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Response of cashew (*Anacardium occidentale* L) to osmopriming with gibberellic acid (GA_3)

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Cashew (*Anacardium occidentale* L.) is commercially propagated by soft wood grafting which necessitates the requirement of healthy graftable seedlings. Hence, quality seedlings play a major role in the successful propagation of cashew. Seed priming has been successfully demonstrated to improve germination and emergence in seeds of many crops. Osmopriming treatments such as soaking cashew nuts in gibberellic acid (GA_3) enhanced the germination, seedling growth and vigour. Synchronization and rapid seedling emergence are the commonly reported benefits of osmopriming. This is particularly important for a crop like cashew which is commercially propagated through soft wood grafting, wherein early attainability of seedling height can reduce the cycle of propagation. Young seedlings of cashew usually do not produce lengthy tap root and secondary roots and probably for want of adequate root system, seedlings suffer heavy casualities especially during summer. Better root system is particularly beneficial for hybrid seedlings when breeder raises seedlings for field planting. Researchers have been using a variety of growth regulators to increase the germination rates in different crops (Ayfer and Serr, 1961; Frutos and Barone, 1988; Ak *et al.*, 1995).

A nursery experiment was conducted to study the effect of osmopriming treatment with GA_3 on seed germination and growth of cashew seedlings with five treatments *viz.*, control (T_1), soaking in water for 48 hrs (T_2), soaking in 50 ppm GA_3 for 48 hrs (T_3), soaking in 100 ppm GA_3 for 48 hrs (T_4) and soaking in 200 ppm GA_3 for 48 hrs (T_5) with 4 replications in completely randomized design during 2011 at Directorate of Cashew Research, Puttur, D.K, Karnataka. The experimental area receives a mean annual rainfall ranging from 3,592 to 3,842 mm. The mean annual temperature was 27.6 °C and mean maximum and minimum temperatures were 36 °C and 20 °C, respectively. Cashew (variety Vengurla-4) seeds of uniform age, size and weight were taken for experiment to find out germination percentage. Seeds were subjected to the treatments as above. Seeds treated in various GA_3 concentrations were sown with stalk end facing upwards in black coloured polythene bags of 25 cm x 15 cm size filled with the potting mixture containing equal quantities of sand, red soil and well rotten farm yard manure. Observations on germination percentage, shoot length, shoot fresh weight, shoot dry weight, seedling length, seedling girth, number of leaves per seedling, root length, root fresh weight, root dry weight, and vigour index were recorded at 30, 60, 90 and 120 days after sowing (DAS). The parameters were recorded at different days to ascertain the rate of increase in different parameters over a period of time as influenced by GA_3. Under normal conditions seedlings take about 60 days to reach graftable height. Germination percentage and vigour index (per cent germination x length of seedling) were also calculated and the data were analysed using SAS 9.3 version.

Seeds treated with 200 ppm GA_3 recorded the highest germination percentage (100%) followed by 100 ppm GA_3 (95%), 50 ppm GA_3 (95%), water soaking (90%) and control (83%) as indicated in Table 1. The effect of GA_3 on germination revealed

Table 1. Effect of GA_3 on germination (%) and shoot length (cm) of cashew by seed treatment

Treatment (T)	Germination (%)				Shoot length (cm)			
	Days after sowing (D)				Days after sowing (D)			
	30	60	90	120	30	60	90	120
control	83	83	83	83	18.6	22.8	33.7	34.4
water soaking	90	90	90	90	18.8	24.9	34.1	36.4
50 ppm GA_3	95	95	95	95	21.6	30.6	36.5	40.8
100 ppm GA_3	95	95	95	95	24.5	31.2	37.6	46.8
200 ppm GA_3	100	100	100	100	27.6	33.7	38.5	51.5
Source	T	D	T*D		T	D	T*D	
SEm	0.30	0.27	0.59		0.11	0.10	0.21	
LSD (P=0.05)	0.84	0.75	NS		0.30	0.27	0.57	

that GA_3 induced better germination of cashew. This has also been reported by Shanmugavelu (1985) in cashew, Shabon (2010) in mango, Burns *et al*. (1966) in avocado, Gholap *et al*. (2000) in aonla and Al-Imam (2007) in pistachio seeds. Application of 200 ppm GA_3 increased the shoot length significantly during different period of observation. At 120 DAS, seeds treated with 200 ppm GA_3 recorded maximum shoot length followed by 100 ppm GA_3, 50 ppm GA_3, water soaking and control as given in Table 1. The minimum number of days (53) to reach graftable shoot height was recorded with 200 ppm GA_3. The highest rate of increase in shoot length was associated with 50 ppm GA_3 at 60 DAS, control at 90 DAS and 200 ppm GA_3 120 DAS. This increase in shoot length with GA_3 might be related to the fact that gibberllic acid promote stem and shoot elongation through the increase of both cell division and internodal elongation in higher plants (Hartmann *et al*., 2002; Harris *et al.*, 2004; Hopkins and Huner, 2004). Shanmugavelu (1985) reported that the most striking response of GA_3 on cashew is on stem elongation.

Fresh weight and dry weight of shoot were significantly increased over number of days irrespective of treatments. At 120 DAS, seeds treated with 200 ppm GA_3 recorded highest fresh and dry weight of shoot followed by 100 ppm GA_3, 50 ppm GA_3, water soaking and lowest in control. All the osmopriming treatments increased the fresh and dry weight as compared to control. The highest rate of increase in fresh weight was associated with 100 ppm GA_3 at 60 DAS followed by water soaking at 90 DAS and 200 ppm GA_3 at 120 DAS. The rate of increase in dry weight was also highest with 200 ppm GA_3 at 60 DAS followed by 100 ppm GA_3 at 90 DAS and control at 120 DAS. The increased weight of shoot was mainly attributed to enhanced germination, early seedling emergence and better seedling growth. This can also be attributed to the increase in the overall assimilation and redistribution of materials within the plant (Shanmugavelu, 1985). Significant increase in shoot dry weights of pistachio seedling occurred under 24 hours seed soaking period and with increasing GA_3 concentration was also reported by Al-Imam (2007).

At 120 DAS, seeds treated with 200 ppm GA_3 recorded maximum seedling length followed by 100 ppm GA_3, 50 ppm GA_3, water soaking and control as given in Table 2. This is the first report on influence of GA_3 on seedling growth in the cashew variety V-4. The highest rate of increment in seedling length was observed with 50 ppm GA_3 at 60 DAS, 100 ppm GA_3 at 90 DAS and water soaking at 120 DAS. This increase in seedling growth parameters with GA_3 might be related to the fact that GA promote stem and shoot elongation through the increase of both cell division and from internodes elongation in higher plant (Hartmann *et al*., 2002; Hopkins and Huner, 2004; Harris *et al.*, 2004). The increased dry weight of shoots and the data on dry matter content of different organs strongly support the view that GA effects on photosynthesis are linked with a more effective translocation to shoots which will use them for their increased growth in length.

Table 2. Effect of GA_3 on seedling length (cm) and seedling girth (cm) of cashew by seed treatment

Treatment (T)	Seedling length (cm)				Seedling girth (cm)			
	Days after sowing (D)				Days after sowing (D)			
	30	60	90	120	30	60	90	120
control	28.25	36.25	38.25	40.75	1.57	2.12	2.27	2.50
water soaking	31.37	42.12	45.12	47.37	1.57	2.00	2.20	2.50
50 ppm GA_3	37.00	49.25	51.25	54.25	1.82	2.07	2.50	3.00
100 ppm GA_3	43.37	52.25	55.25	61.25	2.02	2.50	2.80	3.27
200 ppm GA_3	48.25	58.37	68.25	82.37	2.10	2.80	3.00	3.37
Source	T	D	T*D		T	D	T*D	
SEm	0.83	0.74	1.66		0.02	0.02	0.04	
LSD (P=0.05)	2.35	2.11	4.48		0.05	0.05	0.10	

Various levels of GA_3 application significantly increased the length of seedlings as well as the girth of the seedlings. Seeds treated with 200 ppm GA_3 recorded highest seedling girth followed by 100 ppm GA_3, 50 ppm GA_3, water soaking and control at 120 DAS as given in Table 2. Seedling girth significantly increased over number of days irrespective of treatments. Similar kind of results were also reported by Shanmugavelu (1985) in cashew, Shabon (2010) in mango, Burns *et al*. (1966) in avocado, Gholap *et al*. (2000) in aonla and Al-Imam (2007) in pistachio seeds. Burns *et al*. (1966) reported that soaking Duke variety avocado seeds in high concentrations of gibberellic acid for 24 hours prior to planting increased the rate of stem diameter. This growth regulator has been used successfully to stimulate the growth of many plants through elongation of the internodes. Application of 500 GA_3 and 750 mg after stratification significantly increased seedling diameter, in beneh, wild species of pistachio, but in kolkhong species, application of GA_3 during stratification was more effective in increasing seedling diameter. Kafkas and Kaska (1998) also reported similar findings with *Pistacia khinjuk*. They concluded that pre-soaking seeds with GA_3 for 48 h significantly increased stem diameter of some selected *P. khinjuk* seedlings. The highest rate of increase in seedling girth was found with control at 60 DAS, 50 ppm GA_3 at 90 DAS and 50 ppm GA_3 at 120 DAS.

With respect to number of leaves per seedlings, seeds treated with 200 ppm GA_3 recorded highest number of leaves per seedling followed by 100 ppm GA_3, 50 ppm GA_3, water and control at 120 DAS. Number of leaves per seedling significantly increased over number of days irrespective of treatments. The highest rate of increase in number of leaves of seedling was in 50 ppm GA_3 at 60 DAS, control at 90 DAS and water soaking at 120 DAS. Shabon (2010) reported that mango seeds treated with 200 ppm GA_3 for 48 hours

Table 3. Effect of GA_3 on root length (cm) and vigour index of cashew by seed treatment

Treatment (T)	Root length (cm)				Vigour index			
	Days after sowing (D)				Days after sowing (D)			
	30	60	90	120	30	60	90	120
control	10.37	12.25	12.25	14.25	2331	2990	3156	3363
water soaking	12.13	16.37	17.12	18.12	2824	3791	4061	4264
50 ppm GA3	15.00	18.37	19.50	22.00	3527	4679	4869	5154
100 ppm GA3	18.25	20.12	22.12	24.50	4121	4964	5249	5819
200 ppm GA3	20.25	25.00	28.25	30.37	4825	5850	6825	8238
Source	T	D	T*D		T	D	T*D	
SEm	0.060	0.053	0.119		13.36	11.95	26.73	
LSD (P=0.05)	0.169	0.151	0.320		37.84	33.85	71.69	

increased the number of leaves in the seedlings. The data on root length and vigour index are presented in Table 3. Seeds treated with 200 ppm GA_3 recorded maximum root length of 30.37 cm followed by 100 ppm GA_3, 50 ppm GA_3, water soaking and control recorded the minimum root length of 14.25 cm at 120 DAS. Root length significantly increased over number of days irrespective of treatments. The highest rate of increase in root length was noted with water soaking at 60 DAS, 200 ppm GA_3 at 90 DAS and control at 120 DAS. Shabon (2010) reported that mango seeds treated with 200 ppm GA_3 for 48 hours increased the root length of the studied root stocks in the seedlings. At 120 DAS, seeds treated with 200 ppm GA_3 recorded highest vigour index followed by 100 ppm GA_3, 50 ppm GA_3), water and control as given in Table 3. At 120 days after sowing, highest and lowest vigour index was recorded with application of 200 ppm GA_3 and control, respectively. The data on vigour index revealed a similar pattern as that of per cent germination. Vigour index also significantly increased over number of days irrespective of treatments. GA_3 induced stem elongation in seedlings was due to increase in the cell number and cell elongation. Highest vigour index with application of 200 ppm GA_3 was mainly attributed to enhanced germination, early seedling emergence and better seedling growth. The rate of increase in vigour index was highest with water soaking at 60 DAS, 200 ppm GA_3 at 90 DAS and 200 ppm GA_3 at 120 DAS.

Highly significant differences were recorded among the treatments at 120 days after sowing with respect to fresh and dry weight of roots. The increase in fresh and dry weight of roots might be attributed to the increase in the overall assimilation and redistribution of materials within the plant (Shanmugavelu, 1985). The highest rate of increase in root fresh weight was associated with 100 ppm GA_3 at 60 DAS, 100 ppm GA_3 at 90 DAS and water soaking at 120 DAS. Regarding root dry weight, the highest rate of increase was associated with water soaking at 60 DAS, 200 ppm GA_3 at 90 DAS and 100 ppm GA_3 at 120 DAS. The effect of GA_3 on dry weight of roots shows the same trend as with the fresh weight of the stems in pistachio. In plants, GA_3 applications may promote growth by increasing water uptake, resulting in fresh weight increase, without changes in dry weight. GA_3 applications may increase dry weight by increasing total leaf area and enhancing photosynthesis per unit leaf area (Salisbury and Ross, 1978). GA_3 had a significant effect on fresh weight of roots in pistachio seeds (Rahemi and Bannisab, 2000). From this study, it can be concluded that 200 ppm GA_3 can be effectively employed in seed priming treatment for increasing the seedling growth and vigour index of cashew which would help propagating healthy seedlings at a short period for grafting operations and inturn ultimately reduce the duration of propagation.

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