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Response of papaya to split application of inorganic nutrients at various stages of growth

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Abstract
Experiments were conducted to standardize the inorganic nutrient requirement in split doses at various stages of crop growth for papaya varieties viz., TNAU Papaya CO.8 at Coimbatore centre and Pusa Dwarf at Pusa and Ranchi centres under ICAR- AICRP (Fruits) programme. Out of 13 treatments imposed, L_1T_1 which received 100% of Recommended Dose of Fertilizers (RDF) split as 50:50:25 per cent from transplanting to flower emergence, 25:25:25 per cent from flowering to first harvest and 25:25:50 from first harvest to end of first cropping period recorded better growth attributes and higher fruit yield at Pusa and Ranchi centres. However, at Coimbatore centre the control (recommended practice) comprising of application of 100% of recommended dose of NPK (300:300:300 g NPK/plant/first crop) split at 50:50:50 g at bimonthly interval starting from 3rd month after planting was found to be the best with the highest fruit yield of 91.21 kg/tree/year. Treatments had significant influence on growth parameters such as plant height, stem girth, number of leaves, first bearing height and number of fruits also. TSS of the fruit was not significantly influenced by the treatments in all the centres. The high BCR was obtained with control in Coimbatore (5.18) while in L_1T_1 at Pusa (3.18) and Ranchi (3.03).

Keywords: Papaya, stage wise nutrients, split doses, yield

Introduction
Papaya (*Carica papaya* L.) is one of the important fruit crops of the tropics and sub-tropics. It has long been cultivated by the people in the home garden. Since the recent past, it has emerged as a commercial crop in India, owing to the demand for the nutritionally rich fruits as well as "papain" a proteolytic enzyme used in pharmaceutical and cosmetic industries.

It is well established that the nutrient up take pattern and nutrient requirement varies at different growth phases of fruit crops such as juvenile phase, flowering phase and fruit initiation, fruit development and fruit ripening phases. The nutrition of papaya differs from other fruit crops due to its quick growth, continuous fruiting habit, heavy feeding ability and fruit yield. Papaya is an exhaustive crop requiring heavy and continuous supply of nutrients in order to sustain its high yield potential and also for its indeterminate growth habit with simultaneous leaf and fruit production (Purohit, 1993). As such, judicious application of fertilizers is needed to meet out the nutritional requirement of plants. However, continuous application of huge amount of chemical fertilizers hampers the soil health and biological environment (Tandan, 2000) [14]. The enhancement of plant height by nitrogen was explained in many studies (Purohit, 1977; Purohit *et al*., 1979; Biswas *et al*., 1989; Reddy *et al*., 1989; Wagh *et al*., 1994 and Ghanta *et al*., 1995) [10, 11, 6, 12, 15, 7]. Purohit (1977) [10] found that besides nitrogen, the plant height was also affected by phosphorus or potash application. On contrary, Purohit (1984) [11] also reported that the excess level of nitrogen resulted in significant reduction in plant height in papaya var. Coorg Honey Dew.

Higher fruit weight and number with higher level of nitrogen and phosphorus application was also reported by Sulladmath *et al*. (1984) [13]. Biswas *et al*. (1989) observed a gradual increase in thickness of fruit pulp with increasing level of nitrogen application.

Different levels of nitrogen did not affect average fruit weight in 'Coorg Honey Dew' (Reddy *et al.*, 1989) [12]. However, nitrogen in combination with potassium remarkably increased the individual fruit weight when compared to plants receiving potash fertilizers without nitrogen. Aneesa Rani (1995) [2] obtained increased fruit number, fruit weight and fruit volume due to increased level of nitrogen and phosphorus fertilizers in CO 6 papaya. In an experiment at

South Africa, it was revealed that 'Solo' papaya showed a linear response to application of phosphorous from start of flowering to end of fruit set (Allan *et al*., 2000) [1]. He further reported that applied potassium exhibited quadratic response until end of fruit harvest and linear response thereafter. Aapplication of nitrogen showed linear response at all phonological stages from start of flowering, end of fruit set, start of harvest, end of first harvest and end of second fruit set period. For Tamil Nadu, the current nutrient recommendation for papaya is bimonthly application of 50:50:50 g N:P_2O_5: K_2O from third month after planting which works out to 300 g N:P_2O_5: K_2O/tree/year (Anon,1999). A fertilizer dose of 250 g N, 250 g P_2O_5 and 500 g K_2O / tree /year is recommended to be applied in six equal splits at bi-monthly intervals for Cv. Coorg Honey Dew at Karnataka (IIHR website). Bindu (2015) reported that application of 200:250:500g of N:P_2O_5:K_2O split at six equal doses at two months interval had a positive effect on fruit yield and high BC ratio in papaya under Kerala conditions. Since then in many of the states like Bihar and Jharkhand, where papaya is grown under non-drip farming system (rainfed cultivation), still the farmers adopt two split application of fertilizers coinciding with monsoon rains. In papaya, though several attempts made on nutrient requirement, studies related to split application at various stages is limited. Hence, a programme was formulated to study the stage wise nutrient requirement for papaya under ICAR-AICRP (Fruits) programme at Coimbatore, Pusa and Ranchi centres.

Material and Methods

Field experiments were carried out at Coimbatore centre with papaya var. TNAU Papaya Co.8 and at Pusa and Ranchi centres with Pusa Dwarf variety of papaya adopting Randomized Complete Block Design. In each replication, 15 plants were maintained per plot. The treatments include three levels of fertilizers viz., 100% RDF (L_1), 80 % RDF (L_2) and 60% RDF (L_3) applied as four split doses as per the four treatment schedule (Table.1). Totally there were 12 treatment combinations (3 fertilizer levels x 4 split doses) along with a control.

Table 1: Treatment details

Treatment	Stage wise split doses (per cent) of nutrients								
	I Phase (Transplanting to flower emergence)			II Phase (Flower emergence to first harvest)			III Phase (First harvest to end of first cropping period)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	50	50	25	25	25	25	25	25	50
T_2	75	75	0	25	25	50	0	0	50
T_3	100	25	25	0	50	50	0	25	25
T_4	50	50	0	50	50	25	0	0	75

Control

Recommended Dose of Fertilizer (RDF) and application time already in practice at the respective centres was individually followed.

RDF for Coimbatore: 300:300:300g N: P_2O_5: K_2O /tree/first cropping year split as 50:50:50 g at bimonthly interval starting from 3rd MAP after thinning

RDF for Pusa: 200g: 250g: 200g of N: P_2O_5: K_2O/tree/year in two splits (75% from transplanting to flower emergence and 25% from flowering to first harvest)

RDF for Ranchi: 300: 300: 300g of N: P_2O_5: K_2O/tree/year in two splits (50% from transplanting to flower emergence and 25% from flowering to first harvest

The tretments combinassions were L_1T_1, L_1T_2, L_1T_3, L_1T_4, L_2T_1, L_2T_2, L_2T_3, L_2T_4, L_3T_1, L_3T_2, L_3T_3, L_3T_4 and control. Observations on plant and fruit biometric characters and fruit yield were recorded at the time of harvest. Number of fruits including the youngest fruit borne on the tree at the commencement of first harvest was counted and expressed as number of fruits per crop. Fruit yield was calculated in the first cropping period by multiplying the number of fruits with its average fruit weight. The statistical analysis of the data to estimate variance and critical differences in RCBD was done by adopting the standard procedures of Panse and Sukhatme (1967) using Agrees software

Results and Discussion

The results on the growth parameters of different treatments are presented in Table.1.

Growth and development in plants are the consequences of excellent coordination of several processes operating at different growing phases of the plants. The growth parameters decide the final yield of a plant. In the present investigation, plant height, stem girth, number of leaves and first bearing height were significantly influenced by split application of nutrients at different levels (Table.2)

Plant height increased to the highest level in treatment L_1T_4 (172.60 cm) at Pusa and L_2T_4 (190.60 cm) at Ranchi wherein application of entire N and P_2O_5 was made in equal splits (50:50g as in T_4) during first two phases of crop growth. Similar increasing trend in plant height was noticed in L_3T_4 at Coimbatore. However, increase in plant height is not a desirable character for papaya which reduces the economic life span of the crop. The lowest plant height (170.00 cm) and fruit bearing height (74.80 cm) was recorded in control followed by L_1T_1 at Coimbatore. Dwarf statured types bearing fruits at lower height on the trunk have greater significance in papaya (Singh, 1990) [10]. Further reducing the fertilizer dose from 100% (L_1) to 80% (L_2) and 60% (L_3) has increased the plant height and reduced the fruit yield irrespective of the per cent of splits at different crop growth stages at Coimbatore. This was in line with the findings of Purohit (1984) [11] who reported that higher level of nitrogen resulted in significant reduction in plant height in papaya var. Coors Honey Dew. On contrary, reduced fertilizer level had reduced the plant height in Pusa Dwarf variety at Pusa and Ranchi. Different varieties may respond differently with fertilizer application. Fruit bearing height does not follow a definite trend at Pusa and Ranchi. Stem girth in papaya is the indication of vigor of the plant. In the present study, the stem girth was the highest in L_1T_1 at Pusa and Ranchi centres, while at Coimbatore L_1T_1 was on par with control. Continuous application of nutrients ensures the efficient allocation of nutrients and assimilates for the radial growth of the tree, during which, there is a gradual change in the orientation of phloem ray cells and sieve tubes for improving the bark thickness.

As far as papaya is concerned, the leaf production and leaf area are important phenomenon especially at the time of fruiting, since every leaf is acting as a source of assimilates for all the developing fruits. On the other hand, first bearing height reflects the overall yielding pattern, besides deciding the economic life span of the crop. At Coimbatore, the lowest plant height (170.00cm), number of leaves (39.70) and leaf area (4.03m^2) were recorded in T_{13} (control). This was followed by L_1T_1 for number of leaves and leaf area, while on par with control for plant height and stem girth. Similar trend was observed in Pusa and Ranchi with the treatment L_1T_1

At Coimbatore, the highest fruit yield of 91.21 kg/tree/year was recorded in control wherein 100% of RDF (300:300:300gNPK/tree/first crop) was split as 50:50:50 g at bimonthly interval from 3rd month after planting. The treatment L_1T_1 was on par with control (85.33kg/tree/year) for fruit yield. Reducing the fertilizer dose by 80% and 60% in (L_2 and L_3) has reduced the fruit yield irrespective of the per cent of splits at different crop growth stages. At Pusa and Ranchi, the highest fruit yield (54.29kg/tree and 63.21kg/tree) was recorded in L_1T_1, where in 100% of NPK applied in three splits viz., 50:50:25 at 1st stage, 25:25:25 at 2nd stage and 25:25:50 at 3rd stage. However, at Pusa, when RDF was reduced to 80%, the three splitting of NPK (L_2T_1) produced yields on par with the control (Table.3; Fig.1)

In all the three centres, application of entire dose of nitrogen (100%) at early stage of the crop (as in L_1T_3) i.e) from transplanting to flower emergence and leaving the remaining period of the crop cycle without any nitrogen application has reduced the fruit yield. This indicated the requirement of nitrogen during the entire growth phase of the crop. Unlike other fruit crops, papaya is unique in its growth habit. It produces leaves, flowers and fruits simultaneously and continuously. Hence, it is evident from the study that nitrogen is also required continuously throughout the cropping period for continuous production of leaves, besides P and K. The requirement of all nutrients throughout the crop growth cycle of papaya is reported earlier (Kumar *et al*., 2010 and Bindhu, 2015) [8]. TSS was found to be non-significant in all the centres (Table.4). The high BCR was obtained with control in Coimbatore (5.18) while in L_1T_1 at Pusa (3.18) and Ranchi (3.03) (Table.3; Fig.1)

Table 2: Stage wise application of nutrients on growth attributes of papaya at three locations

Treatments	Coimbatore centre (TNAU Papaya CO.8)				Pusa centre(Pusa Dwarf)				Ranchi centre (Pusa Dwarf)			
	Plant height (cm)	Plant girth (cm)	No. of leaves	Fruit bearing ht (cm)	Plant height (cm)	Plant girth (cm)	No. of leaves	Fruit bearing ht (cm)	Plant height (cm)	Plant girth (cm)	No. of leaves	Fruit bearing ht (cm)
L_1T_1	184.60	37.80	21.20	86.60	168.20	35.10	55.05	82.50	176.64	33.42	48.71	96.40
L_1T_2	192.50	35.00	22.00	81.40	160.50	33.40	50.60	85.70	166.20	30.51	45.38	87.50
L_1T_3	219.00	42.30	20.76	85.00	161.30	34.20	56.10	84.50	173.02	28.80	43.10	77.60
L_1T_4	192.30	35.50	22.56	67.37	172.60	32.41	49.60	88.40	184.13	34.32	49.01	96.80
L_2T_1	205.76	36.80	21.50	94.20	172.50	31.80	48.30	79.30	187.90	31.40	46.30	90.20
L_2T_2	206.40	33.90	22.60	93.50	161.70	32.20	56.50	80.20	174.25	29.00	44.81	86.00
L_2T_3	231.90	32.30	19.20	82.90	164.10	31.90	53.00	85.70	176.30	28.20	42.80	76.30
L_2T_4	205.40	35.60	19.50	102.50	162.60	29.60	56.90	94.10	190.61	33.10	47.18	92.60
L_3T_1	207.60	35.90	19.90	77.50	151.00	30.10	51.20	88.50	176.68	29.00	44.31	82.10
L_3T_2	217.20	32.50	17.10	88.10	149.30	30.30	48.90	91.90	169.43	28.30	43.54	75.70
L_3T_3	213.30	32.70	20.80	93.40	144.60	29.70	46.70	83.00	164.20	27.75	42.70	74.50
L_3T_4	219.40	32.66	22.20	88.60	147.60	28.60	48.05	90.80	161.52	30.75	46.72	83.40
Control	170.00	38.80	37.70	94.80	160.20	32.60	54.06	81.30	165.69	28.50	44.00	81.70
SEM (±)	31.58	6.42	7.08	17.80	17.80	1.329	2.043	-	-	0.97	NS	4.19
CD at 5%	71.44	14.54	16.02	40.26	40.26	3.684	5.664	NS	NS	2.79		12.02

Table: 3 Effect of stage wise application of nutrients on yield attributes of papaya at three locations

Treatments	Coimbatore centre (TNAU Papaya CO.8)				Pusa centre (Pusa Dwarf)				Ranchi centre (Pusa Dwarf)			
	No. of fruits / plant	Fruit yield (kg/tree)	Fruit yield (t/ha)	BCR	No. of fruits / plant	Fruit yield (kg/tree)	Fruit yield (t/ha)	BC R	No. of fruits / plant	Fruit yield (kg/tree)	Fruit yield (t/ha)	BCR
L_1T_1	85.33	85.33	255	4.79	48.20	59.76	179	3.18	44.52	63.21	189	3.03
L_1T_2	81.54	81.54	245	4.53	47.00	58.70	176	3.10	42.43	59.40	178	2.96
L_1T_3	70.84	70.84	212	3.80	41.14	43.60	130	2.01	37.30	41.77	125	2.04
L_1T_4	76.91	76.91	230	4.21	45.10	50.96	152	2.52	43.31	58.90	176	2.78
L_2T_1	81.90	81.90	245	4.29	42.10	43.36	130	2.22	39.00	29.25	87	2.13
L_2T_2	72.68	72.68	218	4.23	41.31	41.31	129	2.06	36.01	35.28	105	2.33
L_2T_3	71.48	71.48	214	4.14	32.14	32.14	96	1.41	32.11	27.93	83	1.80
L_2T_4	75.01	75.01	225	4.39	43.34	43.34	130	2.25	33.52	43.57	130	2.30
L_3T_1	67.41	67.41	202	4.16	28.66	28.66	85	1.31	30.20	24.16	72	1.72
L_3T_2	68.28	68.28	204	4.23	30.50	27.75	83	1.22	31.00	25.42	76	1.34
L_3T_3	32.60	63.89	190	3.89	27.30	22.38	67	0.89	28.10	21.07	63	0.98
L_3T_4	33.29	69.05	207	4.29	27.60	25.66	76	1.05	29.52	23.02	69	1.18
Control	39.66	91.21	273	5.18	42.20	48.10	144	2.35	40.00	48.40	145	2.47
SEM (±)	1.53	3.28	-	-	2.87	2.26	-	-	3.24	3.31	-	-
CD at 5%	3.17	6.78	-	-	7.973	5.52	-	-	9.29	7.63		-

Table 4: Effect of stage wise application of nutrients on fruit characters of papaya at three locations

Treatments	Coimbatore centre (TNAU Papaya CO.8)			Pusa centre (Pusa Dwarf)			Ranchi centre (Pusa Dwarf)		
	Fruit weight (kg)	Cavity index (%)	TSS (^{0}brix)	Fruit weight (kg)	Cavity index (%)	TSS (^{0}brix)	Fruit weight (kg)	Cavity index (%)	TSS (^{0}brix)
L_1T_1	2.30	25.75	12.3	1.24	24.80	9.40	1.42	29.65	9.32
L_1T_2	2.31	22.15	11.4	1.25	23.30	8.74	1.40	27.10	8.00
L_1T_3	2.16	20.60	10.5	1.06	26.60	9.20	1.12	29.30	9.39
L_1T_4	2.05	24.67	11.5	1.13	26.20	9.54	1.36	29.82	9.41
L_2T_1	2.06	25.73	11.1	1.03	26.70	8.92	0.75	28.80	9.8
L_2T_2	1.93	23.77	11.9	1.02	22.60	8.05	0.98	23.30	8.80
L_2T_3	1.78	24.87	11.8	0.94	24.20	8.64	0.87	26.45	8.70
L_2T_4	2.28	33.47	11.7	1.12	22.50	8.98	1.30	20.93	9.00
L_3T_1	2.11	21.87	11.4	0.91	23.50	8.65	0.80	22.20	9.65
L_3T_2	2.23	25.43	10.8	0.91	20.90	8.54	0.82	25.10	9.25
L_3T_3	1.96	26.69	10.5	0.82	21.60	8.78)	0.75	26.10	9.40
L_3T_4	2.08	23.97	11.7	0.93	21.30	8.11	0.78	22.00	8.72
Control	2.30	20.18	11.9	1.14	24.50	9.00	1.21	29.00	8.92
SEM (±)	0.42	5.27	NS	0.033	NS	NS	0.05	1.04	NS
CD at 5%	0.95	11.93		0.092			0.14	5.43	

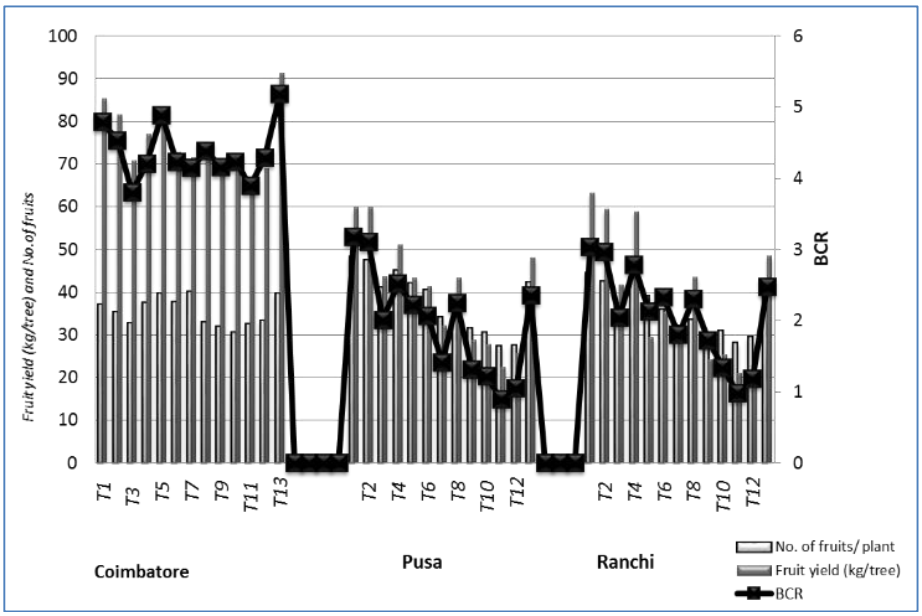

Fig 1: Effect of stage wise application of nutrients on yield and BCR

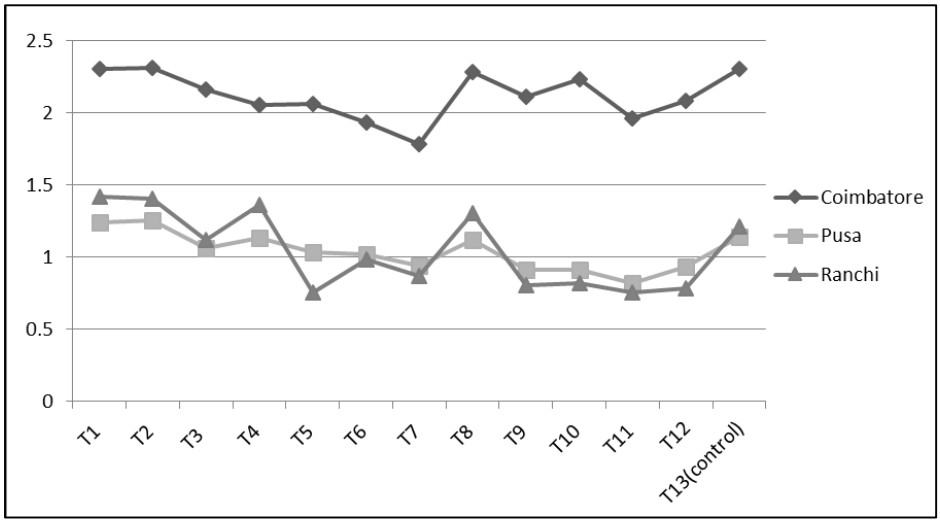

Fig 2: Effect of stage wise nutrient application on fruit weight (kg)

Conclusion

In papaya, the results of the trials conducted at Ranchi, Pusa and Coimbatore centres have clearly indicated that application of N, P_2O_5 and K_2O should be distributed throughout the crop growth phases starting from vegetative phase, flowering and till the end of harvest as papaya possess a unique feature of producing leaves, flowers and fruits simultaneously and continuously.

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References

1. Allan P, NJ Taylor, Dicks HM. Fertilization of "Solo" papayas with nitrogen, phosphorus and potassium. Acta Horticulturae. 2000; 511:27-33.
2. Aneesa Rani MS. Integrated nutrient management of nitrogen and phosphorus in Co 6 Papaya (*Carica Papaya* L.) M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 1995.
3. Anonymous. Crop production manual for horticultural Crops, Department of Horticulture, 1999.
4. Government of Tamil Nadu, Chennai and Tamil Nadu Agricultural University, Coimbatore.
5. Bindu B. Nutrient requirement of papaya (*Carica papaya* L): A study for enhancing fruit production. Indian Journal of Research. 2015; 4(3):6-7.
6. Biswas B, Sen SK, Maity SC. Effect of different levels of nitrogen and potassium on growth yield and quality of papaya var. 'Ranchi'. Harayana J hort. Sci. 1989; 18(3-4):197-203.
7. Ghanta PK, Dhua RS, Mitra SK. Effect of varying levels of nitrogen, phosphorus and potassium on growth, yield and quality of papaya. Annals of Agricultural Research. 1995; 16(4):405-408.
8. Kumar N, Soorianathasundaram K, Meenakshi N, Manivannan MI, Suresh J, Nosov V. alanced fertilization in papaya (*Carica papaya*, L) for higher yield and Quality. In Proc. of the International symposium on papaya. Acta Horticulturae. 2010; 851:357-360.
9. Purohit AG. Response of Papaya (*Carica Papaya* L.) to nitrogen, phosphorus and potassium. Indian J Hort. 1977; 34:350-353.
10. Purohit AG, Singh HP Ganapathy KM. Effect of varying levels of N, P and K on growth and yield of Papaya (*Carica Papaya* L.). Indian J Hort. 1979; 36:131-133.
11. Purohit AG. Studies on growth, yield and nutrition of papaya. In: Proc. of National Seminar on Papaya and Papain production. Faculty of Horticulture, TNAU, Coimbatore, 1984, 64-69.
12. Purohit AG. Papaya nutrition. Advances in Horticulture 2 (Fruit Crops part. 1993; 2:906-913. Reddy YTN, Kohli RK, Bhargava BS. Yield and petiole nutrient composition of papaya as influenced by different levels of N, P and K. Prog. Hort. 1989; 21(1-2):26-29.
13. Sulladmath UV, Narayanagowda JV, SV. Ravi JV. Effect of nitrogen, phosphorus and potassium on yield and quality of Papaya cv. 'solo'. In: Proc. of National Seminar on Papaya and Papain production. Faculty of Horticulture, TNAU, Coimbatore, 1984, 70-74.
14. Tandan HLS. Fertilizer, organic manures, recyclable waste and biofertilizers. Fertilizer Development and Consultation Organization, New Delhi, 2000, 98.
15. Wagh AN, Bhalekar MN, Patil SP, Chaudhari SM. Effect of varying levels of N, P and K on growth, fruit and papain yield and nutrient status of papaya cv.CO.2. Maharashtra. J Hortic. 1994; 8(1):40-44.