation. Application of 125 per cent RDF plant^{-1} recorded significantly higher plant dry matter production and pod dry matter production (4070.67 and 2981.63 kg ha^{-1}), (4148.00 and 3055.42 kg ha^{-1}) and (4109.33 and 3018.57 kg ha^{-1}), respectively than 75 per cent RDF and it was at par with 100 per cent RDF plant^{-1} (4001.33 and 2731.38 kg ha^{-1}), (4080.00 and 2920.76 kg ha^{-1}) and (4040.67and 2826.07 kg ha^{-1}), respectively during 2016-17, 2017-18 and pooled mean. Significantly minimum plant dry matter production (3612 and 1995.29 kg ha^{-1}), (3652 and 2105.40 kg ha^{-1}) and (3632 and 2050.35 kg ha^{-1}), respectively was observed under 75 per cent of RDF plant^{-1} during both the years and on pooled mean.

In this present investigation, accumulation of pod dry matter increased significantly due to application of higher fertilizer dose. The results showed that the highest pod dry matter production was recorded in fertilizer level of 125 per cent RDF plant^{-1} it can be concluded that, fertilizers have positively influenced the pod dry matter production and were directly proportional to each other. This might be due to increased nutrient uptake and transport efficiency partitioning

the nutrients, enhanced enzyme synthesis etc. finally leads to enhanced plant dry matter which has considerable bearing on the growth and growth parameter. In this present investigation, accumulation of plant dry matter increased significantly due to application of higher fertilizer dose. This is in conformity with finding of Vijaykumar (2000) [13], Beaulah and Vadivel (2001) [2], Vaishapayan and Joshi (2003) [12], Jadhav *et al.* (2010) [4] and Sagvekar *et al.* (2017) [11] in papaya.

Pruning techniques

Data presented in Table 2 indicated that pruning of main shoot of drumstick at a height of 60 cm from the ground level at 90 days after transplanting recorded significantly higher plant dry matter production and pod dry matter production (4268.44 and 3464.72 kg ha^{-1}), (4293.33 and 3605.28 kg ha^{-1}) and (4280.89 and 3534.99 kg ha^{-1}, respectively than rest of the pruning techniques 2016-17, 2017-18 and on pooled mean. The pruning of main shoot at 90 cm from ground level at 90 days after transplanting found second in rank in respect of plant dry matter production and pod dry matter production (4010.67 and 2931.53 kg ha^{-1}), (4090.67 and 3050.90 kg ha^{-1}) and (4050.67 and 2991.21 kg ha^{-1}), respectively of drumsticks during both the years and on pooled mean. Significantly minimum plant dry matter production and pod dry matter production (3477.33 and 1366.37 kg ha^{-1}), (3557.33 and 1392.76 kg ha^{-1}) and (3517.33 and 1379.56 kg ha^{-1}), respectively of drumstick was registered by no pruning technique during both years and on pooled mean.

It was interesting to note that the plant dry matter production was influenced more positively when fertilizers were coupled with pruning techniques rather than applied individual. This might be due to the pruning of main shoot of drumstick at a height of 60 cm from the ground level at 90 days after transplanting and well-established root system in addition to the improved plant height, number of branches, plant spread and number of leaf petioles. The pruning of main shoot of drumstick at a height of 60 cm would have stimulated better root growth and translocated higher quantities of nutrients resulting in vigorous vegetative growth (Beaulah and Vadivel, 2001) [2] in moringa have made similar report on increased plant dry matter production because pruning of main shoot of drumstick at a height of 60 cm also increased dry matter production significantly. This is in conformity with finding of Vijaykumar (2000) [13], Beaulah and Vadivel (2001) [2], Vaishapayan and Joshi (2003) [12], Jadhav *et al.* (2009) and Nouman *et al.* (2013) [9].

Interaction

The interaction effect of fertilizer levels and pruning techniques on plant dry matter production and pod dry matter production of drumstick was found significant during both the years and on pooled mean. The application of 125 per cent of RDF plant^{-1} to drumstick along with pruning of main shoot at 60 cm from ground level at 90 days after transplanting recorded significantly higher plant dry matter production and pod dry matter production (4629.33 and 4373.33 kg ha^{-1}), (4704 and 4531.15 kg ha^{-1}) (4666.67 and 4452.24 kg ha^{-1}), respectively than rest of the treatment combinations and it was at par with 100 per cent of RDF plant^{-1} to drumstick along with pruning of main shoot at 60 cm from ground level at 90 days after transplanting (4400, 4480 and 4440 kg plant^{-1}, respectively) during 2016-17, 2017-18 and on pooled mean in respect of plant dry matter production. Whereas significantly minimum plant dry matter production and pod dry matter production of drumstick (3424 and 1135.37 kg ha^{-1}), (3504 and 1247.58 kg ha^{-1}) and (3464 and 1191.47 kg plant^{-1}), respectively was observed with application of 75 per cent of RDF plant^{-1} to drumstick coupled with no pruning technique during both the years and on pooled mean.

B. Nutrient uptake (kg ha^{-1})

The uptake of nitrogen, phosphorous and potassium by drumstick pod, plant and in total after harvest of crop in different fertilizer levels and pruning techniques was more in pooled mean and which are presented in Table 2.

Fertilizer levels

Data presented in Table 2 revealed that the uptake of nitrogen, phosphorous and potassium by drumstick pod, plant and in total after harvest, was influenced significantly due to the different fertilizer levels during both the years of experimentation. Application of 125 per cent RDF plant^{-1} noticed significantly maximum uptake of nitrogen (58.68, 89.29, 147.97 kg ha^{-1}, respectively), phosphorous (24.98, 14.04, 38.85 kg ha^{-1} respectively) and potassium (54.62, 64.10, 119.02 kg ha^{-1} respectively) by pod, plant and in total than 75 per cent RDF and it was at par with application of 100 per cent RDF plant^{-1} nitrogen (86.85, 141.05 kg ha^{-1}, respectively), phosphorus (13.21, 36.07 kg ha^{-1},respectively) and potassium (62.07, 112.68 kg ha^{-1}, respectively) by pod, plant and in total during both the year and on pooled mean. Significantly minimum uptake of nitrogen, phosphorous and potassium by drumstick pod, plant and in total was observed under 75 per cent of RDF plant^{-1} during both the years and on pooled mean.

The significantly maximum uptake of nitrogen, phosphorus and potassium by drumstick crop recorded due to application of fertilizer levels of 125 per cent RDF plant^{-1} during first and second year of study, respectively. This might be attributed due to higher nutrient concentration and total dry matter production of drumstick plant. The frequently split application of nutrients in the vicinity of root zone of the crop created congenial condition for enhancing the uptake of these nutrients up to fruiting or pod development period. These findings were in the line of those reported by Hanchinamani and Madalageri (1994) [3], Beaulah and Vadivel (2001) [2], Kavino *et al.* (2002) [6] in banana, Vaishapayan and Joshi (2003) [12], Jaykumar *et al.* (2010) in papaya and Ahmed *et al.* (2016) [1] in drumstick.

Pruning techniques

Data presented in Table 2 indicated that pruning of main shoot of drumstick at a height of 60 cm from the ground level at 90 days after transplanting recorded significantly higher uptake of nitrogen (67.82, 91.70, 159.52 kg ha^{-1}, respectively), phosphorus (28.60, 14.13, 42.50 kg ha^{-1}, respectively) and potassium (63.63, 65.16, 128.79 kg ha^{-1}, respectively) by pod, plant and in total during both the year and on pooled mean and it was at par with pruning of main shoot of drumstick at a height of 90 cm from the ground level at 90 days after transplanting uptake of nitrogen (85.93 kg ha^{-1}, respectively) by plant during both the year and on pooled mean. Significantly minimum uptake of nitrogen, phosphorous and potassium by pod, plant and in total of drumstick was registered by no pruning technique during both years.

The significantly maximum uptake of nitrogen, phosphorus and potassium by drumstick crop recorded due to pruning of main shoot of drumstick at a height of 60 cm from the ground

level at 90 days after transplanting during first and second year of study, respectively. This might be attributed due to higher nutrient concentration and total dry matter production of drumstick plant during growth of both the year. These findings were in the line of those reported by Hanchinamani and Madalageri (1994) [3], Beaulah and Vadivel (2001) [2], Kavino *et al.* (2002) [6] in banana, Vaishapayan and Joshi (2003) [12] and Jaykumar *et al.* (2010) in papaya.

Interaction

The interaction effect of fertilizer levels and pruning techniques on uptake of nitrogen, phosphorus and potassium by pod and in total of drumstick was found significant during both the years and on pooled mean. The application of 125 per cent RDF plant^{-1} to drumstick along with pruning of main shoot at 60 cm from ground level at 90 days after planting recorded significantly higher uptake of nitrogen (186.20, 192.81 kg ha^{-1}, respectively), phosphorus (51.17, 57.32, 54.24 kg ha^{-1}, respectively) and potassium (150.91, 161.12 kg ha^{-1}, respectively) by pod and in total than rest of the treatment combinations during 2016-17, 2017-18 and on pooled mean. Whereas significantly minimum uptake of nitrogen, phosphorus and potassium by pod and in total of drumstick was observed with application of 75 per cent RDF plant^{-1} to drumstick coupled with no pruning technique during both the years and on pooled mean.

C. Nutrient balance

The balance sheet of available nitrogen, phosphorous and potassium as influenced by different fertilizer levels and pruning techniques after harvest of drumstick crop are presented in Table 3.

Fertilizer levels

Data presented in Table 3 revealed that, the fertilizer levels under study recorded gain in available nitrogen, phosphorous and potassium after harvest of drumstick crop during both the year of study. Application of 125 per cent RDF plant^{-1} to drumstick recorded maximum gain of available nitrogen (51.56 kg ha^{-1}) and available phosphorus (7.19 kg ha^{-1}) and available potassium (43.55 kg ha^{-1}) than 75 per cent RDF plant^{-1} and 100 per cent RDF plant^{-1} to drumstick found second in rank in respect of gain of available nitrogen (48.56 kg ha^{-1}) and available phosphorus (6.49 kg ha^{-1}) and available potassium (41.81 kg ha^{-1}) of drumsticks during both the year under study. The minimum gain in available nitrogen, phosphorous and potassium after harvest of drumstick crop was observed under 75 per cent RDF plant^{-1} during both the year under study.

Pruning techniques

Data presented in Table 3 indicated that pruning of main shoot of drumstick at a height of 60 cm from the ground level at 90 days after transplanting recorded numerically more gain in available nitrogen (53.21 kg ha^{-1}), available phosphorous (8.35 kg ha^{-1}) and available potassium (47.19 kg ha^{-1}) after harvest of drumstick crop than rest of the pruning techniques during both the year of study. The pruning of main shoot at 90 cm from ground level at 90 days after transplanting found second in rank in respect of gain in available nitrogen (50.20 kg ha^{-1}), available phosphorous (7.38 kg ha^{-1}) and available potassium (46.33 kg ha^{-1}) after harvest of drumstick crop during both the year of study. The minimum gain in available nitrogen, phosphorous and potassium after harvest of drumstick was registered by no pruning technique during both years.

D. Soil available nutrient (kg ha^{-1})

The available nitrogen, phosphorus and potassium in soil after harvest of drumstick crop as influenced by different fertilizer levels and pruning techniques are presented in Table 4.

The mean available nitrogen (212.46, 221.38 and 216.92 kg ha^{-1}), phosphorus (26.89, 28.59 and 27.74 kg ha^{-1}) and potassium (302.62, 312.45 and 307.54 kg ha^{-1}) after harvest of drumstick crop during first, second year and pooled mean, respectively.

Fertilizer levels

Data presented in Table 4 revealed that the soil available nitrogen, phosphorous and potassium in soil after harvest of drumstick crop was influenced significantly due to the different fertilizer levels during both the year under study. Application of 125 per cent RDF plant^{-1} to drumstick registered significantly maximum available nitrogen (217.14, 227.56 and 222.35 kg ha^{-1}), phosphorous (27.53, 29.69 and 28.61 kg ha^{-1}) and potassium (307.79, 315.54 and 311.67 kg ha^{-1}) after harvest of drumstick crop than 75 per cent RDF and it was at par with 100 per cent RDF plant^{-1} nitrogen (214.28, 224.56 and 219.42 kg ha^{-1}, respectively), phosphorous (27.09, 28.99 and 28.04 kg ha^{-1}, respectively) and potassium (300.08, 313.81 and 306.95 kg ha^{-1}, respectively) during 2016-17, 2017-18 and pooled mean. Significantly minimum soil available nitrogen, phosphorus and potassium was observed under 75 per cent RDF plant^{-1} during both the years and on pooled mean.

The higher soil available nitrogen, phosphorous and potassium in soil after harvest of drumstick crop in fertilizer levels 125 per cent RDF plant^{-1} it might be due to application of higher levels of fertilizer and lower uptake of nutrients by the crop and as results of which remained unutilized by the drumstick crop and reflected as soil available nitrogen, phosphorous and potassium in soil after harvest. Similar results were reported by Mir *et al.* (2013) [7] in pomegranate, Ahmed *et al*. (2016) [1] in drumstick and Sagvekar *et al.* (2017) [11] in papaya.

Table 2: Influence of fertilizer levels and pruning techniques on plant dry matter production, pod dry matter production and nutrient uptake of drumstick

Treatment	Plant dry matter production (kg ha^{-1})			Pod dry matter production (kg ha^{-1})			Pooled nutrient uptake (kg ha^{-1})								
							Nitrogen			Phosphorus			Potassium		
	2016	2017	Pooled	2016	2017	Pooled	Pod	Plant	Total	Pod	Plant	Total	Pod	Plant	Total
A. Fertilizer levels (F)															
F_1:75% RDF plant^{-1}	3612.00	3652.00	3632.00	1995.29	2105.40	2050.35	36.00	72.83	108.83	12.89	8.72	21.62	33.79	49.57	83.36
F_2:100% RDF plant^{-1}	4001.33	4080.00	4040.67	2731.38	2920.76	2826.07	54.20	86.85	141.05	22.86	13.21	36.07	50.61	62.07	112.68
F_3:125% RDF plant^{-1}	4070.67	4148.00	4109.33	2981.73	3055.42	3018.57	58.68	89.29	147.97	24.98	14.04	38.85	54.92	64.10	119.02
S.Em. (±)	54.30	62.16	71.48	85.68	65.28	87.34	1.50	2.64	3.86	0.65	0.37	1.02	1.39	1.67	3.23
C.D. at 5%	159.25	182.30	203.72	251.29	191.46	248.93	4.29	7.53	11.01	1.85	1.05	2.92	3.96	4.76	9.19
B. Pruning techniques (P)															
P_1: No pruning of main shoot	3477.33	3557.33	3517.33	1366.37	1392.76	1379.56	25.11	73.05	98.16	9.56	9.72	19.28	23.31	51.23	74.55
P_2: Pruning of main shoot at 30 cm from ground level	3822.22	3898.67	3860.44	2515.23	2726.53	2620.88	49.02	81.27	130.30	19.54	11.26	30.80	45.78	57.19	102.96
P_3: Pruning of main shoot at 60 cm from ground level	4268.44	4293.33	4280.89	3464.72	3605.26	3534.99	67.82	91.70	159.52	28.60	14.13	42.50	63.63	65.16	128.79
P_4: Pruning of main shoot at 90 cm from ground level	4010.67	4090.67	4050.67	2931.53	3050.90	2991.21	56.55	85.93	142.47	23.28	12.86	36.13	53.05	60.75	113.79
S.Em. (±)	62.70	71.77	62.70	98.93	75.38	88.76	1.32	2.47	3.48	0.58	0.33	0.97	1.30	1.51	2.89
C.D. at 5%	183.89	210.51	178.70	290.17	221.08	252.99	3.77	7.05	9.92	1.65	0.95	2.76	3.70	4.30	8.23
C. Interaction effect (F x P)															
F_1P_1	3424.00	3504.00	3464.00	1135.37	1247.58	1191.47	19.52	67.77	87.30	6.39	7.26	13.65	18.85	45.24	64.09
F_1P_2	3552.00	3632.00	3592.00	1766.53	1918.85	1842.69	31.49	71.60	103.09	10.83	8.27	19.10	30.10	48.50	78.59
F_1P_3	3776.00	3696.00	3736.00	2567.33	2642.02	2604.68	47.38	76.47	123.85	17.71	10.00	27.72	43.85	52.83	96.68
F_1P_4	3696.00	3776.00	3736.00	2511.93	2613.16	2562.55	45.59	75.47	121.06	16.64	9.37	26.00	42.36	51.71	94.07
F_2P_1	3536.00	3616.00	3576.00	1525.33	1602.22	1563.78	29.39	76.19	105.59	11.61	10.68	22.29	26.97	54.36	81.33
F_2P_2	4005.33	4080.00	4042.67	2816.00	3200.00	3008.00	57.46	86.54	144.00	23.59	12.50	36.09	53.15	61.86	115.01
F_2P_3	4400.00	4480.00	4440.00	3453.50	3642.61	3548.06	68.83	96.39	165.22	29.99	15.55	45.54	64.81	68.85	133.66
F_2P_4	4064.00	4144.00	4104.00	3130.67	3238.20	3184.43	61.13	88.27	149.40	26.25	14.09	40.35	57.51	63.22	120.73
F_3P_1	3472.00	3552.00	3512.00	1438.40	1328.48	1383.44	26.41	75.18	101.60	10.67	11.22	21.89	24.11	54.10	78.22
F_3P_2	3909.33	3984.00	3946.67	2963.17	3060.73	3011.95	58.12	85.68	143.80	24.21	13.01	37.22	54.09	61.20	115.29
F_3P_3	4629.33	4704.00	4666.67	4373.33	4531.15	4452.24	87.26	102.25	189.51	38.08	16.83	54.24	82.23	73.79	156.02
F_3P_4	4272.00	4352.00	4312.00	3152.00	3301.33	3226.67	62.92	94.04	156.96	26.94	15.10	42.04	59.27	67.31	126.57
S.Em. (±)	108.60	124.32	142.95	171.36	130.56	174.68	3.01	5.29	7.72	1.30	0.74	2.05	2.78	3.34	6.45
CD at 5%	318.50	364.61	NS	502.58	382.91	497.85	8.57	NS	NS	3.69	NS	5.84	7.92	NS	NS

Table 3: Balance sheet of mean available nitrogen, phosphorus and potassium as influenced by fertilizer levels and pruning techniques after harvest of drumstick (2016-2018)

Treatment	Initial nutrient status (A) (kg ha^{-1})			Nutrient added (B) (kg ha^{-1})			Total nutrient uptake (C) (kg ha^{-1})			Expected nutrient balance (D) (kg ha^{-1}) [D=(A+B)-C]			Actual nutrient status (E) (kg ha^{-1})			Apparent gain or loss (F) (kg ha^{-1}) [F=E-D]			Actual gain or loss (G) (kg ha^{-1}) [G=E-A]		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
A. Fertilizer levels (F)																					
F_1: 75% RDF plant^{-1}	176	22.5	272	608.96	137.60	261.48	217.65	43.23	166.72	567.31	116.87	366.76	212.01	27.10	308.01	-355.30	-89.77	-58.76	36.01	4.60	36.01
F_2: 100% RDF plant^{-1}	176	22.5	272	808.96	181.60	344.48	282.10	72.13	225.37	702.86	131.97	391.11	224.56	28.99	313.81	-478.30	-102.98	-77.30	48.56	6.49	41.81
F_3: 125% RDF plant^{-1}	176	22.5	272	1008.96	225.60	427.48	295.93	77.70	238.05	889.03	170.40	461.43	227.56	29.69	315.54	-661.47	-140.71	-145.89	51.56	7.19	43.55
B. Pruning techniques (P)																					
P_1: No pruning of main shoot	176	22.5	272	808.96	181.60	344.48	196.32	38.55	149.09	788.64	165.55	467.39	208.45	25.12	297.61	-580.19	-140.43	-169.78	32.45	2.62	25.61
P_2: Pruning of main shoot at 30 cm from ground level	176	22.5	272	808.96	181.60	344.48	260.59	61.60	205.93	724.37	142.50	410.55	221.65	28.52	314.69	-502.71	-113.98	-95.86	45.65	6.02	42.69
P_3: Pruning of main shoot at 60 cm from ground level	176	22.5	272	808.96	181.60	344.48	319.05	85.00	257.57	665.91	119.10	358.91	229.21	30.85	319.19	-436.70	-88.25	-39.72	53.21	8.35	47.19
P_4: Pruning of main shoot at 90 cm from ground level	176	22.5	272	808.96	181.60	344.48	284.95	72.26	227.58	700.01	131.84	388.90	226.20	29.88	318.33	-473.81	-101.95	-70.57	50.20	7.38	46.33
General mean	176	22.5	272	808.71	181.60	344.48	265.23	64.35	210.04	719.73	139.74	406.44	221.38	28.59	321.66	-498.35	-111.15	-93.98	45.38	6.09	40.45

Table 4: Available nutrient in soil as influenced by fertilizer levels and pruning techniques after harvest of drumstick

Treatment	Soil available nutrient (kg ha^{-1})								
	Nitrogen			Phosphorus			Potassium		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
A. Fertilizer levels									
F_1:75% RDF plant^{-1}	205.97	212.01	208.99	26.06	27.10	26.58	299.99	308.01	304.00
F_2:100% RDF plant^{-1}	214.28	224.56	219.42	27.09	28.99	28.04	300.08	313.81	306.95
F_3:125% RDF plant^{-1}	217.14	227.56	222.35	27.53	29.69	28.61	307.79	315.54	311.67
S.Em. (±)	2.89	3.68	3.29	0.37	0.61	0.48	2.20	2.03	2.10
C.D. at 5%	8.49	10.80	9.64	1.07	1.79	1.46	6.45	5.97	6.33
B. Pruning techniques (P)									
P_1: No pruning of main shoot	196.74	208.45	202.60	25.40	25.12	25.26	281.93	297.61	289.77
P_2: Pruning of main shoot at 30 cm from ground level	213.73	221.65	217.69	26.79	28.52	27.65	306.44	314.69	310.56
P_3: Pruning of main shoot at 60 cm from ground level	222.28	229.21	225.75	27.78	30.85	29.31	311.94	319.19	315.56
P_4: Pruning of main shoot at 90 cm from ground level	217.08	226.20	221.64	27.60	29.88	28.74	310.17	318.33	314.25
S.Em. (±)	3.34	4.25	3.79	0.42	0.71	0.57	2.54	2.35	2.43
C.D. at 5%	9.80	12.47	11.13	1.24	2.07	1.68	7.45	6.89	7.32
C. Interaction effect (F x P)									
F_1P_1	193.63	200.32	196.97	27.10	24.76	25.93	286.24	291.38	288.81
F_1P_2	209.63	214.42	212.03	24.95	26.95	25.95	299.48	311.15	305.32
F_1P_3	212.29	217.08	214.68	27.00	28.95	27.98	308.22	315.34	311.78
F_1P_4	208.32	216.24	212.28	25.17	27.75	26.46	306.02	314.15	310.09
F_2P_1	192.24	209.36	200.80	24.35	24.84	24.60	262.37	299.20	280.79
F_2P_2	214.31	221.29	217.80	27.24	29.00	28.12	309.50	315.62	312.56
F_2P_3	230.32	236.24	233.28	27.75	31.65	29.70	315.28	321.24	318.26
F_2P_4	220.25	231.35	225.80	29.00	30.45	29.73	313.17	319.17	316.17
F_3P_1	204.37	215.67	210.02	24.75	25.75	25.25	297.18	302.24	299.71
F_3P_2	217.26	229.25	223.26	28.18	29.61	28.89	310.33	317.31	313.82
F_3P_3	224.24	234.31	229.28	28.58	31.94	30.26	312.32	320.97	316.65
F_3P_4	222.69	231.02	226.85	28.62	31.45	30.03	311.33	321.66	316.49
S.Em. (±)	5.79	7.36	8.11	0.73	1.22	1.23	4.40	4.07	5.19
CD at 5%	NS	NS	NS	2.15	NS	NS	12.91	NS	NS
General mean	212.46	221.38	216.92	26.89	28.59	27.74	302.62	312.45	307.54
Initial status	176.00	--	--	22.50	--	--	272.00	--	--

Pruning techniques

Data presented in Table 4 revealed that the soil available nitrogen, phosphorous and potassium in soil after harvest of drumstick crop was influenced significantly due to the different pruning techniques during both the year of the experimentation. The pruning of main shoot of drumstick at a height of 60 cm from the ground level at 90 days after transplanting recorded significantly higher nitrogen (222.28, 229.21 and 225.75 kg ha^{-1}, respectively), phosphorous (27.78, 30.85 and 29.31 kg ha^{-1}, respectively) and potassium (311.94, 319.19 and 315.56 kg ha^{-1}, respectively) than rest of the pruning techniques during 2016-17, 2017-18 and on pooled mean and it was at par with pruning of main shoot at 30 cm from ground level at 90 days after transplanting nitrogen (213.73, 221.65 and 217.69 kg ha^{-1}, respectively), phosphorous (26.79 and 27.65 kg ha^{-1}, respectively) and potassium (306.44, 314.69 and 310.56 kg ha^{-1}, respectively) and pruning of main shoot at 90 cm from ground level at 90 days after transplanting nitrogen (217.08, 226.20 and 221.64 kg ha^{-1}, respectively), phosphorous (27.60, 29.88 and 28.74 kg ha^{-1}, respectively) and potassium (310.17, 318.33 and 314.25 kg ha^{-1}, respectively) during 2016-17, 2017-18 and pooled mean. Significantly minimum soil available nitrogen, phosphorus and potassium of drumstick was registered by no pruning technique during both years and on pooled mean.

The pruning of main shoot of drumstick at a height of 60 cm from the ground level at 90 days after transplanting registered maximum the soil available nitrogen, phosphorous and potassium in soil after harvest of drumstick crop but, did not shown any directly influenced on the soil available nitrogen, phosphorous and potassium in soil after harvest of drumstick crop of drumstick. Similar results were reported by Mir *et al*. (2013) [7] in pomegranate, Ahmed *et al*. (2016) [1] in drumstick and Sagvekar *et al*. (2017) [11] in papaya.

Interaction

The interaction effect between fertilizer levels and pruning techniques were found non-significant in respect of soil available nitrogen, phosphorous and potassium after harvest of drumstick crop during first, second year and on pooled mean.

Conclusion

Based on two years of experimentation, it could be concluded that, application of fertilizer levels 125 per cent RDF plant^{-1} (312.5:156.25: 156.25, N, P_2O_5 and K_2O g plant^{-1}) in five equal splits and pruning of main shoot of drumstick at a height of 60 cm from the ground level at 90 days after transplanting registered maximum plant dry matter production, pod dry matter production, nutrient uptake and soil available nutrients of drumstick and it was at par with fertilizer level 100 per cent RDF plant^{-1} (250:125:125, N, P_2O_5 and K_2O g plant^{-1}) in five equal splits.

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