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Effect of GA_3 and Growing Media on Seedling Vigour and Physiological Parameter of Custard Apple (*Annona squamosa* L.)

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A B S T R A C T

An investigation was carried out to see the effect of GA_3 and growing media on seed germination, survivability and physiological parameters of Custard apple (*Annona squamosa* L.) from December 2014 to April 2015 at Fruit Research Station, Imalia Farm, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur (M.P.) Amongst different growing media, percent of germination, survivability percentage, Leaf Area Index (LAI), Leaf Area Duration (LAD), Light transmission ratio (LTR), Energy Interception (Ei), Seedling vigour index I (cm) and Seedling vigour index II (g) were found significantly superior under M_5 growing media comprising soil + vermicompost + AZO + PSB followed by M_2 (soil + vermicompost), M_4 (soil + FYM + AZO + PSB), M_1 (soil + FYM), M_3 (soil + AZO + PSB) and M_0 (only soil). Survival of seedling and germination percentage was highest in media M_5 which was at par with M_4. As regards the interactions, germination percentage, survivability, Seedling vigour index I (cm) and Seedling vigour index II (g) were found not significant. However, G_2M_5 treatment combination [seed soaked in 400 ppm GA and sown in soil + vermicompost + AZO + PSB] recorded superior and G_0M_0 combination (control) was found inferior in respect to survival and most of growth parameters. In some physiological parameters like Leaf Area Index (LAI), Leaf Area Duration (LAD), Light transmission ratio (LTR) and Energy Interception (Ei), interaction was found significant. In respect to germination, G_3M_5 treatment combination [Seeds soaked in 600 ppm GA concentration and sown in soil + vermicompost + AZO + PSB] showed superiority over rest of the treatment combinations whereas minimum was observed in control (G_0M_0).

Introduction

Custard apple (*Annona squamosa* L.) belongs to family Annonaceae and is one of the finest fruits gifted to India by tropical America. It is commonly found in India and cultivated an area of 23 thousand ha with production of 176 MT (Anonymous, 2013). Custard apple, popularly known as Sitaphal is grown mainly in the States of Andhra Pradesh, Assam, Tamil Nadu, Madhya Pradesh and grows wild in Deccan plateau and some parts of central India. Custard apple is generally classified as semi wild fruit by virtue of its spontaneous spread in forests, wastelands and other uncultivated places. It is hardy, tolerant to drought, salinity and saline irrigation water to certain extent. It grows very well even on a shallow soil. It also sheds off leaves during stress period to minimize the moisture loss from plant tissues through transpiration and thus a most appropriate fruit crop for rainfed region. Custard apple is known by varied name like Sitaphal, Sugar apple and Shariffa. It is considered as one of the delicious and nutritionally valuable fruits meant for table purpose. Fruits have an edible, soft, granular, juicy and sugary pulp with mild flavour and with slight acidity. Fruits are considered for their medicinal value besides their general use in ice cream, confectionery, certain milk products and in making preserves as jam, jelly and other products. It is considered as beneficial for cardiac disease, diabetes, hyperthyroidism and cancer. It contains about 28-55% of edible portion consisting of 73.30% moisture, 1.60% protein, 0.30% fat, 0.70% mineral matter, 23.90% carbohydrates, 0.20% calcium, 0.40% phosphorus, 1.0% iron, 12.4-18.15% sugar and 0.26-0.65% acidity with caloric value of 105 KCal/100g. It is generally propagated by seed since there is little variability among seedlings. Maximum germination can be obtained by sowing of freshly extracted seed upto 20-30 days. The seeds of Annonaceae are albuminous ellipsoids and their length varies between 5 and 30 mm. They have a ruminate endosperm (Corner, 1976). The embryo is small, straight, with moderately developed embryonic axis, rudimentary plumule and a flat and thin cotyledon; which develops after the seed is formed (Corner, 1976). Setten and Koek-Noorman (1992) observed that Annonaceae seeds undergoing dispersal have a small embryo that is considered underdeveloped and immature; immaturity requires time to complete embryo growth after seed dispersion. Meanwhile, Hayat (1963) reported that the seeds of *A. squamosa* have a small embryo with two foliaceous, thin cotyledons that take one to three months to germinate.

Seed germination is the resumption of active growth of embryo that results in the emergence of the young plant. Seeds of many fruit crops remain ungerminated even under favourable conditions. Such kind of dormancy in seeds may be due to presence of hard and impermeable seed coat, germination inhibitors and improper development of embryo. Such seeds may require special treatments like scarification, soaking in water, growth regulators etc. to overcome dormancy. Gibberellins (GA_3) activate the embryonic vegetative growth, weakens the endosperm layer that involves the embryo and restricts its growth, and mobilizes the energetic reserves from the endosperm of cereals (Bewley, 1997; Taiz and Zeiger, 2006). Cereal embryo synthesizes and releases GA during the germination, which leads to the production and/or secretion of several hydrolytic enzymes involved in the solubilization of reserves, including α-amylase and β-amylase (Taiz and Zeiger, 2006).

Growing media is one of the important environmental factors, which plays an important role in growth and survival of seedlings. Several growing media or their combinations are being used for raising the seedling. Different growing media like soil, sand, farm yard manure (FYM) and vermicompost either alone or in different proportion have been found beneficial to influence germination and growth of seedling. A good growing media provides sufficient anchorage or support to the plant, serves as a reservoir for nutrients and water, allows oxygen diffusion to the roots and permits gaseous exchange between roots and the atmosphere outside root substrate. Bio-fertilizers are also beneficial in seed germination and growth of seedling. Bio-fertilizers are the carrier-based preparations containing mainly effective strains of microorganisms in sufficient number, which are useful for nitrogen fixation. Amongst bio-fertilizers *Azotobacter* strains play a key role in harnessing the atmospheric nitrogen through its fixation in the roots. They have been also reported to improve fertility condition of the soil. The seed coat of most of the fruit crops is very hard. To break the seed dormancy, either some chemical treatment or long incubation period is required but bio-inoculants like *Azotobacter*, PSB etc. also can be helpful in breaking the seed dormancy by producing various plant growth substances in combination with either farmyard manure (FYM) or vermicompost on seed germination and plant growth.

Materials and Methods

The experiment was carried out at Fruit Research Station, Imalia, JNKVV, Jabalpur during the year 2014-2015. Jabalpur is situated in "Kymore Plateau and Satpura Hills" Agro-climatic zone of Madhya Pradesh at 23.9ºN latitude and 79.58º east longitudes and an altitude of 411.78 meters above the mean sea level.

The tropic of cancer passes through the middle of the district. The climate of Jabalpur region is semi-arid and subtropical having warm and dry spring summer and cool winter as main characteristics feature, in general the highest temperature reaches above 45°C and below 5°C respectively. The relative humidity varies from 70-80%.

The average annual rainfall is about 1375, mm, which is mainly distributed from mid-June to first week of October from south-west monsoon with occasional rain during winter. The experiment was laid out with Factorial RBD along with six different growing media and four different concentration of Gibberellic acid with three replications.

Preparation of growing media

The media were used to grow seedling in polybags comprising of:

Only soil

Soil + FYM – the ratio of 2:1 of soil and fully decomposed FYM.

Soil + Vermicompost – the ratio of 2:1of soil and vermicompost.

Soil + AZO + PSB – soil enrich with AZO and PSB (each 5 g/kg soil).

Soil + FYM + AZO + PSB – the ratio of 2:1 of soil and FYM enrich with AZO and PSB (each 5 g/kg soil).

Soil + Vermicompost + AZO + PSB – the ratio of 2:1 of soil and vermicompost enrich with AZO and PSB (each 5 g/kg soil) (Table 1).

Germination percentage

The germination in each treatment was recorded at 60 days after sowing. Number of seedlings were counted and expressed as germination percentage.

$$\text{Germination (\%)} = \frac{\text{Total number of seed germinated}}{\text{Total number of seed sown}} \times 100$$

Survival percentage of seedlings

The survival percentage of each treatment was recorded at 150 days after seed sowing. The survival percentage was calculated by using formula as given below:

$$\text{Survival Percentage of seedlings} = \frac{\text{No. of survived seedling}}{\text{Total no. of seedlings}} \times 100$$

Leaf Area Index

LAI expresses the ratio of leaf surface considerably to the ground area occupied by the plant or a crop stand worked out as per specification of Gardner *et al.*, (1985),

$$LAI = \frac{\text{Total Leaf Area}}{\text{Ground area}} = \frac{(LA1+LA2)/2}{P}$$

Where, the LA_1 and LA_2 represent the leaf area during the two consecutive intervals and "p" ground area (Watson, 1952).

Leaf Area Duration (LAD)

Leaf Area Duration expresses the magnitude and persistence of leaf area of leafiness during the period of crop growth. It reflects the extent of period of crop growth.

It reflects the extent of seasonal integral of light interaction and corrected with yield. LAD was computed as follow (Watson, 1952).

$$LAD = \frac{(LA1+LA2)}{2} \times (t2-t1)\ (cm2x\ days)$$

Light Transmission Ratio (LTR)

It was given by Golingai and Mabbayad in 1969.

$$LTR = \frac{I}{I_0} \times 100$$

Where,

I = Light intensity at the base of crop canopy and
I_0 =Total incoming radiation
It was calculated by Lux meter (model LX-105)

Energy interception (Ei)

It can be calculated by lux meter. Its values were converted in terms of energy as per constants.

The values were recorded at 120 and 150 DAS and then the mean value was worked out.

71 K Lux =1 calorie/cm^2/min

Ei = total incident energy – transmitted energy

Seedling vigour index I

It was calculated by adding the values of root length and shoot length which was randomly selected and multiplying with their corresponding germination percentage and the values were recorded (Abdulbaki and Anderson, 1973).

Seedling vigour index I = germination percentage x [root length (cm) + shoot length (cm)]

Seedling vigour index II (g)

It was calculated by multiplying dry weight of seedlings with their corresponding germination percentage.

Seedling vigour index II = dry weight of seedlings (g) x germination percentage

Results and Discussion

Percentage of germination at 60 DAS

The highest germination percentage (77.50%) was obtained under the media M_5 comprising soil + vermicompost + AZO + PSB. This finding is supported by Sinish *et al.*, (2005) who reported that combined inoculation of AZO, PSB and AMF in the potting mixture induced better germination percentage. Gibberellic acid concentration showed significant effect on percentage of germination at 60 DAS. The maximum germination percentage of 73.89 was recorded under G_3 (600 ppm GA) and the minimum germination (59.44%) was recorded under G_0. It might be due to GA_3 which accelerate the activity of specific enzymes such as α-amylase, which have brought an increase in availability of starch assimilation resulting an early germination.

Interaction effect of growing media and gibberellic acid did not show significant effect on seed germination percentage whereas maximum germination percentage (86.67%) was noted under the combination of growing media and gibberellic acid G_3M_5 (soil + vermicompost + AZO + PSB + 600 ppm). It may be due to synergistic effect of both factors.

Survival percentage of seedlings

In the present study, growing media and GA_3 significantly influenced the survival percentage of seedling at 150 DAS. Maximum survival percentage (86.01) was recorded under growing media M_5 comprising soil + vermicompost + AZO + PSB and minimum (76.49) under M_1 at 150 days after seed sowing.

These findings are supported by Parasana *et al.*, (2012). Gibberellic acid concentration had significant effect on survival percentage. Maximum survival percentage (83.75) was recorded under G_1 which was at par with G_2 while it was minimum (76.00) under $G_{0.}$

Seedling vigour index I (cm)

The maximum seedling vigour index at 150 days after sowing (3717.73 cm) was computed under growing media comprising soil + vermicompost + AZO + PSB (M_5) and minimum (2670.25 cm) under $M_{0.}$ The findings are supported by Krishna *et al.*, (2008). All the treatments promoted significantly higher vigour of seedlings, when compared to control. Particularly, treatment with vermicompost recorded highest vigour index-I and vigour index-II. The probable reason of highest seedling vigour in vermicompost can be that it has relatively high content of humus-like compounds, active micro-organisms, enzymes as well as physical and nutritional condition which increased the physiological activities of plant. The findings are supported by Bhardwaj (2014). As regards the GA_3 as well as interaction of media and $GA_{3,}$ did not showed significant effect on seedling vigour (cm).

Seedling vigour index II (g)

In the present study, significantly maximum seedling vigour index II (125.33 g) at 150 days after sowing was computed under M_5 followed by M_2 (106.02 g) and minimum seedling vigour index II (70.98 g) was recorded under M_0. The probable reason is same to seedling vigour index I. The findings are supported by Bhardwaj (2014). The maximum seedling vigour index II (108.99 g) was recorded under G_2 and it was superior over rest of treatments while minimum seedling vigour index II (89.02 g) was recorded under $G_{0.}$ The seedling vigor significantly differed due to invigouration of seeds.

The highest seedling vigour in GA_3 was attributed to enlarged embryos, higher rate of metabolic activity and respiration, better utilization and mobilization of metabolites to growth points and higher activity of enzymes. Enzymatic and hormonal mechanism stimulate metabolic process such as sugar mobilization, protein hydrolysis, oxidation, etc (Earlplus and Lambeth, 1974), which leads to increase in root length, shoot length and seedling dry weight, in turn increase in seedling vigour. The present results are in conformity with the results of Gurung *et al.*, (2014) (Table 2).

Table.1 Treatment details

Treatments	Treatment combinations	composition
T_1	G_0M_0	0 ppm GA_3 + Soil (Control)
T_2	G_0M_1	0 ppm GA_3 + (Soil + FYM)
T_3	G_0M_2	0 ppm GA_3 + (Soil + Vermicompost)
T_4	G_0M_3	0 ppm GA_3 + (Soil + AZO + PSB)
T_5	G_0M_4	0 ppm GA_3 + (Soil + FYM + AZO + PSB)
T_6	G_0M_5	0 ppm GA_3 + (soil + Vermicompost + AZO + PSB)
T_7	G_1M_0	200 ppm GA_3 + Soil
T_8	G_1M_1	200 ppm GA_3 + (Soil + FYM)
T_9	G_1M_2	200 ppm GA_3 + (Soil + Vermicompost)
T_{10}	G_1M_3	200 ppm GA_3+ (Soil + AZO + PSB)
T_{11}	G_1M_4	200 ppm GA_3 + (Soil + FYM + AZO + PSB)
T_{12}	G_1M_5	200 ppm GA_3 + (soil + Vermicompost + AZO + PSB)
T_{13}	G_2M_0	400 ppm GA_3 + Soil
T_{14}	G_2M_1	400 ppm GA_3 + (soil + FYM)
T_{15}	G_2M_2	400 ppm GA_3 + (Soil + Vermicompost)
T_{16}	G_2M_3	400 ppm GA_3 + (Soil + AZO + PSB)
T_{17}	G_2M_4	400 ppm GA_3 + (Soil + FYM + AZO + PSB)
T_{18}	G_2M_5	400 ppm GA_3 + (soil + Vermicompost + AZO + PSB)
T_{19}	G_3M_0	600 ppm GA_3 + Soil
T_{20}	G_3M_1	600 ppm GA_3 + (Soil + FYM)
T_{21}	G_3M_2	600 ppm GA_3 + (Soil + Vermicompost)
T_{22}	G_3M_3	600 ppm GA_3 + (Soil + AZO + PSB)
T_{23}	G_3M_4	600 ppm GA_3 + (Soil + FYM + AZO + PSB)
T_{24}	G_3M_5	600 ppm GA_3 + (soil + Vermicompost + AZO + PSB)

Table.2 Effect of growing media and GA_3 on germination, survival and seedling vigour index

Treatment	% of germination at 60 DAS	Survival % of seedling at 150 DAS	Seedling vigour Index-1 (cm)	Seedling vigour Index-II (g)
Gibberellic acid				
G_0 (0 ppm)	59.44	76.60	3016.23	89.02
G_1 (200 ppm)	68.89	3.75	3262.72	99.08
G_2 (400 ppm)	72.22	83.73	3372.09	108.99
G_3 (600 ppm)	73.89	79.12	3254.77	100.56
SEm	2.604	1.396	117.540	3.758
CD at 5% level	7.436	3.985	NS	10.751
Media				
M_0 (Soil)	60.00	76.49	2670.25	70.98
M_1 (Soil+FYM)	66.67	79.10	3164.39	98.09
M_2 (Soil+VC)	72.50	81.96	3414.55	106.02
M_3 (Soil+BF)	64.17	77.61	2961.22	91.41
M_4 (Soil+FYM+BF)	70.83	82.88	3430.59	104.65
M_5 (Soil+VC+BF)	77.50	86.01	3717.73	125.56
SEm	3.189	1.709	143.956	4.602
CD at 5% level	9.107	4.881	411.116	1.143
Interaction				
G_0M_0	53.33	74.74	2546.03	65.93
G_0M_1	56.67	76.59	2656.20	74.67
G_0M_2	60.00	77.38	3029.60	89.17
G_0M_3	56.67	74.08	3030.33	97.20
G_0M_4	63.33	77.46	3417.17	97.90
G_0M_5	66.67	79.37	3418.07	109.23
G_1M_0	63.33	78.70	2521.47	68.57
G_1M_1	66.67	81.02	3418.60	99.73
G_1M_2	73.33	84.72	3615.40	114.73
G_1M_3	70.00	81.22	2692.47	81.03
G_1M_4	66.67	88.43	3637.00	105.23
G_1M_5	73.33	88.43	3691.37	125.17
G_2M_0	60.00	77.78	2775.27	71.47
G_2M_1	70.00	80.09	3481.13	124.47
G_2M_2	76.67	87.04	3691.80	118.90
G_2M_3	70.00	79.50	3081.47	93.07
G_2M_4	73.33	86.57	3302.53	109.93
G_2M_5	83.33	87.83	3900.37	136.13
G_3M_0	63.33	74.74	2838.23	77.93
G_3M_1	73.33	78.70	3101.63	93.50
G_3M_2	80.00	78.71	3321.40	101.22
G_3M_3	60.00	75.66	3040.60	94.33
G_3M_4	80.00	79.05	3365.61	105.53
G_3M_5	86.67	88.43	3861.10	130.80
SEm	6.378	3.148	287.912	9.204
CD at 5% level	NS	NS	NS	NS

Table.3 Effect of GA_3 and media on physiological parameters of custard apple

Treatment	**Leaf Area Index (LAI)**	**Leaf Area Duration (LAD)**	**Light Transmission Ratio (LTR)**	**Energy Interception (Ei)**
Gibberellic acid				
G_0 (0 ppm)	0.84	7376.60	57.52	0.33
G_1 (200 ppm)	0.92	8031.76	49.50	0.40
G_2 (400 ppm)	1.11	9715.76	37.22	0.49
G_3 (600 ppm)	1.06	9230.46	43.28	0.46
SEm	0.020	174.140	1.056	0.007
CD at 5% level	0.057	497.317	3.015	0.019
Media				
M_0 (Soil)	0.88	7643.52	55.19	0.34
M_1 (Soil+FYM)	0.98	8531.62	50.19	0.40
M_2 (Soil+VC)	1.02	8873.76	41.14	0.47
M_3 (Soil+BF)	0.94	8233.16	52.10	0.36
M_4 (Soil+FYM+BF)	1.01	8815.52	46.59	0.43
M_5 (Soil+VC+BF)	1.08	9434.29	36.65	0.52
SEm	0.024	213.277	1.293	0.008
CD at 5% level	0.070	609.087	3.692	0.024
Interaction				
G_0M_0	0.78	6842.77	67.71	0.26
G_0M_1	0.84	7308.66	63.95	0.30
G_0M_2	0.83	7279.54	46.15	0.42
G_0M_3	0.84	7308.66	64.45	0.28
G_0M_4	0.88	7716.31	62.63	0.29
G_0M_5	0.89	7803.67	42.65	0.46
G_1M_0	0.84	7221.31	58.07	0.29
G_1M_1	0.83	7716.31	48.21	0.42
G_1M_2	0.88	7774.55	45.29	0.43
G_1M_3	0.89	8153.09	59.08	0.30
G_1M_4	0.93	9317.81	46.70	0.42
G_1M_5	1.070.92	8007.50	39.63	0.51
G_2M_0	0.97	8473.39	43.80	0.39
G_2M_1	1.19	10366.07	41.39	0.49
G_2M_2	1.20	10482.54	32.63	0.55
G_2M_3	1.01	8822.80	40.60	0.42
G_2M_4	0.98	8589.86	33.28	0.55
G_2M_5	1.32	11559.91	31.63	0.56
G_3M_0	0.92	8036.61	51.18	0.40
G_3M_1	1.00	8735.45	47.22	0.40
G_3M_2	1.14	9958.41	40.51	0.48
G_3M_3	0.99	8648.10	44.28	0.44
G_3M_4	1.10	9638.11	43.77	0.47
G_3M_5	1.19	10366.07	32.70	0.55
SEm	0.049	426.555	2.586	0.017
CD at 5% level	0.139	1218.174	7.385	0.048

Leaf Area Index (LAI) and Leaf Area Duration (LAD)

Growing media significantly influenced the Leaf Area Index (LAI) and Leaf Area Duration (LAD). The Leaf Area Index (1.08) and Leaf Area Duration (9434.29 cm^2.days) was higher under treatment M_5 comprising soil + vermicompost + AZO + PSB at 150 days after sowing. The growing media had higher magnitude for LAD over remaining treatments which was attributed to increase in LA and LAI influenced by treatment. It might be due to role of nitrogen enhancing persistence and longevity of LA, which is a key factor in terms of photosynthesis productivity of the plants, that assimilates higher amount of photosynthates production and if the mobilization is proper to the sink, it will enhance the economic productivity. The findings are supported by Peng *et al.*, (2013). The effect of GA_3 had significant effect on Leaf Area Index and Leaf Area Duration Significantly maximum Leaf Area Index (1.11) and Leaf Area Duration (9715.76) were noted under 400 ppm (G_2).

This was higher ascribed to higher magnitude increases in parameter associated with the LA. The finding was supported by Munde and Gajbhiye (2010). The treatment combination G_2M_5 was recorded maximum Leaf Area Index (1.32) and Leaf Area Duration (11559.9). However, minimum Leaf Area Index and Leaf Area Duration were noted under treatment combination G_0M_0. The increase of Leaf Area Index due to rich source of nutrient present in media comprising soil + vermicompost + AZO + PSB with 400 ppm GA_3.

Light Transmission Ratio (LTR)

In the present study, significantly maximum Light Transmission Ratio 55.19 at interval of 120 and 150 days after sowing was computed under M_0 media and the minimum Light Transmission Ratio 36.65 was recorded under M_5. The findings of Munde and Gajbhiye (2010) are close conformity with present findings. The maximum Light Transmission Ratio (57.52) was recorded under G_0 and minimum (37.22) was recorded under treatment G_2. The findings are supported by Munde and Gajbhiye (2010).

The interaction of growing media and GA_3 showed significant effect on Light Transmission Ratio. The significantly maximum Light Transmission Ratio (67.71) was obtained under treatment combination of G_0M_0 and minimum Light Transmission Ratio (31.63) was obtained under treatment combination of G_2M_5.

The results were significantly correlated with the LAI which exhibited the lowest and highest magnitude for the above treatments. The low light transmission through the crop canopy is reflected in higher value of LAI, more the canopy size more light interception and less transmission through the canopies (Thakur and Kaur, 2001) (Table 3).

Energy Interception (EI)

In the present study, all the treatment growing media, gibberellic acid concentration and their combination effect showed significant effect on the experiment concern.

The probable reason may be that Interception of light by a crop canopy is strongly related to total leaf area. A crop will thus intercept more PAR and hence grow faster if it develops leaf area rapidly. Similar findings were reported by Maddonni and Otegui (1996).

References

Abdul-baki, A.A. and Anderson, J.D. 1973.Vigour determination in soyabean by multiple criteria. *Crop Science*, 13:630-633.

Anonymous. 2013. India Horticulture Data Base-2013. Ed. Kumar Bijay, Mistry NC, Singh Rajendra B and Gandhi P Chander. Published by ministry of Agriculture, GOI.

Bewley, J.D. 1997.Seed Germination and Dormancy. *Plant Cell*, 9: 1055-1066.

Bhardwaj, R.L. 2014. Effect of growing media on seed germination and seedling growth of papaya (*Carica papaya*) cv. 'Red lady'. *African Journal of Plant science,* 8(4): 178-184.

Corner, E.J.H. 1976. The seeds of dicotyledons, 1 and 2. 1st ed. University Press, Cambridge.

Earlpus, E.J.R. and Lambeth, V.M. 1974. Chemical stimulation of germination rate in aged tomato seeds. *J. Anzer. Sac.Horti. Sci*., 99(1): 912.

Gardner, F.P., Pearces, R.B. and Mitchell, R.L. 1985. Growth and development in physiology of crop plants. The Lowa State Uni Press, 187-208.

Golingai, S.A. and Mabbayad, B.B. 1969. Plant arrangement and spacing study on C_2- 63 and IR (68) rice varieties. *The Phillipine Agri*, 52: 566-577.

Gurung, N., Swamy, G.S.K., Sarkar, S.K. and Ubale, N.B. 2014. Effect of chemicals and growth regulators on germination, vigour and growth of passion fruit (*Passifloraedulis* Sims.). *The Bioscan*, 9(1):155-157.

Hayat, M.A. 1963. Morphology of seed germination and seedling in *Annona squamosa*. Botan. *Gazette,* 124: 360-362.

Krishna, A., Patil, C.R., Raghavendra, S.M. and Jakati, M.D. 2008. Effect of bio-fertilizers on seed germination and seedling quality of medicinal plants. *Karnataka Journal Agriculture Science*, 21(4): 588-590.

Maddonni, G.A. and Otegui, M.E. 1996. Leaf area, light interception and crop development in maize. *Field crops research*, 48(1): 81-87.

Munde, G.R. and Gajbhiye, R.P. 2010. Effect of plant growth regulator on seedling growth of mango stone. *Green Farming,* 1(3): 288-289.

Parasana, J.S., Ray, N.R., Satodiya, B.N., Patel, K.A. and Panchal, G.P. 2012. Effect of mixture of growing media on germination and seedling growth of different mango (*Mangifera indica* L.) cultivars under net house conditions. Asian Journal of Horticulture 7(2): 409-411.

Peng, S.H., Wan-Azha, W.H., Wong, W.Z., Go, W.Z., Chai, E.W., Chin, K.L. and Nq, P.S. 2013. Effect of Using Agro-fertilizers and N-fixing Azotobacter enhanced bio-fertilizers on the growth and yield of Corn. *Journal of Applied Science*, 13: 508-512.

Setten, K. and Koek-Noorman. 1992. Fruits and seeds of Annonaceae: Morphology and its significance for classification and identification. *Bibliot. Botan.* 142, 1-101.

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

Taiz, L.and Zeiger, E. 2006. Plant physiology. R, E. 3.ed. Porto Alegre: Artmed, 719p.

Thakur, P.S. and Kaur, H. 2001. Variation in photosynthesis, respiration, water use efficiency, Light Transmission and Leaf Area Index in multipurpose agro forestry tree species. *Indian Journal of Plant Physiology*, 6(3): 249-253.

Watson, D.J. 1952. The physiological basis of varieties in yield. *Adv. Agron.,* 4:101-145.

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