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Effect of pre-soaking chemicals on germination and subsequent seedling growth of papaya (*Carica papaya* L.) cv. solo

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Abstract
An experiment was conducted during 2016 at New Orchard, department of Horticulture, College of Agriculture, UAS, Dharwad to study the effect of pre-soaking chemicals on germination and subsequent seedling growth of papaya (*Carica papaya* L.) Cv. Solo. Pre-soaking of seeds with GA_3 at 100 ppm had significant effect and taken less number of days to plumule appearance (15.00), emergence of true leaf (22.33), completion of germination (35.00), high rate of germination (0.028) and highest length of tap root (25.83 cm) as compared to other treatments. KNO_3 at 1 % had significant influence on germination percentage (70.00 %) and number of lateral roots per seedling (33.80) as compared to other treatments. Pre-soaking of seeds with thiourea at 1000 ppm had significant influence on height of seedling at 60 DAS (18.40 cm), number of leaves at 60 DAS (9.00) and vigour index- I (2896.09) as compared to control. GA_3 at 200 ppm had significant increase in girth of seedling at 60 DAS (5.77 mm), leaf area at 60 DAS (56.00 cm^2), total fresh weight (17.02 g) and total dry weight (2.46 g) of seedling, vigour index-II (134.89) and quality index (0.35) of seedling.

Keywords: Papaya, Pre-Soaking chemicals, Germination, GA_3

Introduction

Papaya (*Carica papaya* L.) is an important fruit crop of tropical world and has long been known as wonder fruits of the tropics. It gives higher production of fruits per hectare and income next to banana. It belongs to the family Caricaceae and is native of Tropical America. It was introduced into India in the 16^{th} century. It is grown in almost all tropical and subtropical countries of the world and occupies a unique place amongst the fruit crops grown in India. India ranks first among papaya producing countries in the world followed by Brazil, Indonesia and Dominican Republic with a production of more than 56.39 lakh Metric Tonnes. In India papaya is grown throughout the country with an area of 1.3 lakh hectares covering almost all states. It is cultivated on a commercial scale in the states of Karnataka, Bihar, Gujarat, Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra and Madhya Pradesh, where in Karnataka stands fourth in production after Andhra Pradesh, Gujarat and Maharashtra by producing 4.75 lakh Metric Tonnes in 6,750 hectare (Anon., 2015) [5].

Propagation of papaya is only through seeds as a viable option. The germination of papaya seeds is slow, erratic and incomplete (Chacko and Singh, 1966) [10]. The seed is enclosed within a gelatinous sarcotesta (aril or outer seed coat which is formed from the outer integument). This sarcotesta is reported to prevent germination. The slow and asynchronous germination is attributed due to the presence of inhibitors (mainly phenolic compounds) in the sarcotesta and seed coat (Reyes *et al*. 1980) [24]. In addition to inhibitor substances about 20 % of papaya seeds are embryoless (Nagao and Furutani, 1986) [20]. Dormancy is also observed in seeds from which sarcotesta has been removed (Lange, 1961) [17]. Proper seed germination and seedling growth are most important considerations in successful production under nursery technique of papaya cultivation. The seed cost of many gynodioceious cultivars of papaya is very high. So increasing germination and producing vigorous seedling is very important for papaya nursery growers. In view of several treatments in improving the seed germination this study was taken up to know the role of different chemicals on seed germination and subsequent seedling vigour.

Materials and Methods

The experiment was conducted in the year 2016 at New Orchard, Department of Horticulture, College of Agriculture, UAS Dharwad. The experiment was laid out in completely randomized design with three replications in polybags (10×12 cm) and each treatment was composed of fifty seeds. The seeds extracted from 3/4 th ripe papaya fruits were used for sowing. The required quantity of chemicals was prepared through stock solution and seeds were soaked for duration of 12 hours. The experiment was comprised of nine treatments namely, T_1- GA_3 100 ppm, T_2- GA_3 200 ppm, T_3- KNO_3 0.5 %, T_4- KNO_3 1 %, T_5- BA 50 ppm, T_6- BA 100 ppm, T_7- Thiourea 1000 ppm, T_8- Thiourea 2000 ppm, T_9- control (seeds without any trématent). The seed sowing was done in the month of January about 2 cm depth in polybags filled with soil. The polybags were irrigated immediatly after seed sowing and repeated every day till the final emergence. After the completion of germination the polybags were irrigated once in two days.

The count of germinated seeds was taken at an interval of two days after sowing of seeds. The percentage of germination was calculated at the end of the experiment. Similarly days required for plumule appearance, true leaf emergence, days for completion of germination and rate of germination was also recorded. The rate of germination was determined by taking the reciprocal of the number of days require to complete germination (Bewley and Black, 1982) [8]. Observation like height, number of leaves, length of tap root, total biomass and number of lateral roots were also recorded. Girth of seedling were recorded using digital Vernier Caliper, leaf area was measured using leaf area meter and Chlorophyll meter was used to measure chlorophyll content of leaves. Seedling vigour index was calculated using formula (Abdul Baki and Anderson, 1973) [2]: VI_1 = Germination percentage × total seedling length, VI_2 = Germination percentage × total dry weight. Quality index which is a measure to assess the quality of seedling was measured using formula (Dickson *et al*., 1960) [12].

$$\text{Quality index} = \frac{\text{Total dry weight of seedling (g)}}{\frac{\text{Height of seedling (cm)}}{\text{Collar dimeater (mm)}} + \frac{\text{Shoot dry weight (g)}}{\text{Root dy weight (g)}}}$$

Results and Discussions

The results showed that pre-soaking chemicals had beneficial effect on seed germination and growth of papaya seedling.

Seed germination parameters

The seed germination parameters of papaya as affected by pre-soaking chemicals are presented in Table 1.

Table 1: Effect of pre-soaking chemicals on seed germination parameters of papaya

Treatment	Germination (%)	Days to plumule appearance	Days to true leaf emergence	Days require for completion of germination	Rate of germination
T_1: GA 100 ppm	52.67 (46.51)	15.00	22.33	35.00	0.028
T_2: GA 200 ppm	55.33 (48.06)	17.00	23.33	35.00	0.028
T_3: KNO_3 0.5%	51.33 (45.75)	17.67	27.33	40.67	0.024
T_4: KNO_3 1%	70.00 (56.86)	20.33	28.67	44.00	0.022
T_5: BA 50 ppm	53.33 (46.93)	17.00	25.00	42.00	0.024
T_6: BA 100 ppm	61.33 (51.72)	20.00	28.00	43.33	0.022
T_7: Thiourea 1000 ppm	67.33 (55.36)	20.00	29.00	43.33	0.022
T_8: Thiourea 2000 ppm	37.33 (37.38)	18.00	28.33	44.00	0.022
T_9: control	30.67 (33.24)	22.33	33.33	49.33	0.020
S.Em.±	3.89	0.38	0.75	0.80	0.001
C.D. at 5%	11.55	1.14	2.21	2.38	0.002

Figures in the parenthesis indicate arcsine transformed value

The highest germination (70.00%) was recorded in KNO_3 at 1% as compared to control (30.67%). This might be due to nitrogen compounds which affect germination through the detection of nitrogen in the soil. These could stimulate the pentose phosphate pathway in seeds and thereby increasing seed germination by increasing the oxidation of NADPH to NADH. Nitrate can alter hormone levels by inducing the expression of enzymes that catalyze the inactivation of abscisic acid ABA (CYP707A2) and the biosynthesis of gibberellins (GAox1) (Finch *et al*., 2007) [14]. Similar results were obtained by Owino and Ouma (2011) where they have reported highest germination in papaya seeds treated with potassium salts because of increased in water uptake needed by germinating seed. Similar findings were made by Furutani *et al*. (1993) [15] and Dwivedi *et al*. (2015) [13] in papaya. These results are in conformity with the findings of Reddy and Khan (2001) [23] in khirni, Rajamanickam *et al*. (2002) [22] in aonla, Cardenas *et al*. (2013) [9] in sweet granadilla and yellow passion fruit and Aatla and Srihari (2013) [1] in mango.

However, GA_3 at 100 and 200 ppm had taken less number of days for appearance of plumule (15.00 and 17.00) and this had subsequently led to less days for emergence of true leaf (22.33 and 22.33) and also less number of days for completion of germination (35.00 and 35.00) as compared to control which has taken 49.33 days for completion of germination. This results were attained due to GA_3 having stimulatory effect in the formation of enzymes which are important in the early phase of germination which helps for faster radicle protrusion. Faster protrusion of radicle has given higher rate of germination for GA_3 at 100 and 200 ppm (0.028 and 0.028) as compared to control (0.020). Chacko and Singh (1966) [10] also reported higher rate of germination of papaya seeds treated with GA_3. These results are in conformity with the findings of Babu *et al*. (2010) [6] and Anjanawe *et al*. (2013) [4] in papaya.

Growth Parameters

The growth parameters of papaya as affected by pre-soaking chemicals are presented in Table (2 and 3).The plant height is one of the important characters in growth and development of seedling. At 60 DAS seeds treated with thiourea at 1000 ppm recorded highest height (18.40 cm) as compared to control which had recorded the lowest (7.98 cm). Similar findings were made by Anitha *et al*. (2004) [3] in cowpea. From the physiological point of view, leaf is the most important photosynthetic site of the plant. It is the source from which the plant derives energy for its metabolic activities. The primary function of leaves is the carbon assimilation. Regarding the number of leaves, at 60 DAS it was recorded highest in seeds treated with thiourea at 1000 ppm (9.00) which was on par with seeds treated with GA_3 at 200 ppm (8.87) and least was recorded in control (6.40). Similar results were obtained by Anjanawe *et al*. (2013) [4] for seeds of papaya treated with 200 ppm of GA_3. The favourable effect of thiourea on plant growth might be due to improved photosynthetic efficiency. Thiourea is a sulphydral compound which plays a bio-regulatory role in plants due to presence of SH-group and stimulated the photosynthetic CO_2 fixation mechanism. The SH-group has diverse biological activities such as diversion of photosynthates from source to sink (Meena *et al*, 2014) [19]. Similar findings also reported by Balai and Keshwa (2011) [7] and Sanu *et al*. (2013) [25] in coriander.

Girth at collar region is an important factor for giving the support to seedling at initial stage which is a vital character in health of the seedling. At 45 DAS the seeds treated with KNO_3 at 0.5% recorded the highest girth (3.61 mm) which was on par with seeds treated with 200 ppm of GA_3 (3.54 mm). However, at 60 DAS GA_3 at 200 ppm recorded the highest girth (5.77 mm) as compared to control (2.80 mm). The maximum stem girth in case of seedlings obtained from GA_3 pre-soaked seeds might be due to the fact that GA_3 application enhanced the rate of cell division and elongation of stem portion. Increase in stem girth may be possible due to stimulation of cambium and its immediate cell progeny as observed by Dhankhar and Singh (1996) [11] in aonla. Regarding to leaf area, it was recorded highest in seeds treated with GA_3 at 200 ppm (56.00 cm^2) as compared to control (20.02 cm^2). The application of GA_3 might have boosted the leaf growth by increasing cell multiplication and cell elongation resulting in better leaf area. Similar results of increased leaf area with GA_3 pre-sowing treatment were reported by Anjanawe *et al*. (2013) [4]. The chlorophyll content at 60 DAS, pre-soaking of chemicals did not have significant influence. However, the highest (49.48) was recorded in GA_3 at 200 ppm and the least was recorded in control (43.59).

Regarding to length of tap root, seeds treated with GA_3 at 100 ppm recorded the highest (25.83 cm) root length as compared to control (17.50 cm). The maximum root length might be due to elongation of the cells in the sub-apical region of roots as reported by Salisbury and Ross (1988).The number of lateral roots per plant, KNO_3 at 0.5% treated seeds recorded the highest (33.80) which was on par with seeds treated with GA_3 at 200 ppm (31.93). This is in close agreement with Gharahlar *et al*. (2012) [16] in loquat. The fresh weight of shoot, it was highest in seeds treated with BA at 50 ppm (13.79 g) which was at par with seeds treated with GA_3 at 200 ppm (13.39 g) as compared to control (2.49 g). Similarly, the highest fresh weight of roots (3.63 g) was recorded in GA3 treated seeds at 200 ppm followed by BA treated seeds at 50 ppm (2.78 g) as compared to control (1.19 g). However, as a result of high fresh weight shoot and root, the total fresh weight of seedling was observed highest in GA_3 at 200 ppm (17.02). This might be because of higher mobilization of water, nutrient uptake capacity and its transportation by gibberellin than cytokinin which has resulted into more production of photosynthetic products and translocation into various parts of the plant. The result is in conformity with the findings of Dhankhar and Singh (1996) [11] in aonla and Meena and Jain (2012) [19] in papaya. Similarly, because of the more accumulation of photosynthetic products dry weight of shoot, dry weight of root and total seedling dry weight was recorded maximum in GA_3 at 200 ppm. Similar results were obtained by Vasantha *et al*. (2014) [26] in tamarind.

Vigour index-I was recorded highest (2896.09) in seeds treated with thiourea at 1000 ppm. As vigour index-I is dependent on germination percentage and seedling length, the seeds treated with thiourea had highest per cent of germination and also recorded the highest height. In case of vigour index-II it was recorded highest in seeds treated with GA_3 at 200 ppm (134.89). This is due to more seedling dry weight in GA_3 than any other treatment.

Regarding to quality index which is a measure to assess the quality of seedling based on height, stem diameter and dry biomass was recorded highest in seeds treated with GA_3 at 200 ppm (0.35) as compared to control (0.11). This is mainly because of the most of the growth parameters and seedling biomass parameters were recorded highest in GA_3 at 200 ppm. On the basis of the results obtained from this study it can be concluded that pre-soaking of seeds with KNO_3 at 1% led to increase in germination per cent. For getting higher vigour index I seeds must be treated with thiourea at 1000 ppm. However, pre-soaking of seeds with GA_3 at 200 ppm will give higher vigour index II and quality index of the seedling.

Table 2: Effect of pre-soaking chemicals on growth of papaya seedling

Treatment	**Height of seedling (cm)**		**Number of leaves**		**Girth of seedling (mm)**		**Chlorophyll (SPAD units)**	**Leaf area (cm^2)**	**Number of lateral roots/plant**	**Length of tap root (cm)**
	45 DAS	**60 DAS**	**45 DAS**	**60 DAS**	**45 DAS**	**60 DAS**	**60 DAS**	**60 DAS**	**60 DAS**	**60 DAS**
T_1: GA 100 ppm	7.05	12.09	6.07	8.27	2.93	4.92	46.16	31.45	29.07	25.83
T_2: GA 200 ppm	8.11	15.43	7.13	8.87	3.54	5.77	47.64	56.00	31.93	21.10
T_3: KNO_3 0.5%	8.19	14.43	6.67	8.33	3.61	5.56	45.41	44.37	33.80	24.00
T_4: KNO_3 1%	9.28	16.77	7.07	8.80	3.31	5.23	45.61	40.19	30.87	23.37
T_5: BA 50 ppm	9.20	14.97	7.27	8.53	3.28	5.64	46.21	34.29	31.27	20.77
T_6: BA 100 ppm	9.08	15.73	7.07	8.40	3.40	5.34	45.71	55.13	30.33	20.47
T_7: Thiourea 1000 ppm	9.20	18.40	7.27	9.00	3.21	5.67	45.41	45.72	26.47	24.73
T_8: Thiourea 2000 ppm	8.38	13.63	6.60	8.07	2.79	4.51	45.13	30.98	25.07	22.43
T_9: control	5.56	7.98	5.27	6.40	1.91	2.80	43.59	20.02	16.53	17.50
S.Em.±	0.25	0.88	0.21	0.23	0.14	0.26	0.73	2.90	1.46	1.45
C.D. at 5 %	0.73	2.62	0.61	0.67	0.43	0.77	N.S	8.62	4.33	4.31

DAS – Days After Sowing N.S – Non Significant

Table 3: Effect of pre-soaking chemicals on biomass, vigour index-I, vigour index-II and quality index of papaya seedling at 60 DAS

Treatment	Shoot fresh weight (g)	Root fresh weight (g)	Total fresh weight of seedling (g)	Shoot dry weight (g)	Root dry weight (g)	Total dry weight of seedling (g)	vigour index -I	vigour index-II	quality index
T_1: GA 100 ppm	8.89	2.16	11.05	1.11	0.25	1.36	2000.22	71.23	0.20
T_2: GA 200 ppm	13.39	3.63	17.02	2.00	0.46	2.46	2008.86	134.89	0.35
T_3: KNO_3 0.5%	9.90	2.44	12.33	1.29	0.26	1.55	1957.00	78.66	0.20
T_4: KNO_3 1%	11.60	2.54	14.13	1.31	0.34	1.65	2810.13	115.82	0.23
T_5: BA 50 ppm	13.79	2.78	16.57	1.62	0.30	1.92	1911.60	102.74	0.24
T_6: BA 100 ppm	11.49	2.67	14.16	1.28	0.27	1.55	2203.20	94.26	0.20
T_7: Thiourea 1000 ppm	10.17	1.75	11.92	1.19	0.20	1.39	2896.09	93.40	0.15
T_8: Thiourea 2000 ppm	3.71	1.38	5.09	0.51	0.17	0.69	1346.86	25.51	0.11
T_9: control	2.49	1.19	3.69	0.43	0.17	0.60	789.76	18.54	0.11
S.Em.±	0.74	0.17	0.91	0.09	0.02	0.11	229.13	9.87	0.02
C.D. at 5 %	2.21	0.52	2.71	0.28	0.06	0.34	680.80	29.32	0.05

DAS – Days After Sowing

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