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Studies on the Effect of Split Application of NPK Fertilizers on Growth and Yield of Papaya under Central Dry Zone of Karnataka

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ABSTRACT

A field experiment was conducted at Eswargere village, Hiriyur taluk, Chitradurga district during the year 2020-2021 to assess the effects of split application of nitrogen, phosphorus, and potassium (NPK) fertilizer on papaya growth and yield, and the experiment was set up in Randomized Complete Block Design. The treatments include seven treatments comprising varying rates (75, 100 and 125% recommended dose of fertilizers) and time of application (Bimonthly and monthly intervals). Among growth attributes plant height (186.70 cm), stem girth (46.38) was recorded highest in 125% RDF through split application. In yield attributes maximum fruit length (23.54 cm) circumference (44.75 cm), volume (1711.07 cc) firmness (7.43 kg/cm^2), total yield (138.83 t/ha) and lowest cavity index (14.84) were also observed in 125% RDF through split. Applying of 125% RDF through split at different growth stages (187.5:156.25:125 N: P_2O_5: K_2O g/plant) in vegetative stage of 4 months, (62.5:125:187.5 N: P_2O_5: K_2O g/plant) in flowering to fruit set stage of 2 months, (62.5:31.25:312.5 N: P_2O_5: K_2O g/plant) in fruit development stage of 3 months at monthly interval showed to be better for fetching maximum plant growth and yield of papaya fruits.

Keywords *Carica papaya* L., RDF, Leaf area, Fruit volume, Cavity index, Total fruit yield.

INTRODUCTION

Papaya (*Carica papaya* Linn.) a significant tropical fruit crop and has long been referred to as the "miracle fruit of the tropics." Next to bananas, it provides a better income and fruit production per hectare and it belongs to the family Caricaceae. In India it is commonly known as Papita, pawpaw or True Melon. Papaya's country of origin is South American country Mexico. The papaya fruit is attractive, delicious and it has multifarious uses. It contains high amounts of vitamin A. Generally it is imagined that yellow pigment of fruit is due to Carotene, but papaya has yellow

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pigment because of caricaxanthin. The fruit of papaya also have ß-Cryptoxanthin (8.1µg/g) showing 62% of carotenoid content making yellow/orange fleshed cultivars which are common (Saran *et al.* 2019).

It is well established that the nutrient up take pattern and nutrient requirement varies at different growth phases of fruit crops such as the juvenile phase, blooming phase, and fruit initiation, fruit development, and fruit ripening phases, have variable nutrient uptake patterns and requirements. Papaya nutrition was differed from other crops due to its quick growth, continuous fruiting habit, heavy feeding ability and fruit yield (Jone *et al.* 2019).

Papaya being an exhaustic crop it requires heavy doses of manures and fertilizers in order to sustain its high yield potential and also for its indeterminate growth habit with simultaneous leaf and fruit production. Other than basal dose of manures applied in the pits, 250 g each of N and P_2O_5 and 500 g K_2O are recommended by Karnataka horticulture department for getting high yield.

Among the nutritional factors, importance of nitrogen, phosphorus and potash nevertheless are supreme. Nitrogen is an essential aspect of many structural, genetic, and metabolic components found in plant cells. It is also a basic component of many important organic substances such as amino acids, nucleic acids, proteins, enzymes, and the chlorophyll molecule. Nitrogen is the nutrient that often provides the highest yield response in agricultural plants, supporting rapid vegetative development and providing the plant with a healthy green color (Parmar *et al.* 2017). Growth attributes of papaya like plant height, stem girth and number of leaves was accomplished by nitrogen was explained in many reports (Kumar *et al.* 2017, Evangelina *et al.* 2015).

Phosphorus (P) is a soil nutrient that is needed for plant growth and metabolism, and it is primarily responsible for blooming, fruit set, and root formation. It is essential in numerous plant functions, including energy metabolism, nucleic acid and membrane synthesis, respiration, photosynthesis, absorption of nitrogen, and enzyme regulation (Bindu and Podikunju 2017). Many studies (Prajapati and Prajapati 2017, Singh and Varu 2013) have found that phosphorus improves reproductive characteristics such as flowering, fruit set, fruit yield and also source for early flowering and fruiting in papaya. Plants with an overabundance of phosphorus will exhibit symptoms of calcium insufficiency. This is because too much phosphorus interferes with calcium uptake. Symptoms are the browning and dying off of new growth at the tips of leaves and roots, disease susceptibility, and poor-quality fruit and seed production.

Potassium is frequently referred to as the quality nutrient for crop production, and it has been widely illustrated to play an important role in the improvement of many quality parameters, including fruit size, appearance, color, soluble solids, taste, and shelf life of papaya fruits, since it gets involved in the conversion of starch into sugars and also speeds up the various enzyme activities (Panigrahi *et al.* 2015). Potash deficiency in early stage leads to curling of small leaves and gradually declines growth. In acute cases of deficiency, it leads to marginal leaf burning or scorching and discoloration (Vos and Arancon 2020).

Knowing of all these three nutrients importance in fruit growth, appearance of toxicity symptoms when we applied in excess quantities, the mode of application has to be changed i.e., split application. Split application of N, P and K fertilizers doses at different growth stages of papaya plant can leads to optimal use of fertilizers and can also impart the benefit to the papaya growers. Despite multiple attempts on nutritional requirements in papaya, studies on split application at various phases are lacking. Hence a research program was formulated to study the growth and yield of papaya by split application of fertilizers at different growth stages.

MATERIALS AND METHODS

A field trial was carried out on papaya variety Taiwan Red lady at Eswargere village, Hiriyur taluk of Chitradurga district located at 13° 57' North latitude and 70° 37' East longitude at an elevation of 606.1 m above the mean sea level during 2020-21. The soil was red loam with pH 7.10, EC 0.38 dSm^{-1} and available N, P, K was 295.16, 29.10 and 207 kg/ha, respectively. The experiment was designed using

Randomized Block Design, with four replications and seven treatments T_1 – 100% recommend dose of fertilizers (RDF) (250:250:500 g of NPK/ plant), T_2 – 125% RDF (312.5:312.5:625 g of NPK/ plant), T_3 –75% RDF (187:187:375 g of NPK/ plant), T_4 – 100% RDF through split application, T_5 –125% RDF through split application, T_6–75% RDF through split application, T_7 – Absolute control (No fertilizer application) Table 1. Experimental plants were supplied with FYM at 10 kg per plant at the time of planting and fertilizers were applied as per the treatment requirements. Recommended dose of fertilizers 250: 250: 500 N: P_2O_5: K_2O gram/plant was adopted to carry out the experiment. Fertilizer doses were applied during the months of Oct -June. The recommended dose of N, P and K required for different treatments were supplied in the form of Urea – CH_4N_2O (46-0-0), Di-ammonium phosphate – $NH_4H_2PO_4$ (18-46-0) and Muriate of potash - KCL (0-0-60). For treatment T_4, T_5 and T_6 the recommended dose of fertilizers was split and applied at different stages viz., vegetative stage (four equal splits), flowering to fruit set stage (two equal splits) and fruit development stage (three equal splits).

Three plants were selected and labelled in each treatment in all the four replications and were used for recording the observations. The height of the plant was measured from the ground to the bottom of newly emerged leaf, stem girth was measured at 10 cm above from the ground level with help of measuring tape they recorded at 180, 240 and 300 days after transplanting. The observations on yield and yield attributes were fruit length, fruit circumference, fruit volume, fruit firmness, fruit cavity index, total fruit yield. These parameters were taken from five fruits of each treatment at 80% maturity. The data was analyzed statistically by following the procedure outlined by Fisher and Yates (1963) and method proposed by OP Sheoran.

RESULTS AND DISCUSSION

The height and stem girth of the plant are considered to be an important factor to judge the vigour in papaya crop. As recorded in the present study compared to 100% recommended dosage of NPK fertilizers

Table 1. Stages of split application of recommended dosage of NPK fertilizers for T_4, T_5, T_6.

Stages	Duration	Per cent nutrient per plant N	P_2O_5	K_2O
Vegetative	4 months	60%	50%	20%
Flowering to fruit set	2 months	20%	40%	30%
Fruit development	3 months	20%	10%	50%

Note :

1. Treatments T_1, T_2 and T_3 the recommended dose of fertilizers were applied bimonthly as per the treatment.
2. The treatment T_4, T_5 and T_6 (Table 1) the recommended dose of fertilizers were used in accordance with schedule given as under and applied in monthly interval,

250:250:500 g plant^{-1} the height and stem girth of plant at 180 DAT (138.28 cm and 30.85 cm), 240 DAT (161.69 cm and 38.98 cm) and 300 DAT (186.70 cm and 46.38 cm) recorded maximum in the treatment 125 % RDF through split application (Table 2). Which is an added advantage of initial plant height and stem girth due to better nutrient uptake. The plants showed high vigour in terms of vegetative growth in the treatment 125% RDF through split application which can be reflected in terms of increased plant height and stem girth in comparison to other treatments. This is because of continuous availability of nitrogen and phosphorus fertilizer throughout the growing period, which is due to timely split application of appropriate fertilizers. The application of adequate quantity of phosphorus fertilizers helps in healthy root establishment there by enhances the nutrient and water uptake which can be visualized through crop growth. The enhanced uptake of nitrogen promotes the luxuriant growth of plant there by increase the plant height and stem girth. These results are in confirm with the findings reported by Parmar *et al.* (2017) and Jone *et al.* (2019) in papaya, Suhasini *et al.* (2018) in banana.

Results indicated that split application of NPK fertilizers significantly affected the yield and yield attributes viz., fruit length, diameter, volume and circumference. Amongst the treatments, highest fruit length (23.54 cm), diameter (14.36 cm), volume (1711.07 cc), circumference (44.75 cm) and total fruit yield (138.83 t/ha) were observed in the split application of 125% RDF, which was on par with T_4 (100% RDF through split application), when compared to

Table 2. Effect of split application of NPK fertilizers on plant height and stem girth at various stages of growth.

Treatments	Plant height (cm)			Stem girth (cm)		
	180 DAT	240 DAT	300 DAT	180 DAT	240 DAT	300 DAT
T_1-100% RDF (250:250:500 N:P_2O_5:K_2O g/plant)	121.55	142.53	162.30	26.20	33.13	38.50
T_2-125% RDF	127.33	148.35	170.45	27.10	35.80	42.83
T_3-75% RDF	119.55	139.37	157.23	23.14	30.83	35.43
T_4-100% RDF through split application	132.93	153.37	179.78	29.20	36.43	43.60
T_5-125% RDF through split application	**138.28**	**161.69**	**186.70**	**30.85**	**38.98**	**46.38**
T_6-75% RDF through split application	125.25	145.58	167.75	26.30	32.90	39.58
T_7-Absolute control	107.37	119.50	131.58	16.20	23.78	28.63
SEm ±	1.58	2.78	1.91	0.54	0.72	0.78
CD @ 5%	4.70	8.26	5.67	1.62	2.25	2.32

recommended dose of NPK. While lowest values for fruit length, diameter, volume and circumference were recorded in the absolute control (Table 3).

The increase in fruit yield, fruit length, fruit diameter, fruit volume and fruit circumference is possible due to that the increased number of leaves and leaf area, as well as improved physiological features, resulted in better transport of nutrients from source to sink, resulting in better fruit development. The increase in fruit volume could be due to bigger size of fruits under 125% and also 100% of RDF fertilizers through split application. The transport of photosynthates from source to sink, i.e., higher translocation, was perhaps achievable due to increased sink capacity, as evidenced by the increased quantity of fruits per plant. Similarly, improvement in fruit number, fruit weight with split application of NPK resulting higher carbohydrate acquisition in plant at initial stages of growth as a resulted high nutrient supply, which makes an increased in fruit size and there by increased the average fruit weight in terms of length and diameter of fruit (Parmar *et al*. 2018). The higher nutrient content and metabolic levels enhanced the fruit parameters, ultimately leading to higher yield. In split application of NPK increased potassium rates along with moderate levels of nitrogen and phosphorus during fruit development stage is known to regulate the transpiration and water conductance in plant cells, thereby increasing the photosynthetic activity, this results in increased carbohydrate synthesis, translocation, and accumulation, resulting in larger-sized fruits. Fruit yield increased by better availability and uptake of nutrients by plant roots and enhancing the source sink relationship by increasing the movement of carbohydrates from the leaves to the fruits (Jone *et al.* 2019). These results are in agreement with findings of Bindu and Podikunju

Table 3. Effect of split application of NPK fertilizers on yield and yield attributes of papaya.

Treatments	Fruit length (cm)	Fruit circum-ference (cm)	Fruit volume (cc)	Fruit firmness (kg/cm^2)	Fruit cavity index (%)	Total fruit yield (t/ha)
T_1-100% RDF (250:250:500 N:P_2O_5:K_2O g/plant)	19.27	31.53	1381.66	6.17	21.89	94.40
T_2-125% RDF	20.30	38.20	1517.86	6.33	18.85	109.74
T_3-75 % RDF	18.03	30.18	1210.72	6.02	25.66	79.70
T_4-100% RDF through split application	23.01	42.48	1646.60	6.80	15.23	128.53
T_5-125% RDF through split application	**23.54**	**44.75**	**1711.07**	**7.43**	**14.84**	**138.83**
T_6-75% RDF through split application	19.73	34.93	1470.00	6.18	19.98	97.18
T_7-Absolute control	14.71	25.66	966.15	5.14	28.86	35.49
SEm ±	0.75	0.82	41.10	0.26	0.62	4.36
CD @ 5%	2.22	2.44	122.10	0.77	1.83	12.94

(2017), Agarwal and Sahu (2020) and Kanwar *et al.* (2020) in papaya.

Firmness of fruits is an important characteristic that is used to determine stability and it is predominantly determined by structure and composition of cell wall. Which was observed highest (7.43kg/cm^2) in 125% split application of NPK fertilizers. Calcium is important for structural integrity of both the cell wall and plasma membrane. Higher amount of phosphorus is known to form a bond with calcium and make it unavailable keeping this concept in mind we have applied less quantity of phosphorus to enhance the calcium availability binds with the calcium uptake is highly correlated with rhizosphere of the crop and we could find it in split application. Even potash is also known to strengthen the cell tissue there by enhances the fruit firmness. The results are similar with the findings of Tandel *et al.* (2017), Parmar *et al.* (2018) in papaya (Table 3).

Among the treatments cavity index minimum was recorded in (14.84 %) split application of 125% RDF, compared to 100% RDF and maximum was recorded in absolute control. In split application at fruit development stage, potassium was applied in large quantities. So, it may be the reason for low cavity index and more pulp thickness. Increase in pulp thickness may be ascribed to the role of potassium in influencing the developing fruit which is acting as a stronger sink for K than other nutrients. The results are similar with findings of Tandel *et al.* (2017) in papaya (Table 3).

CONCLUSION

By considering the results obtained from the present study, although plant receiving 125% RDF through split application showed maximum growth and yield parameters but found comparable to that of treatment 100% RDF applied through split application. So, it can be concluded that 100% RDF through split application at different growth stages i.e., 150:125:100 N: P_2O_5: K_2O g/plant in vegetative stage, 50:100:150 N: P_2O_5: K_2O g/plant in flowering to fruit set stage, 50:25:250 N: P_2O_5: K_2O g/plant in fruit development stage proved to be better for getting maximum yield of the papaya with the maximum returns and BCR at Hiriyur region of Chitradurga district in Karnataka.

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