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Effect of Foliar Application of Nutrient Formulation on Growth, Yield and PRSV Incidence of Papaya (*Carica papaya* L.)

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ABSTRACT: Papaya is an economically important crop and severe infestation of papaya ringspot virus (PRSV) adversely affects the growth and vigour of the crop leading upto 50-70 per cent yield loss. Improvement of yield with effective PRSV management is essential for commercial production. A field experiment was carried out to study the effect of foliar application of nutrient formulation on growth, yield and PRSV incidence of papayaat Horticultural College and Research Institute, TNAU, Coimbatore during 2021-22. The study involved four treatments *viz.*, T_1 –Recommended NPK dose + Foliar application of nutrient formulation at bimonthly interval (3^{rd}, 5^{th} and 7^{th} MAP), T_2 - Recommended NPK dose + Foliar application of nutrient formulation at monthly interval (3^{rd}, 4^{th}, 5^{th}, 6^{th} and 7^{th} MAP), T_3 - Recommended NPK dose + Foliar application of $ZnSO_4$ (0.5%) + Boric acid (0.1%) + Ca $(NO_3)_2$ (0.5%) + K_2SO_4 (0.25%) at bimonthly interval (3^{rd}, 5^{th} and 7^{th} MAP) and T_4 - Control (Recommended NPK dosealone)with five replications in randomized block design. The results revealed that the plants treated with T_2 performed better for growth and yield parameters with the lowest PRSV incidence when compared to control.

Keywords: Foliar application, nutrient formulation, growth and yieldparameters, PRSV.

INTRODUCTION

Papaya (*Carica papaya* L.) popularly known aswonder fruit of the tropics belongs to the family Caricaceae. Papaya originated in Tropical America and was introduced to India during 16^{th} century from Philippines through Malaysia. Papaya cultivation in India is gaining importance due to its year round production, high productivity, better economic returns coupled with nutritional and medicinal value. The major papaya producing countries are India, Brazil, Nigeria, Indonesia, Thailand, Taiwan and Mexico. India leads in papaya production with 57.80 MT from an area of 1.44 lakh hectares and accounts for 48% of global production. The leading papaya producing states are Andhra Pradesh, Gujarat, Karnataka, West Bengal, Madhya Pradesh, Maharashtra and Tamil Nadu (NHB, 2020-21).

Papaya is a delicious and nutritionally rich fruit. The ripe fruits are used for dessert purpose and the fruit pulp is rich in vitamins (A, C, folate, riboflavin), calcium and fibre. The mature and unripe fruit is used for making salads and pickles in India. Besides, the fruits are also processed to prepare candy, smoothies, tutti-frutti, marmalade, nectar, wine, syrup, dehydrated flakes and baby foods. The latex from the stem and fruit surface of immature papaya contains the proteolytic enzyme papain which is used in the pharmaceutical, beer, meat, dairy, textile, photographic, optical, tanning, cosmetic, food and leather industries for its antibacterial, antiulcer and anti-carcinogenic effects.

The nutritional demand of papaya differs from other fruit crops because of its faster growth, continuous fruiting habit and high yield potential. Due to its shallow rooting, it is not capable of sustaining itselfby drawing up the nutrient reserves from deeper soil layers. To meet out high productivity judicious nutrient management at appropriate crop growth stages is considered asthe most important. In papaya, only application of the major nutrients *viz.*, nitrogen, phosphorus and potassium and micronutrients *viz.*, zinc and boron are recommended for crop growth, development and productivity (CPG, TNAU, 2020).

In addition, foliar application of calcium and sulphurwas found to have a pronounced effect on growth and yield of papaya (Monika *et al.*, 2018). Papaya is severely infected by papaya rings pot virus (PRSV) which affects the growth and vigour of the crop and based on the severity of infection, it may lead upto 50-70 per cent yield loss. Utmost priority should be given for improvement of yield with effective PRSV management to meet high productivity in papaya. Considering this, a study was conducted to understand the effect of nutrient formulation containing cow dung, neem cake, *Bacillus subtilis* along with macro and micronutrients through foliar application forimproving the vigour of the plant toachieve maximum profitable yield with minimum PRSV incidence.

MATERIALS AND METHODS

A field trial was conducted at the College Orchard, Horticultural College and Research Institute, TNAU, Coimbatore to assess the effect of nutrient formulation on growth, yield and PRSV incidence of papaya in the variety "TNAU papaya CO8". The soil type, pH, EC, available nitrogen, phosphorus and potassium content in the experimental was sandy clayey loam, 7.74, 0.67dS/m, 217 kg/ha, 11 kg/ha and 685 kg/ha respectively. The study was carried out with four treatments *viz.*,T_1 - Recommended NPK dose + Foliar application of nutrient formulation at bimonthly interval (3^{rd}, 5^{th} and 7^{th} MAP), T_2 - Recommended NPK dose + Foliar application of nutrient formulation at monthly interval (3^{rd}, 4^{th}, 5^{th}, 6^{th} and 7^{th} MAP), T_3 - Recommended NPK dose + Foliar application of $ZnSO_4$(0.5%) + Boric acid (0.1%) + $Ca(NO_3)_2$ (0.5%) + K_2SO_4 (0.25%) at bimonthly interval (3^{rd}, 5^{th} and 7^{th} MAP) and T_4 - Control (Recommended NPK dose)with five replications in randomized block design.The recommended NPK dose for papaya is 50:50:50 g/plant at bimonthly interval from 3^{rd} MAP.45 days old seedlings were transplanted in the main field withspacing of 1.8 m × 1.8 m and regular cultural operations were followed as per the recommendations in the Crop Production Guide (TNAU, 2020). Nutrient formulation was preparedby mixing 40 kg of freshcow dung, 1 kg of neem cake and 1 kg of *Bacillus subtilis*in 100 L of water, filtered and was allowed for fermentation for 10 days with intermittent mixing on alternate days (Solution A). On the day of foliar application, sulphate of potash (1%), zinc sulphate (0.25%), boric acid (0.25%), ferrous sulphate (0.5%) and calcium nitrate (0.5%) were added in 5 litres of water, mixed completely and filtered (Solution B). Solutions A and B were added together, final volume was made to 100 litres and used for spraying.

Observations were recorded on growth characters *viz.*,plant height (cm), stem girth (cm), days to first flowering and first harvest (days), first fruiting height (cm) and number of leaves. Leaf area was calculated using the prediction method as described by Karikari (1973). The yield attributes *viz*., number of fruits per plant, fruit length (cm), fruit circumference (cm), fruit weight (kg) and fruit yield (kg/plant)were also recorded. Papaya Ring Spot Virus (PRSV) disease incidence was recorded using the score chart suggested by Dhanam (2006).

Disease severity was calculated using the following formula:

$$\text{PRSV \%} = \frac{\text{Total score of all plants}}{\text{Total number of plants}} \times \frac{100}{\text{Maximum score}}$$

Statistical analysis of data was done by adopting statistical procedures as per the methods outlined by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Growth attributes

The present investigationrevealed that the foliar application of nutrient formulation influenced plant height, stem girth, days to first flowering and first harvest, first fruiting height, number of leaves and leaf area significantly (Table 1). Application of recommended NPK dose+ foliar application of nutrient formulation at monthly interval (T_2) had a positive effect on improving the plant height (185.8 cm)as compared to control (168.4 cm) atthe time of first harvest and it was found to be on par with T_1. The stem girth was also positively influenced by the same treatment (T_2) and it registered the highest stem girth of 28.6 cm compared to control (24.2 cm) and was found to be on par with T_3 (27.5 cm). Similar results were obtained by Hanamanth (2002); Tanimu *et al.* (2013); Srivastava *et al.* (2010) indifferent fruit crops. The positive effect might be due to better availability of macro and micro nutrients from nutrient formulation which could have stimulated the synthesis of auxin leading to better plant growth. Veena and Lavanya (1989) also stated that the application of a combined spray of nutrients (Zinc sulphate and Ferrous sulphate) in papaya was found most effective in improving plant height and stem girth. Number of leaves is one of the important growth parameter that influences net photosynthesis. In the present investigation, highest number of leaves was registered in T_2 at first flowering and at first harvest (19.70 and 28.0 respectively) as compared to control. Application of nutrient formulation might have aided in the build-up of resources essential for the increasedproduction of leaves. At first flowering and first harvest, the highest leaf area was recorded in treatment T_2 (1346.32 cm^2 and 2541.2 cm^2) compared to control (T_4) which recorded the lowest leaf area of 1237.5 cm^2 and 2137.5 cm^2 respectively at first flowering and first harvest (Table 1). The increased leaf area might be due to the influence of nutrients*viz*., calcium, sulphur, zinc and boron which might have promoted cell division and thereby increased the growth (Tuteja and Mahajan, 2007; Raja, 2008; Monika *et al.*, 2018).

Table 1: Effect of different foliar treatments on growth parameters of papaya.

Treatments	Plant height (cm)		Stem girth (cm)		Days to first flowering	Days to first harvest	First fruiting height(cm)	Number of leaves		Leaf area at first flowering (cm^2)	Leaf area at first harvest (cm^2)
	At first flowering	At first harvest	At first flowering	At first harvest				At first flowering	At first harvest		
T_1	102.42	181.1	16.75	26.6	102.09	248.09	88.52	17.52	24.8	1307.38	2405.6
T_2	103.68	185.8	18.78	28.6	99.48	244.48	85.24	19.70	28.0	1346.32	2541.2
T_3	99.00	176.1	18.00	27.5	104.14	251.14	93.47	17.06	23.8	1297.20	2230.6
T_4	97.10	168.4	15.24	24.2	108.2	255.16	99.40	15.76	20.2	1237.32	2137.5
SE d	1.27	3.56	0.74	1.01	1.62	2.63	2.10	0.88	1.08	11.11	39.20
CD(p=0.05)	2.35*	7.06*	1.37*	1.80*	3.15*	5.01*	4.12*	1.95*	2.37*	24.47*	86.36*
CV (%)	1.68	3.06	5.87	4.53	4.98	2.29	4.01	3.98	5.02	1.35	2.66

* - Significant at 5% level

Days to first flowering and first harvest are important parameters that positively correlate with the earliness of the crop. Early bearing corresponds to higher yield in a crop like papaya especially if plant growth and development could be maintained by suitable management practices at appropriate time. In this present study, early flowering (99.48 days) and early harvest (244.48 days) were observed by foliar application of nutrient formulation at monthly interval (T_2). Earliness in flowering and fruiting might be due to the synergistic effect of zinc, iron and boron (Preethi *et al.,* 2017). The first fruiting height was also significantly influenced by different treatments and it ranged from 85.24 cm (T_2) to 99.40 cm (T_4).

Yield parameters. In the present study, foliar application of nutrient formulation at monthly interval (T_2) exhibiteda positive influence on yield and yield attributes *viz*., number of fruits/plant (32.5), fruit weight (1.40 kg) and yield/plant (45.46 kg/plant) and was found to be on par with T_1 (43.06 kg/plant). The control recorded the lowest number of fruits (27.17), fruit weight (1.31 kg) and fruit yield (35.42 kg/plant) (Table 2). Papaya is a fast-growing cropexhibitingcontinuous growth habit; and isamenable for year-round production once it starts bearing fruits. An adequate supply of macronutrients along with micronutrients especially at monthly interval from 3rd MAP coinciding with various developmental phases of the crop might have influencedfruit yield. The increase in fruit yield in T_2 was about 28.33% higher than control (T_4). It can be inferred that foliar application of nutrient formulation could have contributed for enhanced photosynthetic assimilation by maintaining proper plant health. Ganeshamurthy *et al.,* (2011) reported that foliar spray of potassium improved fruit weight, number of fruits and increased yield in banana and grapes. Lokanadhan *et al.* (2012) reported that cow dung and neem cake application nourish the plants by providing all the macro and micronutrients and thereby aided in increasing the yield of crop plants. *Bacillus subtilis* isinvolved in production of metabolites related to growth-promoting and disease prevention (Wang *et al.,* 2018). In the present study, cow dung, neem cake and *Bacillus subtilis* in the nutrient formulation might have played critical role in improving the plant vigour and thereby aided in achieving higher yield. Fruit weight is the major determinant of yield. In the present study, highest fruit weight was observed in the treatment T_2 compared with the control (Table 2). Zinc is known to influence cell division and cell expansion resulting in improved physical characteristics of the papaya fruit (Agarwala and Sharma, 1978; Ghanta *et al.,* 1992). An increase in fruit weight might be due to more accumulation of food reserves due to increased enzymatic activity and strengthening of the middle lamella and cell walls of the fruit brought about by calcium interaction with sulphur and micronutrients (Monika *et al.,* 2018).

Table 2: Effect of different foliar treatments on yield parameters and PRSV incidence of papaya.

Treatments	Number of fruits per plant (1st crop)	Fruit weight (kg)	Fruit length (cm)	Fruit circumference (cm)	Yield (kg/plant)	Percent increase over control (T_4)	PRSV disease incidence (%)	
							At first flowering	At first harvest
T_1	31.20	1.38	24.7	39.12	43.06	21.86	33.54 (35.37)	35.78 (36.70)
T_2	32.51	1.40	25.8	40.82	45.51	28.33	31.86 (34.34)	32.22 (34.56)
T_3	28.33	1.32	23.1	36.80	37.40	5.378	35.28 (36.42)	39.24 (38.77)
T_4	27.17	1.31	22.7	34.14	35.59	-	40.44 (39.47)	45.79 (42.56)
SE d	0.81	0.03	0.2	0.47	1.78		0.64	1.05
CD(p=0.05)	1.50*	0.07*	1.01*	0.85*	2.52*		1.42*	2.31*
CV (%)	2.04	1.80	2.13	3.48	3.98		2.80	4.34

* - Significant at 5% level; values in the parenthesis are arcsine transformed

PRSV incidence. Significant differences among the treatments were observed for the PRSV incidence at the time of first flowering and first harvest. The PRSV disease incidence was significantly lowest in the treatment T_2 as compared to other treatments. The highest disease incidence of 40.44 % was observed in control (T_4) (Table 2). Cow dung contains plant growth promoting substances with antiseptic and prophylactic (disease prevention) characteristics (Dhama *et al.,* 2005; Gupta *et al.,* 2016). Inaddition its odour acts as a repellent for the insect vector.It also contains ammonia which is highly dangerous to

pathogens (Srivastava *et al.,* 2010). *Bacillus subtilis* may promote plant growth either directly or indirectly and can reduce disease incidence (Wang *et al.,* 2018). Manipulation of transplanting time with balanced nutrition was found to be most effective in improving the yield and quality of papaya inspite of the presence of the ringspot virus. Increased yield inspite of PRSV prevalence is mainly due to the availability of the nutrients that are essential for the synthesis of enzymes and proteins that are required for flowering, fruit set, fruit growth and development.

CONCLUSION

The results from the study revealed that markedincrease in growth and yield attributeswith a reduction of PRSV incidence in papaya by the application of recommended NPK dose (50:50:50 g /plant at bimonthly interval from 3rd MAP) + Foliar application of nutrient formulation at monthly interval (3rd, 4th, 5th, 6th and 7th MAP). The appreciable increase in plant growth and yield parameters were recorded in the above treatment. Hence the present study confirms that foliar application of nutrient formulation along with soil applicationof nutrients improves plant health and vigour and also reduces the PRSV incidence.

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Conflicts of Interest. None.

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