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EFFECT OF SEED BIOPRIMING ON GERMINATION AND SEEDLING GROWTH OF PAPAYA

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ABSTRACT

An experiment to know the influence of seed biopriming on germination and seedling growth of papaya (*Carica papaya* L.) cv. Red Lady was at Department of Fruit Science, Dr. YSRHU-College of Horticulture, Venkataramanannagudem, West Godavari district of Andhra Pradesh during 2021-22 and 2022-23. The experiment was carried out in a Completely Randomized Design (CRD) comprising of seven treatments *viz.*, biopriming in 10% Azotobacter for 12 h and 24 h, biopriming in 10% PSB for 12h and 24 h, biopriming in 10% Azotobacter + PSB for 12 h and 24 h and hydropriming as control which were replicated thrice. Among the treatments studied 10% Azotobacter + Phosphate solubilizing bacteria for 24 hours seed biopriming was recorded early seed germination, maximum germination percentage, seedling height, stem girth, number of leaves, fresh and dry weight of shoot and root, higher chlorophyll content, root: shoot ratio, vigour index length and vigour index mass, nitrogen and phosphorous content in papaya seedlings and minimum nitrogen and phosphorous content in potting media.

***Keywords*:** Seed biopriming , germination , seedling growth, papaya (*Carica papaya* L.)

Introduction

Papaya (*Carica papaya* L.) is an evergreen herbaceous commercial fruit crop of tropical and subtropical regions and belongs to the family caricaceae with chromosome number 2n=18. Papaya is a dicotyledon, polygamous and diploid species with geographical origin of Southern Mexico and Costa Rica (Candolle, 1884). It is a gynodioecious in nature, adaptable to diverse soil and climatic conditions and its attractive delicious wholesome fruits have multifarious uses.

In recent years, seed bio-priming has been recognized as low-cost but eco-friendly technology that is potent to promote growth, induce stress tolerance and achieve desired crop yield. Many scientists and researchers are now recommending liquid formulations of biofertilizers, since they spread well and mix uniformly without any sticking agent over the seed surface. Scientific research was conducted on the standardization of liquid formulations and compared their performance for productivity with the inorganic fertilizers (Gomathy *et al.*, 2008; Thamizh and Thangaraju, 2006). But, studies on the effect of seed treatment with liquid biofertilizers on the germination and seedling vigour are very negligible. Keeping these points in view, study was undertaken on seed biopriming using liquid Azotobacter and phosphobacteria.

Materials and Methods

The current investigation, "Effect of seed biopriming on germination and seedling growth of papaya (*Carica papaya* L.) cv. Red Lady" was carried out at Shade net, Instructional farm, Department of Fruit Science, Dr. YSRHU-College of Horticulture, Venkataramannagudem, West Godavari district of Andhra Pradesh during 2021-22 and 2022-23. The experiment was laid out in CRD with three replications with seven treatments.

Treatments details:

T_1: Control (water soaking for 24 h- hydropriming)

T_2: Biopriming in 10% *Azotobacter* for 12 h

T_3: Biopriming in 10% *Azotobacter* for 24 h

T_4: Biopriming in 10% PSB for 12 h

T_5: Biopriming in 10% PSB for 24 h

T_6: Biopriming in 10% *Azotobacter* + PSB for 12 h

T_7: Biopriming in 10% *Azotobacter* +PSB for 24 h

Preparation of solutions

To prepare 10% Azotobacter solution, 100 ml of Azotobacter (*Azotobacter chroococcum*) liquid biofertilizer was mixed with 1000 ml of water, for preparation of 10% PSB solution, 100 ml of PSB-Phosphate solubilizing bacteria (*Bacillus megaterium*) liquid biofertilizer was mixed with 1000 ml of water and 10% Azotobacter + PSB solution was prepared by taking 50 ml 10% Azotobacter + 50ml of 10% PSB in 1000 ml of water. Required quantity of solution was prepared for biopriming the papaya seeds.

Preparation of growing media

The soil (red earth) having chemical properties of pH 7.20, electrical conductivity 0.16 ds m^{-1}, organic carbon 0.93 per cent, available nitrogen 260.60 kg ha^{-1}, available phosphorus 35.24 kg ha^{-1} and available potassium 131.00 kg ha^{-1} was passed through 4 mm sieve and mixed thoroughly along with sand, coir pith, and FYM in 2:1:1:1 proportion and potting mixture was prepared. Polythene bags of 9 cm×10 cm with 50 micron thickness were used for filling the potting mixture. On each bag 15 holes of 0.5 cm diameter were punched uniformly for ensuring good drainage. Then the prepared potting mixture was filled properly up to the brim.

Plant material

The F_1 hybrid seeds of papaya variety Red Lady produced by 'Known-You Seed Co., Ltd', Kaohsiung, Taiwan and imported and marketed by 'Known-You Seed (India) Pvt. Ltd', Pune were used in this experiment.

Selection and pre-treatment of seeds

Biopriming was done for the collected seeds with water for 24 h and with 10% Azotobacter, 10% PSB and 10% Azotobacter + PSB for 12 and 24 h before sowing of seeds to break the dormancy.

Sowing of seed and care of the seedlings

Seeds are sown at 1 cm deep in the poly bag size of 9 cm ×10 cm and 50 micron filled with prepared medium. Seeds were dibbled at the rate of 2 seeds per hill, soon after sowing irrigated lightly. All the polybags were kept under 50% shade net house. Germinated seedlings were irrigated regularly and need based hand weeding and plant protection measures were taken up at regular intervals.

The data on various characters studied during the course of investigation were analysed statistically by applying the procedures of analysis of variance as outlined by Sukhatme and Amble (1985). The critical difference among the treatment means was compared at 5 per cent level of significance.

Results and Discussion

Days taken for seed germination (d)

Data recorded on number of days taken for seed germination in papaya influenced by seed biopriming were depicted in table 1.

Significant differences were obtained among different seed biopriming treatments with respect to number of days taken for seed germination. The T_7 (10% Azotobacter + Phosphate solubilizing bacteria for 24 h) had recorded early seed germination (5.46), which was followed by 6.24 in T_6 (10% Azotobacter + Phosphate solubilizing bacteria for 12h) and 8.56 in T_5 treatments (10% Azotobacter for 24 h). The number of days taken for seed germination was found maximum (11.33) in control (T_1).

The lowest number of days taken for seed germination in T_7 treatment could be attributed to creation of favourable conditions such as optimum moisture retention, temperature, secretion of vitamins, growth promoting substances and water absorption. Soaking of seeds in 10% Azotobacter + PSB for 24 h might have also helped to increase the permeability of seed coat to solution. Further, the soaking of seeds might have helped in leaching out of germination inhibitors like p-hydroxybenzoic acid and an increase in endogenous gibberellin like substances. The present findings were in conformity with the earlier findings of Chauhan and Patel (2017) in chilli, Rakesh Kumar Yadav *et al*. (2012) in acid lime, and Vasu *et al*. (2010) in *Lens culinaris* Medic.

Germination percentage

Significant differences were found among the treatments for seed germination percentage (Table 1). Seeds treated with 10% Azotobacter + PSB for 24 h (T_7) had showed maximum germination percentage (99.04) followed by (T_6) bioprimed with 10% Azotobacter + PSB for 12 h (97.35) whereas seeds treated with water (T_1) recorded the minimum germination percentage (90.47).

The T_7 treatment recorded maximum seed germination percentage might be attributed to the synergistic effects of bio-inoculants and soaking period. They were responsible for an improvement in physico-chemical properties of protoplasm, respiratory activity, nucleic acid metabolism *etc.,* which led to stimulation of growth through cell division and expansion. Seed priming boosts the imbibition and metabolic processes which resulted in uniformity and enhanced seed germination, seedling growth and development in both normal and stress conditions. Liquid bacterial cultures *viz.*, *Pseudomonas, Azotobacter* (Shaukat *et al.,* 2006) and Methylobacterium (Nkpwatt *et al.,* 2006) were found to promote seed germination and seedling growth. Similar findings were reported by Sinish *et al*. (2005) in cashew and Pathak *et al.* (2013) in guava.

Plant height (cm)

The effect of seed biopriming on plant height was presented in Table 1. Significant differences were noticed among the treatments with respect to plant height. Among different treatment combinations used, papaya seedlings treated with (T_7) 10% Azotobacter + PSB for 24 h had recorded maximum plant height of 4.60, 15.79, 38.62 and 59.46 at 15, 30, 45 and 60 days after sowing respectively followed by biopriming in 10% Azotobacter + PSB for 12 h (T_6) (4.51, 15.08, 37.15 and 56.47 at 15, 30, 45 and 60 days after sowing respectively). The control (water soaking for 24 h – hydroprimimg (T_1)) had recorded the minimum plant height of 3.32, 11.13, 28.58 and 40.16 at 15, 30, 45 and 60 days after sowing respectively. The maximum plant height was noticed in T_7 could be attributed to the probiotic effect of microbial inoculants helped in mobilization of optimum quantities of water, nutrients and photosynthates to the meristematic tissue that leading to an increase in cell division and cell elongation activities thereby increased the plant height. Similar trend was reported by Rai and Basu (2017) in okra, Rani and Sathiamoorthy (1997) in papaya seedlings and Kerni and Gupta (1986) in mango.

Stem girth (cm)

The information pertaining to the stem girth of papaya seedlings was depicted in Table 1.

Significant differences were found among the treatments for stem girth of papaya seedlings. The stem girth was found maximum (0.48, 1.24, 1.50 and 1.55 at 15, 30, 45 and 60 days after sowing respectively) in T_7 followed by T_6 (0.44, 1.21, 1.44 and 1.46 at 15, 30, 45 and 60 days after sowing respectively) and the lowest stem girth (0.30, 0.81, 1.06 and 1.19) at 15, 30, 45 and 60 days after sowing respectively was recorded in T_1 (control).

Biopriming had significantly increased the stem girth as compared to control. The increase in stem girth might be attributed to an improvement in root growth interms of root length (10.26 cm) and root dry weight (5.89 g) were responsible for better water and nutrient absorption as well as photo assimilates supply to lateral meristems there by improved the stem girth. The results were in accordance with the findings of Ravishankar *et al.* (2008) in papaya cv. Coorg Honey Dew and Shivakumar *et al.* (2012) in papaya cv. Surya.

Number of leaves

As per the data presented in table 1 showed significant differences among the seed biopriming treatments for number of leaves per papaya seedling.

The number of leaves per seedling was found maximum (4.65, 8.79, 11.28 and 15.53 at 15, 30, 45 and 60 days after sowing respectively) in T_7 (10% Azotobacter + PSB for 24 h (T_7) followed by T_6 (4.14, 8.10, 10.76 and 14.24) at 15, 30, 45 and 60 days after sowing respectively *i.e.* biopriming in 10% Azotobacter + PSB for 12 h, whereas minimum (3.00, 6.13, 8.00 and 11.8) number of leaves per seedling was found at 15, 30, 45 and 60 days after sowing respectively in control (T_1).

The number of leaves per papaya seedling were more in T_7 and this might be due to availability of macro/ micronutrients, hormones and growth factors to leaf primordial had improved the cell division as well as number of leaves per seedling. As the age of the seedling increases number of leaves per seedling increases. These findings were in conformity with the outcomes of Chawla and Mehta (2015) in litchi, Kumbar (2018) in papaya and Bharathi *et al*. (2021) in guava.

Fresh weight of shoot (g)

The data recorded on effect of seed bio-priming on fresh weight of shoot were presented in table 2.

Significant differences were found among the treatments for fresh weight of shoot. The shoot fresh weight was highest (29.02) in T_7 (seeds treated with 10% Azotobacter + PSB for 24 h) followed by (T_6) seed biopriming with 10% Azotobacter + PSB for 12 h (27.50). The shoot fresh weight was lowest (17.57) in (T_1) control.

The increase in fresh weight of papaya seedling might be due to stimulation of growth and vigour of the papaya seedlings by secretion of auxin and cytokinin like substances by treatment of seed with 10% Azotobacter and PSB. The present results were in parallel line with findings of Joolka *et al*. (2004) in pecanut, Chawla and Mehta (2015) in litchi.

Dry weight of shoot (g)

Significant differences were found among the treatments for dry weight of shoot (Table 2). The shoot dry weight was maximum (7.41) in T_7 (seeds treated with 10% Azotobacter + PSB for 24 h) followed by (7.13) seed biopriming with 10% Azotobacter + PSB for 12 h (T_6). The shoot dry weight was lowest (4.86) in (T_1) control.

The usage of different bio-inoculant treatments recorded an increase in shoot dry weight of papaya seedlings could be attributed to the good vegetative growth exhibited in terms of plant height (59.46 cm), stem girth (1.55 cm) and number of leaves plant^{-1} (15.53). The total chlorophyll content in leaves (22.42 SPAD units) might have increased the photosynthetic activity as well as dry matter accumulation in papaya seedlings. Similar findings were reported by Yadav *et al.* (2012) in acid lime and Manoj Kumar *et al.* (2013) in pear.

Fresh weight of root (g)

The influence of seed bio-priming on root fresh and dry weight of papaya seedlings were depicted in table 2.

Seeds bio-priming with 10% Azotobacter + PSB for 24 h (T_7) showed the maximum root fresh weight (27.24) followed by seed bio-primed with 10% Azotobacter + PSB for 12 h (T_6) (24.24), whereas the minimum (14.68) root fresh weight was recorded in control (T_1).

The inoculation of seeds with biofertilizers might have increased the production of phytohormones like auxin, gibberellins, cytokinin and nutrient availability (Gerdmann *et al.*, 1975), which in turn improved the cell division and cell elongation thereby increased the root length (10.26 cm), root volume as well as root fresh weight of the papaya seedlings. Similar findings were reported by Yadav *et al.* (2012) in acid lime and Manoj Kumar *et al.* (2013) in pear.

Dry weight of root (g)

The root dry weight was maximum (5.89) in plants raised from the seeds treated with 10% Azotobacter + PSB for 24 h (T_7) followed by seed bio-priming with 10% Azotobacter + PSB for 12 h (T_6) (5.57). The root dry weight was minimum (2.92) in T_1 treatment (control *i.e.,* water soaking for 24 h – hydropriming) (Table 3.2).

The bioinoculants used in the study as stated above might stimulated the production of Indole 3 Acetic Acid (IAA) (Gerdmann *et al*., 1975). IAA production plays a crucial role in promotion of plant growth interms of increase in root length (10.26 cm). In addition to this, IAA might also improved the xylem differentiation, development of lateral and adventitious root formation, root hair formation and root expansion through partitioning of more dry matter towards the root system. Similar findings were observed by Kumbar (2018) in papaya.

Total chlorophyll content (SPAD units)

The data recorded on total chlorophyll content in leaves showed significant difference among the seed bio-priming treatments was presented in table 2.

Among the seed biopriming treatments, higher total chlorophyll content (22.42) was observed in leaves of plants raised from the seeds treated with 10% Azotobacter + PSB for 24 h (T_7) followed by (21.38) T_6 (in the leaves of plants raised from the seeds treated with 10% Azotobacter + PSB for 12 h) and lowest was recorded in control (13.21).

Seed biopriming had showed variation in total chlorophyll content of leaves was might be due to release of auxins, gibberellins and cytokinins decreased chlorophyll degradation or might be due to an increase in chlorophyll biosynthesis. The present results were in line with the findings of Kerni and Gupta (1986) in mango, Entesari *et al*. (2013) in soyabean.

Root: shoot ratio

Significant differences were noticed among the seed biopriming treatments for root: shoot ratio (Table 2).

The maximum root: shoot ratio (0.80) was recorded in seedlings raised from the seeds treated with 10% Azotobacter + PSB for 24 h (T_7) followed by (0.78) the seedlings raised from the seeds treated with 10% Azotobacter + PSB for 12 h (T_6) and the minimum (0.56) root: shoot ratio was recorded in control (T_1).

Maximum root/shoot ratio was noticed in seedlings raised from the seeds treated with 10% Azotobacter + PSB for 24 h indicated better development of root system interms of root length (10.26 cm), root fresh weight (27.24 g) and root dry weight (5.89 g) through efficient absorption of water and nutrients from the soil (Clapperton and Reid, 1992). Similar reports were found by Khade and Rodrigues (2009) in papaya.

Root length (cm)

The influence of seed biopriming on root length showed significant differences among the treatments was presented in Table 2.

The longest root length of 10.26 was observed in T_7 (10% Azotobacter + PSB for 24 h) followed by (10.03) (T_6 -10% Azotobacter + PSB for 12 h) and the smallest root length 7.13 was observed in control (T_1).

The longest root length per plant was noticed in seedlings raised from the seeds treated with 10% Azotobacter + PSB for 24 h might be due to release of auxins by bio-inoculants helped in an increase in cell division and cell elongation activities were attributed. Similar findings were reported by Awasthi *et al.* (1998) in peach and Venkata Rao (2002) in mango.

Vigour index length

Effect of seed biopriming showed significant influence on vigour index length of papaya seedlings was presented in Table 2.

The vigour index length was maximum (6,905.07) in seedlings raised from the seeds treated with 10% Azotobacter + PSB for 24 h (T_7) which was followed by (T_6 -10% Azotobacter + PSB for 12 h) (6,473.78) and the lowest (4,278.33) vigour index length was observed in control (T_1).

The variation in vigour index length among the treatments could be attributed to difference in seed germination percentage (99.04%) and seedling height (69.72 cm) parameters.

Vigour index mass

The perusal of data presented in table 2 showed significant differences among the treatments for vigour index mass.

The highest (1,317.23) vigour index mass was recorded in seedlings raised from the seeds treated with 10% Azotobacter + PSB for 24 h (T_7) followed by seed biopriming treatment with 10% Azotobacter + PSB for 12 h (T_6) (1,236.35) and the lowest (703.86) vigour index mass was recorded in control (T_1).

The highest vigour index mass was noticed in seed biopriming treatments could be due to an improvement in seed germination percentage (99.04%) and seedling dry weight (13.30). It could also increase due to an increase in nitrogen fixation, the solubilization of phosphorus in the soil increases the nutrient availability in addition to the production of auxins, gibberllins, cytokinins which might have helped in healthy and robust growth of papaya seedlings. Biopriming with 10% Azotobacter + PSB for 24 h (T_7) resulted in improved seed germination and final seedling stand. These enhancements could be attributed to either direct suppression of deleterious pathogens or indirectly through production of growth hormones and increase in uptake, solubilization and translocation of less available minerals (Harman, 2006). The present study was in line with the findings of Dhanya (2014) in *Morinda Citrifolia* L. (Noni), Ananthi *et al.* (2017), Monalisa *et al.* (2017) in common bean and Balasubramanian *et al.* (2018) in chilli.

Nitrogen content in potting media (kg ha^{-1})

The seed biopriming treatments (Table 3) had showed the significant influence on nitrogen content in potting media.

The highest (185.56) nitrogen content was observed in potting media of control (T_1) while the lowest nitrogen content (147.78) was observed in potting media used for sowing of seeds treated with 10% Azotobacter + PSB for 24 h (T_7) treatment and it was on par with nitrogen content of potting media used for sowing of seeds treated with 10% Azotobacter + PSB for 12 h (T_6) (149.36).

Phosphorous content in potting media (kg ha^{-1})

The data on phosphorous content in potting media (kg ha^{-1}) as influenced by the different biopriming treatments was presented in table 3.

The maximum (33.27) phosphorous content was observed in control (T_1) while the minimum phosphorous content (22.84) was observed in potting media used for sowing of seeds treated with 10% Azotobacter + PSB for 24 h (T_7) followed by T_6 (10% Azotobacter + PSB for 12 h) (28.42).

The decrease in N and P contents in potting media used for sowing of seeds treated with 10% Azotobacter + PSB for 24 h (T_7) could be attributed to the efficient absorption and utilization of nutrients helped in better development of root (in terms of root length, root fresh and dry weights) and shoot (seedling height, stem girth and more number of leaves per plant) growth in papaya seedlings. PGPR strains were reported to improve the plant nutritional status as earlier reported by El-Gamal *et al.* (2020) and Chakma *et al.* (2021).

Nitrogen content in papaya seedlings (%)

Significant differences were observed among the treatments with respect to nitrogen content in leaves of papaya seedlings (Table 3).

The nitrogen content of leaf was found significantly high (1.213) in seedlings raised from the seeds treated with 10% Azotobacter + PSB for 24 h (T_7) followed by biopriming of seeds with 10% Azotobacter + PSB for 12 h (T_6) treatment (1.178). The nitrogen content of leaf was found significantly lowest (0.452) in seedling raised from the seeds soaked in water for 24 h *i.e.*, control (T_1).

Phosphorous content in papaya seedlings (%)

The results indicated that, there were significant differences among the treatments for leaf phosphorous content in papaya seedlings (Table 3).

The leaf phosphorus content was highest (0.795) in seedlings raised from the seeds treated with 10% Azotobacter + PSB for 24 h (T_7) followed by biopriming of seeds with 10% Azotobacter + PSB for 12 h (T_6) treatment (0.741) and the lowest (0.428) phosphorus content in leaf was observed in control treatment *i.e.*, water soaking for 24 h – hydropriming (T_1). Similar findings were found by Entesari *et al.* (2013) in soyabean and Dhanya (2014) in *Morinda Citrifolia* L. (Noni).

Azotobacter and phosphate solubilizing bacteria (PSB) improves overall soil health by improving nitrogen and phosphorus content in soil. Thus, seed treatment not only plays a dominant role in improving the seed quality, it also aids in the better crop stand establishment during the early vegetative phase, which contributes to the higher productivity. It is evident in the present experiment *i.e.,* decrease in N and P contents of potting media through better absorption and utilization of N and P nutrient contents in leaves of papaya seedlings.

Table 1 : Effect of seed biopriming on germination characters, plant height, stem girth and number of leaves of papaya seedlings cv. Red Lady.

Treatments	Days taken for germination	Germination percentage	Plant height (cm)				Stem girth (cm)				Number of leaves/seedling			
			15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T_1	11.33	90.47 (9.56)	3.32	11.13	28.58	40.16	0.30	0.81	1.06	1.19	3.00	6.13	8.00	11.83
T_2	9.13	93.42 (9.72)	4.27	13.17	34.78	48.64	0.38	1.03	1.14	1.37	3.00	7.06	9.60	13.09
T_3	8.29	94.40 (9.77)	4.33	13.63	36.12	56.26	0.40	1.09	1.32	1.36	3.05	7.26	9.93	13.46
T_4	9.71	93.42 (9.72)	4.06	11.97	34.62	48.46	0.36	1.10	1.33	1.36	3.00	7.17	10.24	14.03
T_5	8.56	95.38 (9.82)	4.20	13.17	34.78	48.64	0.40	1.11	1.34	1.37	3.06	7.33	9.33	13.73
T_6	6.24	97.35 (9.92)	4.51	15.08	37.15	56.47	0.44	1.21	1.44	1.46	4.14	8.10	10.76	14.24
T_7	5.46	99.04 (10.00)	4.60	15.79	38.62	59.46	0.48	1.24	1.50	1.55	4.65	8.79	11.28	15.53
SE m±	0.13	0.07	0.07	0.20	0.58	0.74	0.01	0.01	0.02	0.03	0.04	0.13	0.14	0.22
CD at 5%	0.39	0.20	0.21	0.59	1.75	2.24	0.02	0.04	0.06	0.08	0.13	0.39	0.43	0.66

*figures in parenthesis are square root transformation values

Table 2 : Effect of seed biopriming on fresh and dry weights of shoot and root, total chlorophyll content (SPAD units), root : shoot ratio, root length, vigour index of papaya seedlings cv. Red Lady.

Treatments	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of root (g)	Dry weight of root (g)	Total chlorophyll content (SPAD units)	Root : shoot ratio	Root length (cm)	Vigour Index Length	Vigour Index Mass
T_1	17.57	4.86	14.68	2.92	13.21	0.56	7.13	4278.33	703.86
T_2	21.84	6.97	18.70	3.91	16.76	0.60	8.26	5315.60	1016.41
T_3	24.87	6.93	19.02	4.51	18.13	0.65	8.72	6134.11	1079.94
T_4	20.64	6.50	20.96	4.84	16.56	0.75	9.12	5379.12	1059.38
T_5	22.99	6.66	21.19	5.12	18.08	0.77	9.54	5549.21	1123.58
T_6	27.50	7.13	24.24	5.57	21.38	0.78	10.03	6473.78	1236.35
T_7	29.02	7.41	27.24	5.89	22.42	0.80	10.26	6905.07	1317.23
SE m±	0.35	0.08	0.32	0.07	0.26	0.01	0.14	82.75	15.30
CD at 5%	1.05	0.23	0.98	0.22	0.79	0.03	0.42	250.98	46.41

Table 3 : Effect of seed biopriming on nitrogen and phosphorous content in potting media and in papaya seedlings cv. Red Lady.

Treatments	Potting media		Papaya seedlings	
	N (kg ha^{-1})	P (kg ha^{-1})	Nitrogen content (%)	Phosphorus content (%)
T_1	185.56	33.27	0.452 (1.205)	0.428 (1.194)
T_2	159.38	32.92	0.917 (1.385)	0.522 (1.234)
T_3	156.42	31.53	0.942 (1.394)	0.573 (1.254)
T_4	168.34	30.18	0.823 (1.350)	0.602 (1.265)
T_5	162.43	28.92	0.884 (1.373)	0.645 (1.283)
T_6	149.36	28.42	1.178 (1.476)	0.741 (1.319)
T_7	147.78	22.84	1.213 (1.488)	0.795 (1.339)
SE m±	1.614	0.457	0.003	0.004
CD at 5%	4.896	1.386	0.010	0.013

Figures in parenthesis are square root transformation values

Conclusion

On the basis of results obtained in the present investigation, it could be concluded that, the biopriming with 10% Azotobacter + Phosphate solubilizing bacteria for 24 hours exhibited promising results with respect to germination, growth and nutrient analysis of both potting media and papaya seedlings.

Authors' Contribution

Conceptualization of research (MM, ChS, NB); Designing of the experiments (MM, PVKR, PS, KS, ChS); Contribution of experimental materials (ChS); Execution of field/lab experiments and data collection (ChS); Analysis of data and interpretation (ChS); Preparation of the manuscript (ChS, MM, PVKR, PS, KS, NB).

Declaration

The authors declare that they do not have any conflict of interest.

References

Ananthi, M., Selvaraju, P. and Sundaralingam, K. (2017). Standardization of suitable concentration and duration of seed biopriming with humic acid in chilli. *International Journal Chemical Studies*. **5**, 636- 39.

Awasthi, R.P., Godara, R.K. and Kaith, N.S. (1998). Interaction effect of VA-mycorrhizae and Azotobacter inoculation on micronutrient uptake by peach seedlings. *Journal of Horticulture*. **11**, 1-5.

Balasubramanian, S., Thilagar, G., Ashwin, R. and Bagyaraj, D.J. (2018). Biopriming with microbial consortia on germination and growth of chilly. *Journal of Soil Biology and Ecology*. **38**, 68-74.

Bharathi, N., Madhavi, M., Naram, N.L., Vinaya, K.P., Salomi, S., Rama, D.P. (2021). Influence of liquid and carrier based biofertilizers on growth characters of guava

(*Psidium guajava* L.) cv. Taiwan White. *The Pharma Innovation Journal*. **10** (11), 604-06.

Candolle, D.A. (1884). *Origin of Cultivated Plants*. John Wiley and Sons, New York, 281.

Chakma, R., Saekong, P., Biswas, A., Ullah, H. and Datta, A. (2021). Growth, fruit yield, quality, and water productivity of grape tomato as affected by seed priming and soil application of silicon under drought stress. *Agricultural Water Management*, **256**, 107055.

Chauhan, R. and Patel, P.R. (2017). Evaluation of seed bio-priming against chilli (*Capsicum frutescence* L.) diseases *in vivo*. *Journal of Pharmacognosy and Phytochemistry*, **6**(6), 176-181.

Chawla, W. and Mehta, K. (2015). Effect of different growing media on survival and growth of transplanted litchi layers. *Asian Journal of Horticulture*. **10**(2), 257- 61.

Clapperton, M.J. and Reid, D.M. (1992). A relationship between plant growth and increasing VA mycorrhizal inoculum density. *New phytologist*. 120(2), 227-234.

Dhanya, B.A. (2014). Evaluation of Microbial Seed Priming in Relation to Seed Germination, Plant Growth Promotion in *Morinda Citrifolia L.*(Noni) (*Doctoral dissertation*, University of Agricultural Sciences, GKVK).

El-Gamal, A.D., Ismail, M.A., Amin, M.A. and Sayed, A.M. (2020). Comparative studies between seaweeds and commercial algae in alleviation of harmful effects of drought stress of faba bean (*Vicia faba* L.) plants. *Menoufia Journal of Plant Protection*. **5**(4), 57-72.

Entesari, M., Sharifzadeh, F., Ahmadzadeh, M., Farhangfar, M. (2013). Seed biopriming with *Trichoderma* species and *Pseudomonas fluorescence* growth parameters, enzyme activity and nutritional status of soybean. *International Journal of Agronomy and Plant Protection.* **4**(4),610-19.

Gerdmann, J.W., Torrey, J.G. and Clarkson, D.T. (1975). Vesicular-arbuscular mycorrhizae. In, *Development and Function of Roots*. 571-96

Gomathy, M., Prakash, D., Thangaraju, M. and Sundaram, P. (2008). Impact of biofertigation of Azophosmet on cotton yield under drip irrigation. *Research Journal of Agriculture and Biological Sciences*, **4**(6), 695-99.

Harman, G.E. (2006). Overview of mechanisms and uses of *Trichoderma* spp. *Phytopathology,* **96**, 190-94

Joolka, N.K., Singh, R.R. and Sharma, M.K. (2004). Influence of bio-fetilizers, GA_3 and their combinations on the growth of pecan seedlings. *Indian Journal of Horticulture*, **61**(3), 226-28.

Kerni, P.N. and Gupta, A. (1986). Growth parameters affected by azotobacter of mango seedlings in comparison of different nitrogen doses. *Research and Development Reporter*. **3**(21), 77-79.

Khade, S.W. and Rodrigues, B.F. (2009). Studies on effects of arbuscular mycorrhizal fungi on mineral nutrition of *Carica papaya* L. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*. **37**(1), 183-186.

Kumar, M., Rai, P.N., Hariom, S. and Pratibha (2013). Effect of biofertilizers on growth, yield and fruit quality in low-chill Pear cv. Gola. *Agricultural Science Digest.* **33**(2), 114-17.

Kumbar, S. (2018). Effect of microbial inoculants on growth of papaya *(Carica papaya L.)* cv. Red Lady seedlings under polyhouse conditions (*Doctoral dissertation*, University of Agricultural Sciences, GKVK.).

Monalisa, S.P., Beura, J.K., Tarai, R.K., Naik, M. (2017). Seed quality enhancement through biopriming in common bean (*Phaseolus vulgaris* L.). *Journal of Applied and Natural Science*. **9**(3), 1740-43.

Nkpwatt, D.A., Martina, M., Jochen, T., Mewes, B. and Wilfried, S. (2006). Molecular interaction between methylobacterium extorquens and seedlings, growth promotion, methanol consumption, and localization of the methanol emission site. *Journal of Experimental Botany*. **57**(15), 4025-32.

Pathak, D.V., Singh, S. and Saini, R.S. (2013). Impact of bio-inoculants on seed geemination and plant growth of guava (*Psidium guajava* L.). *Journal of Horticulture Forestry*. **10**(5), 183-85.

Rai, A.K., Basu, K. (2017). Pre sowing seed bio priming in okra, Response for seed production. *The Bioscan*. **9**(2), 643-47.

Rani, M.S.A. and Sathiamoorthy, S. (1997). Effect of organic and bio- fertilizers on root enzyme activity, nematode, total biomass and growth enhancement of papaya cv. Co 6. *South Indian Horticulture*. **45**(5/6), 217-23.

Ravishankar, H., Karunakaran, G. and Srinivasamurthy, D. (2008). Performance of Coorg Honey Dew papaya under organic farming regimes in the hill zone of Karnataka. *Acta Horticulture.* **851**, 259-62.

Shaukat, K., Affrasayab, S. and Hasnain, S. (2006). Growth responses of *Helianthus annus* to plant growth promoting rhizobacteria used as a biofertilizer. *Journal of Agricultural Research*. **1**(6), 573.

Shivakumar, B.S., Dharmatti, P.R. And Channal, H.T. (2012). Effect of organic cultivation of papaya yield, economics and soil nutrient status. *Karnataka Journal of Agricultural Sciences.* **25**(4), 488-92.

Sinish, M.S., Mercy, G. and John, P.S. (2005). Organic methods for cashew root stock production. *Cashew*. **19**(1), 8-15.

Thamizh, R.T. and Thangaraju, M. (2006). Development and standardization of liquid formulation for Azospirillum bioinoculant. *Indian Journal of Microbiology*. **46**(4), 379-87.

Vasu, D., Kumari, M. and Zia-ul-Hasan (2010). Effect of biofertilizers (*Azotobacter* and PSB) and their combinations on germination and survival of *Lens culinaris. Medical Environmental and Ecology,* **28**(1), 703-05.

Venkata, R. (2002). Studies on nursery and propagation techniques in poly embryonic rootstocks of mango (*Mangifera indica* L.). *M.Sc. (Hort) Thesis*, *Univ. Agric. Sci*., Bangalore.

Yadav, R.K., Jain, M.C. and Jhakar, R.P. (2012). Effect of media on growth and development of acid lime (*Citrus aurantifolia* Swingle) seedling with or without azotobacter. *African Journal of Agricultural Research.* **7**(48), 6421-26.

Yadav, R.K., Jain, M.C. and Jhakar, R.P. (2012). Effect of media on growth and development of acid lime (*Citrus aurantifolia* Swingle) seedling with or without Azotobacter. *African Journal of Agricultural Research*, **7**(48), 6421-26.