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A Correlation Study of different Fertigation Doses and Foliar Sprays on Yield of Papaya Variety Surya

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ABSTRACT: A field experiment on papaya variety Surya with different doses of fertigation and micronutrient foliar sprays was conducted during the period 2018 – 2020 at Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram. The experiment was laid out in randomised block design with combination of four fertigation doses of 75%, 100%, 125% and 150% RDF of N and K and three foliar sprays (1% 19:19:19, 0.5% $ZnSO_4$ + 0.3% borax and water spray) which where compared with soil application of recommended dose of NPK (control 1) and soil application of NPK plant^{-1} year^{-1} based on soil test data as organic manures as combination of FYM, poultry manure and vermicompost in the ratio of 2:1:1 (control 2). The correlation coefficients indicate the presence of inherent association between various characters under study. The study revealed that the number of fruits per plant had very highly positive, significant correlation and very dependable relationship with yield (r=0.991), plant height (r=0.976), plant girth (r=0.955), number of leaves (r=0.979), leaf area index (r=0.986), fruit set percentage (r=0.990), fruit weight (r=0.974), fruit length (r=0.983), fruit girth (r=0.977) and flesh thickness (r=0.972).

Keywords: Borax, correlation, fertigation, foliar sprays, $ZnSO_4$.

INTRODUCTION

Papaya (*Carica papaya* L.) is extensively cultivated as a cash crop in tropical and subtropical regions. India is one of the major papaya producing countries and it is the fourth most traded crop. According to data of NHB (2020), India is the leading producer of papaya in the world with an area of 1,42,000 hectares and production of 60,11,000 MT.

In papaya, right choice of adoption of fertigation technology is very much required for reducing the quantity of fertilizers, saving water and labour, increasing yield, and for congenial soil environment. Also, boron and zinc deficiencies are reported in papaya. Micronutrient foliar spray will help to overcome nutrient deficiencies and can also help the plant to shield itself from pest attacks by providing extra nutrients to maintain a healthy immune system. The positive influence of fertigation on yield and yield parameters of papaya was revealed by Jeyakumar *et al.* (2010); Sadarunnisa *et al*. (2010). Kumar *et al*. (2022) reported that foliar application of zinc and boron improved the yield and quality of papaya cv. Red Lady. The present investigation was, therefore, undertaken to study the influence of fertigation and micronutrient foliar sprays on growth and yield attributes of papaya var. Surya.

MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala from June 2018 to February 2020 to study the influence of fertigation and foliar nutrition on growth and yield of papaya variety Surya.

The experiment consists of 14 treatments replicated thrice, which was laid out in Randomised block design. Fertigation treatments were fixed based on the N and K recommendation as per KAU POP (Kerala Agricultural University, Package of Practices) based on soil test data (187:170:341 g NPK plant^{-1} year^{-1}) for papaya. Three foliar sprays (1.0 % 19:19:19 at bimonthly interval starting from 4 MAP to 16 MAP, 0.5% $ZnSO_4$ + 0.3% borax at 4th, 8th, 12th and 16th MAP and water spray at bimonthly interval starting from 4 MAP to 16 MAP) were also used with different levels of fertigation. These were compared with soil application of recommended dose (RD) of NPK (187:170:341 g NPK plant^{-1} year^{-1} based on soil test data) (control 1) and soil application of 187:170:341 g NPK plant^{-1} year^{-1}based on soil test data as organic manures as combination of FYM, poultry manure and vermicompost in the ratio of 2:1:1 (control 2). Treatment details are given in Table 1.

Table 1: Treatment details.

Treatment details	
T_1	75% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19
T_2	75% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax
T_3	75% RD of N and K through fertigation and water spray
T_4	100% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19
T_5	100% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax
T_6	100% RD of N and K through fertigation and water spray
T_7	125% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19
T_8	125% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax
T_9	125% RD of N and K through fertigation and water spray
T_{10}	150% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19
T_{11}	150% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax
T_{12}	150% RD of N and K through fertigation and water spray
T_{13}	Control 1 - KAU POP (187:170:341 g NPK plant^{-1} year^{-1} based on soil test data, soil application of nutrients with conventional land management)
T_{14}	Control 2 - Organic POP (187:170:341 g NPK plant^{-1} year^{-1} based on soil test data as organic manures as combination of FYM, poultry manure and vermicompost in the ratio of 2:1:1

Organic manure (15 kg FYM plant^{-1}) was given uniformly to all treatments as basal. Basal soil application of lime and rock phosphate (500g and 850g respectively based on soil test data) was applied uniformly for all treatments except controls. Urea and Muriate of Potash (MOP) were used as fertilizer sources for fertigation applied weekly from 1 MAP to 20 MAP.

The observations were recorded on plant height, plant girth, number of leaves, leaf area index, fruit set percentage, fruit weight, fruit length, fruit girth, flesh thickness, number of fruits per plant and yield ha^{-1}.

Plant height. Height of plants were recorded in centimeters from soil level to the tip of growing point from all observation plants, 12 months after planting and average were worked out.

Plant girth. Girth of the stem was assessed at 10 cm above the ground level with help of measuring tape, 12 months after planting and average were worked out and expressed in centimeters.

Number of leaves. Total number of active leaves per plant was counted from all observation plants, 12 months after planting and the average number of leaves was worked out. Fully developed and newly emerged leaves, excluding dead and dry leaves were considered as active leaves.

Leaf Area Index. Leaf area was measured with the help of graph paper in square centimetre and average was worked out. The index leaf (sixth leaf) from all observation plants were collected, 12 months after planting and leaf area index was calculated using the formula

$$\text{LAI} = \frac{\text{Leaf area}}{\text{Spacing } (\text{m}^2)}$$

Fruit set percentage. Total number of hermaphrodite and female flowers and fruits produced were recorded in all observation plants and expressed in per cent and average was worked out.

$$\text{Fruit set percentage} = \frac{\text{Number of fruits set plant}^{-1}}{\text{Number of flowers plant}^{-1}} \times 100$$

Fruit weight. Five fruits were randomly selected from each observation plant and average fruit weight was worked out and recorded in grams.

Fruit length. Fruit length was measured from the stalk end to the floral end of five randomly selected fruits from each observation plant and average fruit length was worked out and expressed in centimeters.

Fruit girth. The girth of five randomly selected fruits from each observation plant was assessed at the maximum width point with measuring tape and average girth was worked out and expressed in centimeters.

Flesh thickness. Flesh thickness of five randomly selected fruits from each observation plant was measured and average was worked out and expressed in centimeters.

Number of fruits per plant. Total number of fruits from each observation plant was counted and average worked out.

Yield ha^{-1}. Yield per hectare was calculated by multiplying per plant yield with number of plants per hectare.

Statistical analysis. The experimental data recorded was subjected to statistical analysis as per the method suggested by Panse and Sukhatme (1967). The correlation studies were done by Karl Pearson's method.

RESULTS AND DISCUSSION

Plant height. Plant height recorded at 12 MAP registered highest plant height (236.40 cm) for T_4 (100% RD of N and K through fertigation and foliar sprays of 1.0% 19:19:19) whereas, T_3 (75% RD of N and K through fertigation and water spray) recorded least plant height of 176.52 cm (Table 2), which had significant difference over other treatments. Split application of adequate quantity of fertilizers during growth and development of papaya through fertigation that enhanced fertilizer use efficiency in addition to the foliar application of 1.0% 19:19:19 might have contributed to the maximum plant height in T_4. Similar results of enhanced plant height under 100 % fertigation was reported by Agrawal *et al*. (2010) in papaya cv. Red Lady. Shimi (2014) reported that foliar application of 19:19:19 at 4 MAP was beneficial in improving the plant height in banana cv. Nendran.

Plant girth. At 12 MAP, highest plant girth (51.65 cm) was recorded in T_4 which differed significantly from all

other treatments and lowest plant girth of 30.92 cm was noticed in T_3 (Table 2). Increased uptake of nutrients, nitrogen and potassium under optimum dose of fertigation and foliar application of 1.0%19:19:19 might have contributed to expansion of stem girth. Jeyakumar *et al*. (2010) reported significantly higher stem girth upon fertigation with 100 % RD of N and K in papaya. Enhanced photosynthetic efficiency achieved due to elevated uptake and deposition of nutrients in leaf tissues contributed to the greater synthesis, translocation and accumulation of carbohydrates which in turn improved the trunk girth (Ghanta *et al.,* 1995).

Number of leaves. Data on number of leaves recorded at 12 MAP, revealed the highest number of leaves (31.22) in T_4 and lowest number of leaves (16.56) was noticed in T_3 (Table 2), which differed significantly from other treatments. Majid *et al*. (2022) reported 100% RDF through fertigation at 7 days intervals in apple as efficient for improving vegetative growth characters. Consistent moisture level and nutrient reserve developed in the soil as a result of drip fertigation at frequent intervals makes the roots remain active for a longer period (Wuertz *et al*., 2000). Mishra *et al*. (2005) noticed increase in accessibility of nutrients and enhanced movement of food materials to the plant, grown in soil equipped with adequate and continuous moisture in the soil, which further accelerated the vegetative growth of plant parts. Kachwaya and Chandel (2015) also registered more number of leaves in strawberry plants fertigated with full nutrient package compared to soil fertilization. Shimi (2014) reported that foliar spray with 19:19:19 at 4 and 6 MAP significantly enhanced the number of functional leaves per plant in banana cv. Nendran.

Leaf area index. Observations on leaf area index recorded at 12 MAP registered highest value (4.20) for T_4, which was on par with T_5 (100% RD of N and K through fertigation and foliar sprays of 0.5% $ZnSO_4$ and 0.3% borax) with a leaf area index of 4.11 (Table 2) and differed significantly from other treatments. Lowest leaf area index of 2.71 was recorded in T_3. Higher leaf area index in T_4 might be due to optimum receival of major nutrients round the crop growth period by increased split supply through fertigation in relatively smaller quantity in addition to the foliar application of 19:19:19. Greater uptake and aggregation of nutrients in leaf tissues, contributes to the higher synthesis, transport and accumulation of carbohydrates further resulting in higher photosynthetic efficiency (Ghanta *et al*., 1995). Shimi (2014) reported that foliar supply with 19:19:19 at 4 and 6 MAP significantly increased the leaf area index in banana cv. Nendran.

Fruit set percentage. The fruit set was highest (86.27 %) in the treatment T_4, which was on par with T_5 with a fruit set of 85.43 per cent (Table 2), which differed significantly from all other treatments. T_3 registered lowest fruit set of 64.50 %. Enhanced synthesis of the hormones auxin and gibberellin achieved in plants due to increased uptake of nutrients in treatment T_4 contributed to the highest fruit set. Several studies pointed out minimal fruit drop in crops receiving water through drip irrigation. This is because water is supplied nearer to the root zone in this technique and soil moisture is always maintained in the field capacity range and no moisture stress is experienced during the flowering and fruit development stage, which might have contributed to the higher fruit set per cent. Singh *et al*. (2006) reported similar findings in mango.

Fruit weight. Fruit weight of 14 treatments influenced by different levels of fertigation and different foliar sprays are presented in table 2, which showed significant difference among the treatments. Highest fruit weight of 797.51 g was noticed in T_4, which was on par with T_5 (792.42 g). Lowest fruit weight of 569.84 g was noticed in T_3. According to Sharma *et al*. (2013) internal nutritive condition of plant have improved as a result of fertigation with 100 % RD of N and K, resulting in enhanced photosynthesis contributing to increased growth and vigour. Apart from this, the fertigation accelerated transportation of photosynthates from source to sink and further to fruits as influenced by the growth hormones thereby increasing the fruit weight. Fertigation with 100 % RD of N and K improved the fruit weight in papaya cv. Red Lady (Jadhav *et al*., 2016). Increase in fruit weight with foliar sprays of borax may be due to involvement of boron in hormonal metabolism, and thereby improvement in cell division and cell expansion. Zinc plays a crucial role in facilitating formation of starch and transportation of carbohydrates in plants. Bhatt *et al.* (2012) reported a significantly highest fruit weight in mango cv. Dashehari treated with Borax 0.5%. Deshmukh and Hardaha (2014) documented lowest fruit weight in plants receiving lower dose through fertigation in papaya cv. Taiwan 786.

Fruit length. Highest fruit length (16.90 cm) was observed in T_4 which was on par with T_5 (16.79 cm) in the present study, whereas, lowest fruit length of 9.15 cm was noticed in T_3 (Table 2). The increase in fruit length upon receiving optimum doses of nutrients through fertigation in addition to foliar spraying of 19:19:19 and 0.5 % $ZnSO_4$ + 0.3 % borax may be due to the incitation in the growth of flesh. Also, it seems that under fertigation, uniform distribution of N and K, and its confinement to the root zone might have increased its uptake and enhanced synthesis of metabolites resulting increase in fruit size. Jadhav *et al.* (2016) inferred that application of 100 % RD of N and K through fertigation was favourable for higher fruit length in papaya cv. Red Lady. Increase in fruit length in T_5 might be due to the function of zinc in governing the semi-permeability of cell walls, thus mobilizing more water into fruits resulted in increased fruit size. Similar findings were observed in papaya by Pant and Lavania (1989). A similar finding of lowest fruit length in lowest fertigation dose was reported by Sharma *et al*. (2005) in papaya.

Fruit girth. Effect of different levels of fertigation and different foliar sprays on fruit girth of 14 treatments are presented in Table 2 and it exhibited significant variation among treatments. T_4 reported highest fruit girth of 13.90 cm, which was on par with T_5 (13.74 cm). Lowest fruit girth of 7.86 cm was noticed in T_3. In papaya cv. Red Lady, application of 100 % RD of N and K through fertigation registered highest fruit girth (Jadhav *et al*., 2016). Similar result of increment in fruit

girth due to combined application of zinc and boron was reported by Trivedi *et al*. (2012) in guava.

Flesh thickness. T_4 recorded highest flesh thickness of 3.42 cm, which was on par with T_5 (3.39 cm) and differed significantly from other treatments (Table 2). Fruits with lowest flesh thickness of 1.55 cm were observed T_3. Highest flesh thickness observed in T_4 and T_5 may be due to the efficient and timely usage of optimum dose of nutrients through fertigation and foliar sprays of 1.0% 19:19:19 and 0.5% $ZnSO_4$ + 0.3% borax. According to Jadhav *et al*. (2016) fertigation with 100 % RD of N and K registered highest flesh thickness in fruits of papaya cv. Red Lady. Hada (2013) reported highest flesh thickness in guava cv. L-49 fruit on spraying with 0.8% $ZnSO_4$ and 0.4% borax.

Number of fruits per plant. In the present study, T_4 registered highest number of fruits (48.11) (Table 2). It was on par with T_5 with 47.45 fruits. Efficient and timely use of optimum quantity of nutrients through fertigation and foliar sprays might have contributed to the highest number of fruits registered in T_4 and T_5. Similar results of increment in number of fruits on supply of 100 % RD of N and K was reported by Tank and Patel (2013) and Jadhav *et al*. (2016) in papaya cv. Madhu Bindu and Red Lady respectively. Gurjar *et al*. (2015) also reported similar results of highest number of fruits per tree in mango cv. Alphonso treated with 0.5% borax and 1% $ZnSO_4$ compared to plants which received water spray. Decrease in the fruit drop achieved as a result of micronutrient spray with borax and $ZnSO_4$ might have increased the fruit number. Deshmukh and Hardaha (2014) reported less number of fruits in plants receiving lower fertilizer dose in papaya cv. Taiwan 786.

Yield ha^{-1}. Highest yield per hectare (95.76 t ha^{-1}) was recorded in T_4 in the present study, which was on par with T_5 with an yield of 93.99 t ha^{-1} (Table 2). Lowest yield per hectare (40.52 t ha^{1}) was noticed in T_3. Optimum nutrient concentration in the root zone maintained throughout the crop growth period by supply of optimum dose of nutrients through fertigation enhanced the fruit yield in T_4 and T_5 by way of increasing weight, diameter and length of fruit. Also, these increase in yield can be justified by the fact that timely application of judicious amounts of nutrients directly to the crop root zone by fertigation improved the nutrient use efficiency of crops and reduced the N and K losses through leaching and percolation (Rolston *et al*., 1986; Kavino *et al*., 2002). Growth attributes of plants witnessed an increasing trend with fertigation due to enhanced uptake of moisture and nutrients which increases the photosynthetic rate and absorption of photosynthetically active radiation. It will further leads to translocation of photosynthates towards reproductive organ (sink) which results in increased yield of plant (Kaur *et al*., 2019). Bura *et al*. (2023) noticed enhanced yield per hectare in strawberry cv. Camarosa, supplied with 100 % of recommended dose of NPK through drip. A similar findings of enhanced fruit yield in papaya upon raised bed cultivation + drip irrigation + fertigation + micronutrient spray $ZnSO_4$ 0.5% + boric acid (0.2%) was reported by Auxcilia *et al*. (2022).

Correlation analysis of different fertigation doses and foliar sprays on biometric and yield parameters of papaya variety Surya. It is evident from Table 3 that there was a significant, highly positive correlation and marked relationship between plant height and yield (r=0.987). The plant girth showed a strong positive and significant linear correlation with yield (r=0.964) and plant height (r=0.969). Number of leaves had significant and strong positive linear relationship between yield (r=0.985), plant height (r=0.975) and plant girth (r=0.957). The leaf area index had significant and strong positive linear relationship between yield (r= 0.991), plant height (r=0.986), plant girth (r=0.955) and number of leaves (r=0.985). Fruit set percentage had very strong positive and significant correlation with yield (r=0.978), plant height (r=0.967), plant girth (r=0.931), number of leaves (r=0.973) and leaf area index (r=0.974).

Fruit weight had very highly positive and significant correlation as well as very dependable relationship with yield (r=0.993), plant height (r=0.983), plant girth (r=0.944), number of leaves (r=0.978), leaf area index (r=0.986) and fruit set percentage (r=0.967). Fruit length had significant correlation and positive relationship with yield (r=0.977), plant height (r=0.973), plant girth (r=0.935), number of leaves (r=0.973), leaf area index (r=0.978), fruit set percentage (r=0.993) and fruit weight (r=0.971). Fruit girth had strong positive and significant correlation with yield (r=0.989), plant height (r=0.984), plant girth (r=0.951), number of leaves (r=0.986), leaf area index (r=0.988), fruit set percentage (r=0.978), fruit weight (r=0.991) and fruit length (r=0.987). Flesh thickness had a highly positive correlation and marked linear relationship with yield (r=0.990), plant height (r=0.989), plant girth (r=0.971), number of leaves (r=0.979), leaf area index (r=0.989), fruit set percentage (r=0.954), fruit weight (r=0.988), fruit length (r=0.968) and fruit girth (r=0.988). Number of fruits per plant had very highly positive, significant correlation and very dependable relationship with yield (r=0.992), plant height (r=0.976), plant girth (r=0.955), number of leaves (r=0.979), leaf area index (r=0.986), fruit set percentage (r=0.991), fruit weight (r=0.974), fruit length (r=0.983), fruit girth (r=0.977) and flesh thickness (r=0.972).

Table 2: Effect of fertigation and foliar sprays on biometric and yield parameters of papaya variety Surya.

Treatments	Plant height (cm) (12MAP)	Plant girth (cm)12 MAP	Number of leaves (12 MAP)	Leaf area index (12 MAP)	Fruit set (%)	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Flesh thickness (cm)	Number of fruits per plant	Yield (t ha^{-1})
T_1	208.55	40.00	26.22	3.60	80.57	708.93	14.60	11.83	2.48	41.00	72.66
T_2	205.27	37.94	23.89	3.44	79.34	703.47	14.45	11.13	2.41	40.11	70.53
T_3	176.52	30.92	16.56	2.71	64.50	569.84	9.15	7.86	1.55	28.45	40.52
T_4	236.40	51.65	31.22	4.20	86.27	797.51	16.90	13.90	3.42	48.11	95.76
T_5	230.15	49.99	29.33	4.11	85.43	792.42	16.79	13.74	3.39	47.45	93.99
T_6	199.98	37.01	21.00	3.27	75.13	634.60	13.03	9.98	2.14	37.22	59.05
T_7	221.62	45.27	27.66	3.95	82.12	747.95	16.09	12.74	3.04	44.33	82.89
T_8	226.05	48.90	29.22	4.00	83.18	754.60	16.31	12.98	3.18	45.00	84.89
T_9	201.64	39.99	23.11	3.31	77.25	644.11	13.37	10.20	2.16	38.44	61.90
T_{10}	194.23	32.01	19.45	3.14	70.87	631.38	10.98	8.96	1.90	33.78	53.32
T_{11}	219.33	43.91	26.66	3.85	81.47	741.49	15.62	12.68	2.90	42.00	77.84
T_{12}	183.54	31.00	19.11	2.83	66.70	592.45	9.89	8.45	1.72	30.00	44.45
T_{13}	185.69	35.17	19.78	3.05	70.20	608.71	10.43	8.51	1.80	34.55	52.58
T_{14}	209.19	39.73	26.67	3.79	80.80	711.31	15.01	11.90	2.69	42.56	75.67
SEm (±)	1.38	0.42	0.36	0.07	0.57	2.80	0.14	0.16	0.05	0.40	0.80
CD(5%)	4.02	1.21	1.07	0.20	1.67	8.13	0.41	0.46	0.15	1.15	2.32

Table 3: Correlation analysis of fertigation and foliar sprays on biometric and yield parameters of papaya variety Surya.

	Yield (t ha^{-1})	Plant height (12 MAP)	Plant girth (12 MAP)	No. of leaves (12 MAP)	LAI (12 MAP)	Fruit set (%)	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Flesh thickness (cm)	Number of fruits per plant
Yield (t ha^{-1})	1										
Plant height (12 MAP)	0.987	1									
Plant girth (12 MAP)	0.963	0.969	1								
No. of leaves (12 MAP)	0.985	0.975	0.957	1							
LAI (12 MAP)	0.991	0.986	0.955	0.985	1						
Fruit set (%)	0.978	0.967	0.931	0.973	0.974	1					
Fruit weight (g)	0.993	0.983	0.944	0.978	0.986	0.967	1				
Fruit length (cm)	0.976	0.973	0.935	0.973	0.978	0.992	0.971	1			
Fruit girth (cm)	0.989	0.984	0.951	0.986	0.988	0.977	0.990	0.987	1		
Flesh thickness (cm)	0.990	0.989	0.971	0.979	0.989	0.954	0.988	0.968	0.988	1	
Number of fruits per plant	0.992	0.976	0.9551	0.979	0.986	0.991	0.974	0.983	0.977	0.972	1

* Correlation is significant at 0.05 level of probability

CONCLUSIONS

The findings of the study revealed that application of 100% RD of N and K through fertigation at weekly interval from one MAP to 20 MAP and foliar sprays of 1.0% 19:19:19 at bimonthly interval starting from 4 MAP to 16 MAP (T_4) along with basal application of 850g rock phosphate and 15 kg FYM improved the biometric and yield parameters in papaya variety Surya and can be recommended for commercial papaya cultivation. The correlation analysis revealed a significantly superior and highly positive correlations between various parameters under study.

FUTURE SCOPE

Future studies can be carried out to standardize the fertigation dosages for higher yield and better fruit quality in other fruit crops.

Author contributions. Karishma Sebastian contributed to carrying out the experiment, gathering and analysing the data, and writing the manuscript. Dr. Bindu B. contributed to formulating and conceptualizing the research problem and Dr. Sajitha Rani. T. provided expert guidance, suggestions, and critical insights throughout the research.

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Conflict of Interest. None.

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