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Growth, Fruit Yield and Disease Index of Carica Papaya L. inoculated with *Pseudomonas straita* and Inorganic Fertilizers

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Abstract

Experiment was conducted to study the effects of *Pseudomonas straita* and chemical fertilizers on growth, fruit yield and leaf mosaic virus in *Carica papaya* var. Sinta F1. The experiment comprised four treatments namely Farmers practices (T0- NP (Nitrogen: Phophorus) 100:50+10 kg FYM (Farm Yard Manure)/plant/year), Phosphorus Solubilizing Bacteria (T1- *Pseudomonas straita* @20 g culture/plant/year), Recommended fertilizer dose (T2- NPK 300:300:300+FYM 10kg/plant/year), T3- *Pseudomonas straita* + NPK (300:300:300 NPK + FYM 10 kg + *P. straita* 20 g/plant/year) in seven replications. The planting density was 2500 ha^{-1} (2m × 2m). The treatment effects found significant ($p<0.05$) for plant height, leaf number, leaf length, fruit weight, fruit volume and fruit yield while, non-significant for trunk girth, inter nodal length and pulp thickness. The treatment T3 plants occurred growth and fruit yield maximum followed with T_2. *Pseudomonas straita* (T_1) alone gave poorest result but its combination with NPK (T_3) rendered highest number of fruit (48 fruit /plant) with an average weight of 675 g. The plant with T_2 showed 18.18% higher leaves, 36.84% higher fruit weight and 41.03% higher yield compared to T_0. Trends of Plant Disease Index (PDI) was declining by 50.36% with T1 followed with T_3 (27.88%) and T2 (13.40%) compared T0. The treatment effects were positively correlated with plant height (r_2=0.78), leaf number (r2=0.81), fruit yield (r2=0.97) and recorded negative for PDI (Plant Disease Index) (r2=0.30).

Keywords: *Carica papaya*, *Pseudomonas straita*, Percent Disease Index, Fruit yield

Introduction

Papaya (*Carica papaya* L.) is widespread throughout India and in globe considered as one of the most important, economic and nutritious fruit crop with rich antioxidants, carotene, vitamins, and flavonoids. Due to its easy growing and early fruiting ability, it occupied significant positions in homestead, kitchen garden, home back space for family use and commercial production. Papaya is reported in more than 60 countries with 11.22 million metric ton yield (FAOSTAT, 2012) dominated in Asia (52.2%), South America (23.8%), Africa (13.2%), Central America and the Caribbean region (10.9%). It is successfully grown in wide range of soils but best in slightly acidic and sandy loam soils [1].

Presently the papaya production is dependent upon inorganic fertilizers, High Yielding Variety (HYV) and plant protection chemicals. The fertilizer requirements in papaya have been studied throughout the World for many years [2] and have reported variations in plant growth and yields due to varying rate of fertilizer doses [3]. Moreover, it is also observed that the long-term applications of inorganic fertilizers not only decrease the crop productivity [4] but also make the plants susceptible to insects and diseases, besides deterioration of fruit minerals and quality. Now, judicious use of organic manures, inorganic and microbial fertilizers is rapidly gaining favor in fruit and vegetable crops [5,6].

It observed that in high yielding papaya varieties, during reproductive stage, the high demand for P exceeds the capacity of the root system [7]. Naturally the plant interacts with many microorganisms to fulfill the requirements of nutrients and water but apparent result is not seen because of the presence of low and ineffective microorganism in soil [8]. Thus, it is imperative to use the potential soil microorganisms in production system by selecting their best combinations. It becomes thus possible to encourage healthy cultural systems without depending totally on chemical fertilizers to sustain a better productivity and ecosystem conservation [9]. *Pseudomonas* is one of the beneficial soil microorganism solubilize fixed P into an available form which are easily absorb by plant. Currently considerable information is available on phosphorus solubilizing bacteria indicating enhanced mineral nutrition in many agricultural crops grown on wide soil types [8,10,11]. Many studies are reported on the positive effects of arbuscular mycorrhizal fungi on papaya [12,13], but the information is limited on phosphorus solubilizing microorganism. Therefore, in the present study effects of *Pseudomonas straita* was examined singly and in combinations with recommended dose of chemical fertilizers for India with respect to growth, fruit yield and leaf mosaic virus incidence in papaya under field condition.

Material and Methods

The study was conducted in the Department of Forestry, Wildlife and Environmental Sciences, Guru Ghasidas Vishwavidyalaya, Bilaspur (Chhattisgarh, India) lies within latitude 21°47' to 23°8' and longitude 81°14' to 83°15' (Figure 1). Seeds of *Carica papaya* variety-Sinta F1, gynodioecious high yielding (50-60 kg/plant) was procured from commercial source, Varanasi (India) and sown in plastic root trainers on 15th August 2012, transplanted after 15 days of germination into polyethylene bag of size 23 × 12.5 cm filled with autoclaved nursery soil: sand (1:1v/v) and kept in glass house. Final transplanting of seedling was done in field on dated 30 October 2012 in 30 cm^3 size pits at spacing of 2m × 2m, when plants attained 30 cm height.

Figure 1: Experimental view of Papaya.

RBD (Randomized Block Design) experiment comprised four treatments Farmers practices (T0- NP (Nitrogen:Phosphorus)100: 50+10 kg FYM/plant/year), Phosphorus Solubilizing Bacteria (T1- *Pseudomonas straita* @20 g culture /plant/year), Recommended fertilizer dose (T2- NPK (Nitrogen : Phosphorus : Potassium) 300:300:300 g+FYM (Farm Yard Manure) 10 kg/plant/year), T3- *Pseudomonas straita* + NPK (300:300:300 g NPK+FYM 10 kg + *P. straita* 20 g/plant/year) in seven replications. Application doses were determined based on the recommendations by Agriculture University for papaya and personnel communication from the papaya growing farmers. Half dose of NPK and full quantity of FYM were given to plants at the time of transplanting while remaining fertilizers were applied in 3 equal splits after 45 days (December 2012), 100 days (March 2013) and 150 days (August 2013) of planting. *Pseudomonas straita* culture (Inoculum load 2.17 × 10^6) was obtained from College of Agriculture (Indira Gandhi Agriculture University), Bilaspur (Chhattisgarh) was placed @ 20 g/plant in a depth of 10 cm near root zone at the time of transplanting into field. Most Papaya growers apply hardly 100g nitrogen and 50 g phosphorus per year at various times in eastern Chhattisgarh which was kept as such in T0. Multiplex (micronutrient) 3 mL/L was sprayed after 55 days and 125 days of transplanting and Chlorpyriphos 1 mL/L and Carbendazim 2 g/L water was given through foliar spray on 15th November, 2012. Emidachlorprid 0.2 mL and Copper Oxychloride 3 g/L of water was also sprayed during February, 2013 to control aphids and leaf diseases of papaya.

Stem diameter, height and leaf disease index were measured and flowering and fruiting behavior of each plants were observed at regular intervals. Finally, the experiment was terminated after 365 days of field planting and data were recorded analyzed statistically using SPSS software. Percent Disease Index (PDI) was worked out after examining the leaves infected by LCMV (Leaf Curl Mosaic Virus) and YLMV (Yellow Leaf Mosaic Virus) under Windias instrument and determined as per Wheeler by following formula:

$$PDI = \frac{X}{N \times H} \times 100$$

Where PDI = Percent Disease Index, X= Sum of all numerical rating, N= number of leave observed and H= Highest rating of the disease. Analysis of experimental data was subjected using SPSS software for the critical difference and correlation studies.

Results and Discussion

Treatment effect on plant growth parameters

The distinct treatment effects on the plant growth of papaya are depicted in Table 1. There was a highly significant effect on plant height varied within treatment (CD 0.22) at $p<0.05$. The plant height increased polynomial and T3 (Recommended NPK + *P. straita*) gave best results as height increased of 16.54% while the trunk girth was not influenced by any treatment ($p<0.05$). T1 (*P. straita*) treated plant exhibited lowest growth and reported 17.29% and 20.00% less height and girth respectively compared with T0.

Treatments	Plant height (m)	Trunk Girth (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)	Inter-nodal length (cm)
T0	2.66	40.00	22	52	45	3.70
T1	2.20	32.50	16	33	35	3.30
T2	2.80	43.00	26	58	44	3.70
T3	3.10	48.44	31	65	68	3.90
CD (P < 0.05)	0.22	NS	2.33	3.40	4.65	NS*

Table 1: FYM, NPK and *Pseudomonas straita* effects on plant growth parameters of *Carica papaya*. CD-Critical differences, NS-Not Significant.

Number of leaves, leaf length and leaf width were also increased due to the bipartite application of NPK and *P. straita* (T3). There was 40.90% more foliage in T3 followed by T2 (18.18%) than T0 (22 leaves /plant). Similarly leaf length and leaf width was improved by 25.00% and 51.11% respectively in T3 plants than T0. Application of *P. straita* alone could not show significant results in papaya. The treatment effect was recorded positive on plant height (r2=0.78) and leaf number (r2=0.81) Figure 2. The increase in plant height, leaf number and leaf width was due to the NPK and *P. straita* by which the plant could able to absorb nutrients in a higher rate and in a better way as also reported by Raman. Previous papaya studies also suggested that N rate had no effect on stem diameter.

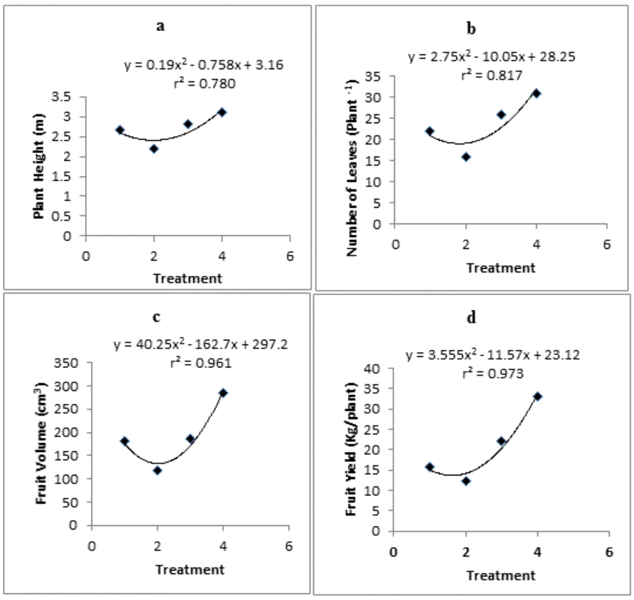

Figure 2: The effect of treatments on plant growth, number of leave, fruit volume, fruit yield respectively of *Carica papaya*. Results are expressed as means by treatment (n=10).

Treatment effect on fruits and yield

The fruit weight and fruit yield were observed significantly difference ($p<0.05$) within treatment (Table 2; Figure 3). Observations revealed that the maximum 48 fruit was recorded with T3 which was about 45% high compared to T0. Similarly, fruit weight was also recorded high in the same treatment (45.26%) followed by T2 (36.84%). The increase in fruit weight was due to increase in growth and fruit volume (r_2= 0.96) (Figure 1). The performance of T1 (*P. straita)* was unsatisfactory as compared to T0 (Control plant) due to poor growth and smaller fruit size respectively.

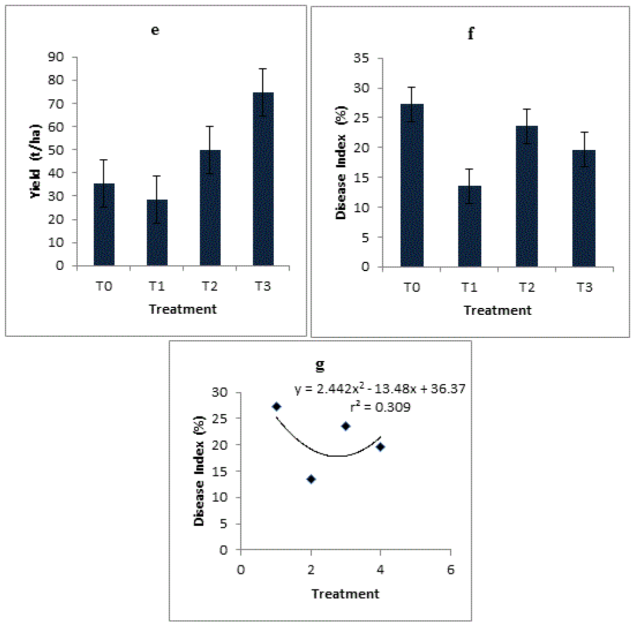

Figure 3: It indicates the effect of treatments on Yield, Disease Index (DI) percent and correlation of treatments on DI respectively. Results are expressed as means by treatment (n=10).

Treatments	Number of Fruit	Maximum Weight (kg)	Average Fruit Weight (g)	Fruit Length (cm)	Fruit Width (cm)	Fruit Volume (cm^3)	Pulp Thickness (cm)	Fruit Yield (kg/ plant)
T0	33	2.00	475	15	12	180	2.20	15.67
T1	29	1.30	430	13	9	117	1.50	12.47
T2	34	2.50	650	17	11	187	2.40	22.10
T3	48	2.90	690	19	15	285	2.60	33.12
CD(P<0.05)	2.50	0.20	7.51	1.90	1.10	26.33	NS	3.15

Table 2: Fruiting parameters of *Carica papaya* applied with different doses of chemical fertilizers and *Pseudomonas straita*. CD-Critical differences, NS-Not Significant.

The fruit yield per plant varied statistically (CD 3.15, $P<0.05$) within treatments. In contrast, there was a highly significant polynomial increase in fruit yield (r_2=0.97) (Figure 2) when recommended dose of NPK and *P. straita* was applied. The maximum fruit yield occurred at an application of NPK with *P. straita* (T_3) doubled the fruit yield followed by T_2 (41.03%) compared to T0 (15.67 kg/plant). This was an agreement with the increase in number of fruit and fruit volume due to better plant growth in the presence of chemical and bio-fertilizer (T3) as also reported by other workers [14,15]. Yield was considerably lower for papaya plants growing withT1 (Table 2 and Figure 3). In the present study, the effect of treatment on pulp thickness was not significant at p<0.05 however it noticed thickest in T_3 than other treatments due to bigger fruit volume. Due to higher number of fruit and greater size the overall yield of papaya was increased of 74.52 t/ha with T_3 compared T0 (35.25 t/ha).

Treatment Effect on Percent Disease Index (PDI)

The examination results of LCMV and YLMV in papaya experiment are shown in Figure. 4 and Figure 5. PDI varied significantly within the treatments (CD 2.57, P<0.05). Interestingly, in the presence of *P. straita* the disease index was decreased by 50.0% followed by T3 (27.88%) and T2 (13.40%) compared T0. It indicates that the application of NPK + *P. straita* reduces the incidence of LCMV and YLMV (r2 =0.30) by way of maintaining higher nutrients availability in soil results in a better plant growth and fruiting as also reported by Bueno-Jaquez et al. [16] and Kumar et al. [2].

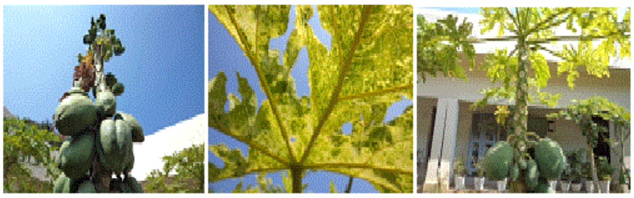

Figure 4: LCMV and YMLV of Papaya.

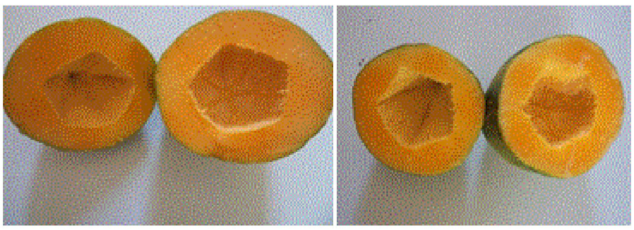

Figure 5: Pulp thickness of papaya in T3 and T0 treatments.

Conclusions

In the present study, NPK (300:300:300 g) + FYM (10 kg) and *Pseudomonas straita* (20 g/plant) increased fruit yield is a function of increases in plant height, leaf number, fruit number and fruit volume. In contrast, fruit weight and fruit number reached maxima at T3 results 100% increment in yield. Trends for both fruit volume (r_2=0.96) and fruit yield (r_2=0.97) with the treatment effects were highly correlated. PDI (Plant Disease Index) also reduced significantly with the inclusion of *P. straita* used with NPK compared to control plant however; application of *P. straita* only did not perform satisfactorily. Therefore, tripartite application of FYM, NPK and *P. straita* appears to have more effective than only NPK and *P. straita*. This practice will decrease in production costs and increasing yield with reduction of diseases in papaya by maintaining healthy plant growth.

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