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Role of pre-sowing seed treatment on germination behavior and seedling vigour of papaya (*Carica papaya* L.)

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Abstract
An experiment entitled "Role of pre-sowing seed treatment on germination behavior and seedling vigour of papaya (*Carica papaya* L.)" was conducted at Instructional cum Research Farm, College of Agriculture and Research Station, (IGKV), Bemetara, Chhattisgarh, India during the year 2018 and 2019. The experiment was laid out in Completely Randomized Design (CRD) with Seventeen different treatments replicated three times. The papaya seeds were sown in polybags which was filled with common media and treated with three different concentration of GA_3 (*viz.*, 50, 100 and 150) and 10 per cent cow urine with addition of bio-fertilizers in media soil. The results revealed that the application of treatment T_{11} (seed soaking with 150 ppm GA_3 + 12 hours + azotobacter) was given early germination, rate of emergence as well as highest germination percentage, seed vigour index – I and seed vigour index – II. While, T_{15} (seed soaking with cow urine 10 (%) + 12 hours + azotobacter) had given maximum root: shoot ratio.

Keywords: GA_3, papaya, *Azotobacter*, cow urine, phosphate solublizing bacteria

Introduction
Papaya (*Carica papaya* L.) is an important fruit crop of the tropical and subtropical regions of the world, in the genus carica belonging to the caricaceae family and chromosome number is 2n = 18. It is originated from tropics of America (Hofmeyr, 1938) [16]. In India, papaya is being cultivated an area of about 138.4 thousand hectares having annual production of 5989.88 thousand metric tonnes with productivity of 43.30 mt/ha. Andhra Pradesh is leading state in papaya production followed by Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Chhattisgarh. In Chhattisgarh, papaya is cultivated in an area of about 14.40 thousand hectares with production of 381.42 thousand metric tonnes and productivity is 26.48 mt/ha. In Chhattisgarh, top five major papaya producing districts are Durg, Mahasamund, Raipur, Bilaspur and Bemetara (Anon., 2018) [3].
Papaya is a very delicious, nutritious, refreshing fruit and highly valued for its digestive properties. 100g of papaya contains (89.6%) moisture, (9.5%) carbohydrate, (4.0%) calorific value, (0.5%) proteins, (0.1%) fat, (0.4%) minerals, (0.01% calcium, 0.01% phosphorus, 0.4mg iron), 2020 IU Vitamin A (Carotene), 40 IU Vitamin B (Thiamine) 250 IU Vitamin B_2 (riboflavin), 85 mg Vitamin C (ascorbic acid), and 0.2 IU nicotinic acid (Ram, 2005) [5].
Papaya cultivation is restricting some areas in the country due to several limitations on its cultivation. Under present situation, propagation problems, different sex-forms, water logging, frost susceptibility and fungal and viral diseases are well known problems in its cultivation of all over India. Papaya plants react best with integrated management. Because, commercially propagation of papaya is seed and it is highly cross pollinated crop, variability is very much possible. Several internal and external factors such as oxygen, temperature, plant species, water, growth regulators and radiation effect etc. affect the consistency of the plants.
Phosphorus solubilizing bacteria *Pseudomonas spp*. and Nitrogen fixing bacteria *Azotobacter spp*. is known to produce many growth hormones, which often increased root and shoot growth. The useful effect of bio-fertilizers is now well established in fruit crops like banana (Gogoi *et al*., 2004) [14] and papaya (Sukhade *et al*., 1995) [28]. Still, very small work has been done on the use of bio-fertilizers in papaya.
For successful seedling production of papaya appropriate seed germination and seedling growth are most imperative consideration under nursery technique. As the germination rate and seedling growth are affected by different pre-sowing seed treatment of papaya. A wide variety of pre-sowing seed treatment, which includes the plant growth regulators and growing media are used to increase the seed germination and seedling growth in several fruit crops.

Papaya seed declines viability rapidly with aging (Begum *et al*., 1988). The gelatinous sarcotesta (outer seed coat) enclosed with seed which is formed from the outer integument, which can inhibit germination. The papaya seed viability decreases when the sarcotesta remains intact and dry seeds are more prominently affected than fresh ones. GA_3 200 ppm used as seeds soaking for 12 hours reduced the time taken for 50 per cent germination (Anburani and Shakila, 2010) [1].

Materials and Methods

The study was carried out during the year 2018 and 2019 at Intructional cum Research Farm, College of Agriculture and Research Station, (IGKV), Bemetara, Chhattisgarh, India. The experiment was laid out in Completely Randomized Design (CRD) with three replications. The treatments included T_1: Untreated (control), T_2: Seed soaking with 50 ppm GA_3 + 06 hours + Azotobacter), T_3: Seed soaking with 50 ppm GA_3 + 12 hours + Azotobacter, T_4: Seed soaking with 50 ppm GA_3 + 06 hours + Phosphate solubilizing bacteria, T_5: Seed soaking with 50 ppm GA_3 + 12 hours + Phosphate solubilizing bacteria, T_6: Seed soaking with 100 ppm GA_3 + 06 hours + Azotobacter, T_7: Seed soaking with 100 ppm GA_3 + 12 hours + Azotobacter, T_8: Seed soaking with 100 ppm GA_3 + 06 hours + Phosphate solubilizing bacteria, T_9: Seed soaking with 100 ppm GA_3 + 12 hours + Phosphate solubilizing bacteria, T_{10}: Seed soaking with 150 ppm GA_3 + 06 hours + Azotobacter, T_{11}: Seed soaking with 150 ppm GA_3 + 12 hours + Azotobacter, T_{12}: Seed soaking with 150 ppm GA_3 + 06 hours + Phosphate solubilizing bacteria, T_{13}: Seed soaking with 150 ppm GA_3 +12 hours + Phosphate solubilizing bacteria, T_{14}: Seed soaking with Cow urine 10 (%) + 06 hours + Azotobacter, T_{15}: Seed soaking with Cow urine 10 (%) +12 hours + Azotobacter, T_{16}: Seed soaking with Cow urine 10 (%) + 06 hours + Phosphate solubilizing bacteria and T_{17}: Seed soaking with Cow urine 10 (%) + 12 hours + Phosphate solubilizing bacteria. Observations were recorded in respect to first germination from the date of sowing up to germination of the first seedling, germination percentage at 30 days after sowing by counting number of papaya seeds germinated out of total seed dibbled. Seed vigour index – I, seed vigour index – II and root: shoot ratio at 60 days after sowing. The data generated from these investigations were appropriately computed, tabulated and analyzed as described by Panse and Sukhatme, 1985) [23] and OPSTAT in Completely Randomized Design (CRD).

Results and Discussion

Effect of pre-sowing seed treatment on germination parameters

On the basis of pooled data (Table 1), gibberellic acid significantly affects the various germination parameters of papaya seeds which is clearly evident from the experiment. In pooled data, Minimum days required for germination 6.83 days was recorded in the treatment T_{11} (seed soaking with 150 ppm GA_3 + 12 hours + Azotobacter) followed by 7.17 days in treatment T_{10} (seed soaking with 150 ppm GA_3 + 06 hours + Azotobacter) and 7.39 days in the treatment T_{13} (seed soaking with 150 ppm GA_3 + 12 hours + PSB). Gibberellic acid acts on the embryo and causes synthesis of hydrolyzing enzymes particularly amylase and protease and this hydrolyzed food is utilized for growth of embryo and thereby enhanced the germination (Paleg, 1965) [21]. Similar findings were reported by Suryakanth *et al*. (2005) [29] in guava; Dhankar and Singh (1996) [11] and Gholap *et al*. (2000) [13] in aonla; Barche *et al.* (2010) [5] and Dhinesh Babu *et al.* (2010) [12], Anjanwe *et al*. (2013) [2] and Amit Desai *et al.* (2017) [9] in papaya. This finding is similar to that of Vasu *et al.* (2010) [31] reported that 10 g inoculation of *Azotobacter* showed highest germination and also reduced the average time taken to start germination.

On the basis of pooled data (Table 1), the maximum rate of emergence 79.38 (%) was recorded in the treatment T_{11} (seed soaking with 150 ppm GA_3 + 12 hours + Azotobacter) followed by 77.38 (%) in treatment T_{10} (seed soaking with 150 ppm GA_3 + 06 hours + Azotobacter) and 74.45 in the treatment T_{13} (seed soaking with 150 ppm GA_3 + 12 hours + PSB). The promising effect of gibberellic acid on seed germination might be due to its participation in the activity of alpha-amylase, which catalyzes the starch conversion in to simple carbohydrates and chemical energy is liberated which is used in the activation of embryo (Anjanawe *et al.*, 2013) [2]. The results are in conformity with the findings of Babu *et al.* (2010) [4, 7], Singh *et al.* (2002) [27], Kadam *et al.* (1992) [17], Palanisamy *et al.* (1987) [20].

Similar trend was also found during the year 2018 and 2019 for rate of emergence and on the basis of pooled data (Table 1), the maximum germination percentage 94.17 (%) was recorded in the treatment T_{11} (seed soaking with 150 ppm GA_3 + 12 hours + Azotobacter) followed by 90.83 (%) in treatment T_{10} (seed soaking with 150 ppm GA_3 + 06 hours + Azotobacter) and 88.33 in the treatment T_{13} (seed soaking with 150 ppm GA_3 + 12 hours + PSB). The maximum germination percentage was recorded when seeds soaked in gibberellic acid might be due to fact that GA_3 involved in the activation of cytological enzymes with GA_3 stimulates seed germination of *a* – amylase enzymes which convert insoluble starch into soluble sugars and it also initiates the radical growth by removing some metabolic blocks. This might be due to fact that gibberellic acid play an important role in leaching out of the inhibitors into the soaking medium and breaking seed dormancy. This result are conformity with Deb *et al*. (2010) [10], Babu *et al*. (2010) [4, 7] Barche *et al*. (2010) [5], and Anjanwe *et al*. (2013) [2] in papay and Amit Desai *et al.* (2017) [9] in papaya. This finding is also supported by Sinish *et al.* (2005) [26] who reported that inoculation of *Azotobacter* in the potting mixture induced better germination percentage.

Effect of pre-sowing seed treatment on seedling vigour of papaya

On the basis of pooled data (Table 1), at 60 days after sowing of papaya seeds, the maximum shoot/root ratio of papaya 1.07 was recorded in the treatment T_{15} (seed soaking with cow urine 10 (%) + 12 hours + Azotobacter) followed by 1.05 in treatment T_{14} (seed soaking with cow urine 10 (%) + 06 hours + Azotobacter) and 1.05 in the treatment T_3 (seed soaking with 50 ppm GA_3 + 12 hours + Azotobacter).

It might be due to the cow urine was maintaining of high water content in cell, increased cell division and cell elongation which had increased the overall growth of seedlings and thereby increased root:shoot ratio. These results were conformity with the findings of Sutheesh *et al.* (2016) [30] in sandal wood and Amit Desai *et al.* (2017) [9] in papaya.

On the basis of pooled data (Table 2), at 60 days after sowing of papaya seeds, the maximum seedling vigour index-I of the papaya sapling 3939.83 was recorded in the treatment T_{11} (seed soaking with 150 ppm GA_3 + 12 hours + Azotobacter) followed by 3755.45 in treatment T_{10} (seed soaking with 150 ppm GA_3 + 06 hours + Azotobacter) and 3008.44 in the treatment T_7 (seed soaking with 100 ppm GA_3 + 12 hours + Azotobacter).

In present study, the seed vigour index-I of seedling due to GA_3 pre-soaking can be correlated with higher seed germination, higher shoot length and root length and number of leaves has lead to over all assimilation and distribution of food material with the plant (Brain and Hemming,1955) [8] and hence resulted in higher seedling vigour (Pampanna and Sulikeri, 2001) [22]. The results were in close agreement with the Pampanna and Sulikeri (2001) [22] in sapota; Kumar *et al.* (2011), Padma Lay *et al.* (2013) [19] and Amit Desai *et al.* (2017) [9] in papaya.

On the basis of pooled data (Table 2), at 60 days after sowing of papaya seeds, the maximum seedling vigour index-II of the papaya sapling 259.61 was recorded in the treatment T_{11} (seed soaking with 150 ppm GA_3 + 12 hours + Azotobacter) followed by 239.20 in treatment T_{10} (seed soaking with 150 ppm GA_3 + 06 hours + Azotobacter) and 200.65 in the treatment T_{15} (seed soaking with cow urine 10 (%) + 12 hours + Azotobacter).

In present study, the seed vigour index-II of sapling due to GA_3 pre-soaking can be correlated with higher seed germination, higher shoot length and root length and number of leaves has lead to over all assimilation and distribution of food material with the plant (Brain and Hemming,1955) [8] and hence resulted in higher seedling vigour (Pampanna and Sulikeri, 2001) [22]. The results were in close agreement with the findings of Amit Desai *et al.* (2017) [9] in papaya; Patil *et al.* (2012) in Rangpur lime and Gurung *et al*. (2014) in passion fruit.

Table 1: Effect of pre-sowing seed treatment on germination behavior on papaya

Treatments	Days taken to germination			Rate of emergence			Germination percentage		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1	11.67	12.33	12.00	61.57	57.87	59.73	65.00	63.33	64.17
T_2	10.00	10.67	10.33	70.71	67.68	69.20	75.00	78.33	76.67
T_3	09.33	09.67	09.50	71.15	68.59	69.87	80.00	78.33	79.17
T_4	10.33	11.00	10.67	71.72	68.69	70.21	76.67	75.00	75.83
T_5	09.33	10.00	09.67	68.79	65.76	67.28	80.00	76.67	78.33
T_6	08.33	08.67	08.50	73.93	71.15	72.54	81.67	80.00	80.83
T_7	07.33	07.67	07.50	73.26	70.70	71.98	81.67	83.33	82.50
T_8	08.33	08.67	08.50	73.08	70.30	71.69	80.00	78.33	79.17
T_9	07.33	07.67	07.50	65.81	63.25	64.53	81.67	80.00	80.83
T_{10}	07.00	07.33	07.17	78.57	76.19	77.38	90.00	91.67	90.83
T_{11}	06.67	07.00	06.83	80.42	78.33	79.38	95.00	93.33	94.17
T_{12}	08.33	08.67	08.50	74.60	72.22	73.41	85.00	88.33	86.67
T_{13}	07.33	07.33	07.39	75.64	73.26	74.45	86.67	90.00	88.33
T_{14}	09.00	09.33	09.17	65.76	62.73	64.25	78.33	76.33	77.50
T_{15}	08.67	09.00	08.83	68.69	65.66	67.18	80.00	78.33	79.17
T_{16}	09.33	09.67	09.50	65.76	62.73	64.25	73.33	71.67	72.50
T_{17}	09.00	09.33	09.17	65.56	62.22	63.89	75.00	73.00	74.17
SEm±	0.291	0.323	0.252	2.739	2.65.	2.293	2.021	2.858	1.739
C.D. at 5%	0.841	0.933	0.729	7.907	7.650	6.619	5.834	8.250	5.018

Table 2: Effect of pre-sowing seed treatment on seedling vigour of papaya

Treatments	Seedling vigour index-I			Seedling vigour index-II			Root/ shoot ratio		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T_1	1242.15	1215.23	1228.69	75.83	79.10	77.47	0.91	0.86	0.89
T_2	2538.25	2540.47	2539.36	154.58	162.18	158.38	1.04	1.03	1.03
T_3	2575.42	2579.28	2577.35	169.80	174.52	172.16	1.05	1.04	1.05
T_4	1655.33	1649.13	1652.23	98.12	102.48	100.30	0.98	0.95	0.96
T_5	1794.93	1802.73	1798.83	112.27	112.70	112.48	0.98	0.96	0.97
T_6	2928.82	2876.00	2902.41	185.68	179.47	182.58	1.02	1.01	1.02
T_7	2973.18	3043.70	3008.44	191.62	190.23	190.93	1.03	1.05	1.04
T_8	1973.07	1940.28	1956.68	119.65	118.62	119.13	0.93	0.88	0.91
T_9	2092.85	2057.33	2075.09	126.88	124.27	125.58	0.95	0.90	0.92
T_{10}	3718.80	3792.10	3755.45	237.90	240.50	239.20	0.98	1.00	0.99
T_{11}	3983.98	3895.68	3939.83	260.3	258.92	259.61	1.00	1.01	1.01
T_{12}	2138.40	2225.45	2181.93	146.77	154.03	150.40	0.97	1.00	0.98
T_{13}	2242.07	2337.60	2289.83	158.85	168.00	163.43	0.99	1.01	1.00
T_{14}	2550.40	2518.80	2534.60	191.98	192.13	192.06	1.05	1.06	1.05
T_{15}	2640.00	2615.35	2627.68	202.13	199.17	200.65	1.06	1.08	1.07
T_{16}	1757.98	1723.28	1740.63	117.78	117.97	117.88	0.96	0.98	0.98
T_{17}	1784.83	1753.50	1769.17	126.77	125.48	126.13	0.97	1.00	0.99
SEm±	61.719	65.511	51.665	4.585	5.787	4.555	0.011	0.030	0.019
C.D. at 5%	178.145	189.089	149.126	13.235	16.704	13.148	0.031	0.080	0.055

Conclusion

From the present study it may be concluded pre-sowing seed treatment of papaya gave significant result on improving the germination parameters and seedling vigour of papaya. Application of GA_3, with bio-fertilizers provide the additional benefits on media and proved better in the germination under condition of Chhattisgarh. The treatment T_{11} (Seed soaking with 150 pppm GA_3 + 12 hours + Azotobacter) may be recommended for the enhancement of seed germination and vigour of papaya.

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