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Influence of Decapitations and PGR'S on Plant Growth, Seed Yield and Quality of Seed of Cluster Bean (*Cyamopsis tetragonoloba* L. Taub.) Variety Pusa Navbahar in Summer

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Abstract A field experiment was conducted to find out the influence of decapitation and plant growth regulators on seed yield and quality of cluster bean seed cv Pusa Navbahar with three decapitation treatments and three plant growth regulators each at two concentrations with water sprays control in factorial randomized design with three replications during summer season 2013. The results observed that decapitation at 75 DAS significantly recorded maximum seed yield parameters with better quality. Plant growth regulators treatments also recorded significant result. Application of thiourea 500 mg/l at flowering stage recorded maximum yield parameters as well as seed yield (973.78 kg/ha), which was at par with GA_3 400 ppm. Combinations of decapitation at 75 DAS and spraying of thiourea 500 mg/l registered significantly higher values for all seed quality parameters except germination percentage.

Keywords Decapitation, Vigor, Diversification, Cluster bean.

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Introduction

Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.) it is commonly known as Guar. It can be grown on soils of low fertility as well as drought prone arid and semiarid area of the tropics and sub tropics, which receive an annual rainfall of 200-600 mm. Unlike some other legume crops, cluster bean is a warm season vegetable crops. It grows well in *kharif* and summer seasons. In Gujarat, it is widely cultivated as vegetable crop in the district of Banaskantha, Katchh, Junagadh, Ahemdabad, Sabarkantha, Kheda and Suren-dranagar. Total cluster bean area 37105 hectare, production 330010 M.T. and productivity 8.89 T./ha during 2011-2012 [1]. Pusa Navbahar is most popular variety for vegetable purpose. Pods are about 15 cm in length, tender, green in color and are of better

Table 1. Influence of decapitations, PGR's and their interaction on plant height (cm) at 60 DAS, 75 DAS and at harvest stage and number of leaves per plant at 60 and 75 days after sowing and leaf area (cm^2) at 60 DAS and 75 days after sowing.D_1- Without decapitation, D_2-Decapitation at 60 DAS, D_3-Decapitation at 75 DAS, G_1-Water spray (control), G_2-NAA 20 mg/l, G_3-GA_3 40 mg/l, G_4-GA_3 20 mg/l, G_5-GA_3 40 mg/l, G_6-Thiourea 500 mg/l, G_7-Thiourea 1000 mg/l.

Treatments	Plant height (cm)			Number of leaves/plant		Leaf area (cm^2)	
	60 DAS	75 DAS	At harvest	60 DAS	75 DAS	60 DAS	75 DAS
A. Decapitation							
D_1	46.07	87.55	100.82	53.97	63.60	1402.76	1470.42
D_2	48.02	67.16	76.45	54.57	48.76	1340.58	1011.92
D_3	46.83	87.08	69.33	53.55	50.22	1329.56	1159.92
SEm ±	0.78	0.85	1.51	0.93	0.89	35.83	32.54
CD at 5%	NS	2.45	4.33	NS	2.26	NS	92.92
B. Plant growth regulators							
G_1	45.57	76.97	76.26	52.19	49.92	1250.77	1042.13
G_2	48.68	82.78	82.19	53.78	54.00	1351.22	1126.38
G_3	46.33	81.44	80.42	52.52	52.60	1258.19	1159.61
G_4	48.06	79.33	83.66	53.50	55.45	1417.98	1243.20
G_5	48.40	82.86	87.87	56.59	56.94	1487.64	1352.12
G_6	46.37	79.33	83.20	55.84	56.23	1389.60	1232.27
G_7	46.91	81.47	81.82	53.79	54.22	1347.85	1342.89
SEm ±	1.19	1.31	2.13	1.42	1.36	54.74	49.71
CD at 5%	NS	3.74	6.61	NS	3.91	NS	141.94
C. Interaction							
D × G	NS	NS	NS	NS	Sig	NS	Sig
Control	48.86	89.53	93.20	55.52	61.13	1470.21	1525.9
Rest	47.19	80.60	82.20	54.03	54.19	1357.63	1214.09
SEm ±	1.49	1.64	2.90	1.78	1.71	68.21	62.31
CD at 5%	NS	4.69	8.28	NS	4.90	195.58	177.89
CV (%)	7.57	4.85	8.40	7.90	7.82	12.18	12.39

quality. It can be cultivated during both summer and rainy seasons. Due to the wide spread cultivation and nutritive important in our daily life demand for seeds requirement is increasing day by day but availability of pure and good quality seeds is not satisfactory. However, the seed yield of cluster bean is low. Various attempts have been made to increase better quality seed but results are not satisfactory. The present study was aimed to improve the seed yield with better quality by clipping and spraying of plant growth regulators. Objectives were 1. To find out the suitable stage of decapitation for growth, seed yield and its quality. 2. To find out the most effective plant growth regulators and their concentration for growth, seed yield and its quality. 3. To find out the best combination of decapitation and plant growth regulators for growth, seed yield and its quality.

Materials and Methods

An experiment comprising 3 levels of decapitation (no decapitation, decapitation at 60 DAS and at 75 DAS) of shoot up to 5 cm and 3 growth regulators each of two concentrations (NAA-20 and 40 mg/l, GA_3 20 and 40 mg/l and thiourea 500 and 1000 mg/l) along with water sprayer a control in factorial randomized block design replicated thrice was conducted at Main Vegetable Research Station, Anand Agriculture University, Anand during summer season of 2013.

The details of all the treatments are furnished below.

Symbol	Treatment details
T_1-D_1G_1	Without decapitation/control +water spray
T_2-D_1G_2	Without decapitation/control+NAA 20 mg/l

T_3-D_1G_3	Without decapitation/control+NAA 40 mg/l
T_4-D_1G_4	Without decapitation/control+GA_3 20 mg/l
T_5-D_1G_5	Without decapitation/control+GA_3 40 mg/l
T_6-D_1G_6	Without decapitation/control+Thiourea 500 mg/l
T_7-D_1G_7	Without decapitation/control+Thiourea 1000 mg/l
T_8-D_2G_1	Decapitation at 60 DAS + water spray
T_9-D_2G_2	Decapitation at 60 DAS+NAA 20 mg/l
T_{10}-D_2G_3	Decapitation at 60 DAS+NAA 40 mg/l
T_{11}-D_2G_4	Decapitation at 60 DAS+GA_3 20 mg/l
T_{12}-D_2G_5	Decapitation at 60 DAS+GA_3 40 mg/l
T_{13}-D_2G_6	Decapitation at 60 DAS+Thiourea 500 mg/l
T_{14}-D_2G_7	Decapitation at 60 DAS+Thiourea 1000 mg/l
T_{15}-D_3G_1	Decapitation at 75 DAS+ water soray
T_{16}-D_3G_2	Decapitation at 75 DAS+NAA 20 mg/l
T_{17}-D_3G_3	Decapitation at 75 DAS+NAA 40 mg/l
T_{18}-D_3G_4	Decapitation at 75 DAS+GA_3 20 mg/l
T_{19}-D_3G_5	Decapitation at 75 DAS+GA_3 40 mg/l
T_{20}-D_3G_6	Decapitation at 75 DAS+Thiourea 500 mg/l
T_{21}-D_3G_7	Decapitation at 75 DAS+Thiourea 1000 mg/l
T_{22}	Absolute control

For analyzing the growth patterns of the crop viz. plant height and number of leaves was recorded on five randomly selected plants in a plot of each treatment at different stages viz. 60 DAS and 75 DAS. Other growth parameter viz. Leaf area (cm^2) and LAI was recorded on five randomly selected plants in a plot of each treatment at different stages viz. 45 DAS, 60 DAS and 75 DAS using digital leaf area machine. Dry weight of pant (g) recorded on randomly selected plants in a plot of each treatment at different stages viz. 60 DAS and 75 DAS and CGR is calculate by using formula. The fruit maturity was decided based on the drying of fruits and development of hairline cracks on the fruits. The observations on yield parameters like number of pods per cluster, number of cluster per plant, number of pods per plant, number of seeds per pod, seed yield per plant and seed yield per hectare were recorded based on five randomly selected plants in a plot of each treatment at the time of harvest. Test weight of 1000 seeds (g) is calculated by analytical balance. The observations on seed quality attributes like germination percentage, test weight, seedling length and seedling dry weight as per the standard procedures. The seedling vigor index 1 and II.

Results and Discussion

The results obtained from the present investigation are summarized below. The growth parameters of cluster bean viz. plant height and number of leaves per plant were recorded and analyzed at 60, 75 DAS and harvest. Results revealed that differences among the various decapitation treatments were showed non-significant for plant height (Table 1) and number of leaves per plant (Table 1) at 60 DAS. However, differences among the decapitation treatments showed significant results for plant height at 75 DAS and at harvest and number of leaves per plant at 75 DAS (Table 1). The treatment D_1 (without decapitation) recorded the highest plant height (87.55 cm and significantly

Table 2. Influence of decapitations, PGR'S and their interaction on leaf area index at 60 and 75 days after sowing, dry weight of plant (g) at 60 and 75 days after sowing and crop growth rate ($g/cm^2/day$). D_1-Without decapitation, D_2-Decapitation at 60 DAS, D_3-Decapitation at 75 DAS, G_1-Water spray (control), G_2-NAA 20 mg/l, G_3-GA_3 40 mg/l, G_4-GA_3 20 mg/l, G_5-GA_3 40 mg/l, G_6-Thiourea 500 mg/l, G_7-Thiourea 1000 mg/l.

Treatments	Leaf area index		Dry weight of plant (g)		Crop growth rate ($g/cm^2/day$)
	60 DAS	75 DAS	60 DAS	75 DAS	CGR ($= \times 10^3$)
A. Decapitation					
D_1	1.03	1.09	30.54	52.12	1.426
D_2	0.99	0.74	28.48	47.60	1.167
D_3	0.98	0.83	27.68	50.92	1.347
SEm ±	0.0026	0.024	0.82	1.26	0.047
CDat 5%	NS	0.068	NS	5.60	0.134
B. Plant growth regulators					
G_1	0.918	0.722	26.89	46.79	1.014
G_2	1.015	0.834	28.02	47.44	1.277
G_3	0.947	0.858	29.57	52.08	1.281
G_4	1.056	0.882	28.75	47.40	1.247
G_5	1.100	1.040	31.95	52.82	1.651*
G_6	1.033	0.913	30.10	54.43	1.594
G_7	0.970	0.994	27.01	50.52	1.311
SEm ±	0.41	0.036	1.25	1.92	0.718
CD at 5%	NS	0.104	NS	5.50	0.205
C. Interaction					
D × G	NS	Sig	NS	NS	Sig
Control	1.09	1.13	29.72	48.12	1.213
Rest	1.005	0.892	28.90	50.21	0.313
SEm±	0.051	0.045	1.57	2.41	0.090
CD at 5%	NS	0.131	NS	NS	NS
CV (%)	12.40	14.99	13.23	11.76	16.44

Table 3. Influence of decaptations, PGR's and their interaction on No. of pods/cluster, No. of clusters/plant, No. of pods/plant, No. of seeds per pods, seed yield per plant (g), seed yield kg/ha. weight of 1000 seeds (g) and harvest index. D_1-Without decapitation, D_2-Decapitation at 60 DAS, D_3-Decapitation at 75 DAS, G_1-Water spray (control), G_2-NAA 20 mg/l, G_3-GA_3 40 mg/l, G_4-GA_3 20 mg/l, G_5-GA_3 40 mg/l, G_6-Thiourea 500 mg/l, G_7-Thiourea 1000 mg/l.

Treatments	No. of pods/ cluster	No. of cluster/ plant	No. of pods/ plant	No. of seeds per pods	Seed yield per plant (g)	Seed yield kg/ha	Weight of 1000 seeds (g)	Harvest index
A. Decapitation								
D_1	4.61	12.55	54.90	6.38	5.54	816.71	37.65	22.46
D_2	4.92	12.58	66.30	6.44	6.31	901.22	38.72	23.82
D_3	5.30	13.74	72.33	6.75	6.64	981.69	38.79	25.49
SEm ±	0.097	0.30	1.77	0.10	0.14	21.89	0.33	0.65
CD at 5%	0.279	0.88	5.07	0.29	0.41	62.50	0.96	1.87
B. Plant growth regulators								
G_1	4.74	12.11	56.40	6.02	5.53	786.07	36.83	21.96
G_2	4.90	12.37	66.96	6.54	5.96	885.58	39.02	24.65
G_3	4.86	12.32	62.69	6.47	6.06	869.13	37.69	22.69
G_4	4.86	12.68	61.38	6.52	6.09	925.41	38.40	24.63
G_5	4.88	13.49	63.03	6.38	6.48	970.48	38.82	26.69
G_6	5.62	14.27	78.39	7.12	7.03	973.78	39.59	23.07
G_7	4.83	13.44	62.69	6.61	6.01	888.66	38.36	23.78
SEm ±	0.14	0.47	2.71	0.15	0.22	33.44	0.51	1.003
CD at 5%	0.42	1.34	7.74	0.44	0.63	95.47	1.47	2.86
C. Interaction								
D × G	Sig	NS	NS	Sig	NS	NS	Sig	NS
Control	4.66	11.50	53.90	6.20	5.13	701.81	37.73	21.05
Rest	4.95	12.95	64.51	6.52	6.16	899.87	38.39	23.93
SEm ±	0.18	0.59	3.40	0.19	0.27	41.91	0.64	1.25
CD at 5%	NS	NS	9.70	NS	0.79	119.65	NS	3.59
CV (%)	9.07	11.18	12.71	7.15	10.87	11.26	4.03	12.65

higher 100.82 cm) at 75 DAS and at the time of harvest and also significantly higher number of leaves per plant (63.60) at 75 DAS. This might be due to contineous growth of apical bud and decapitation treatment adversely affected the vegetative growth of terminal bud, which ultimately slow down the growth. Thus, slow plant growth reflected on less plant height and less number of leaves per plant in 60 DAS decapitation treatments.

Looking to the physiological parameters i.e. LA, LAI, and dry weight at 60 DAS showed non-significant differences among the decapitation treatments (Tables 1 and 2). At 75 DAS differences among the treatments for physiological parameters viz. LA, LAI, CGR and dry weight showed significant differences (Table 1 and 2). This might be due to defoliation/senescence of mature leaves at later stage. Most of the physiological parameters were found higher in the treatment D_1 (without decapitation) treatment i.e. LA (1470.42 cm^2), LAI (1.090), dry weight (52.12 g) at 75 DAS and CGR (1.4260 g/cm^2/day). This might be due to adverse effect of decapitation on vegetative growth and accumulation of metabolites and photosynthetic product, resultant that the dry weight of the vegetative organs was decreased by removal of the terminal bud.

Results presented for various seed yield parameters showed significant differences among the different decapitation treatments. The treatment D_3 (Decapitation at 75 DAS) registered significantly the higher number of pods per cluster i.e. 5.3 (Table 3), number of clusters per plant i.e. 13.74 (Table 3) num-

Table 4. Influence of decapitation and PGR's on germination (%), seedling length (cm), seedling dry weight (g) (= ×10), vigor index-I, vigor index-II. D_1-Without decapitation, D_2-Decapitation at 60 DAS, D_3-Decapitation at 75 DAS, G_1-Water spray (control), G_2-NAA 20 mg/l, G_3-GA_3 40 mg/l, G_4-GA_3 20 mg/l, G_5-GA_3 40 mg/l, G_6-Thiourea 500 mg/l, G_7-Thiourea 1000 mg/l.

Treatments	Germination (%)	Seedling length (cm)	Seedling dry weight (g) (=×10)	Vigor index-I	Vigor index-II
A. Decapitation					
D_1	91.65	10.46	1.032	902	9.17
D_2	92.96	10.55	1.047	1097	10.23
D_3	94.21	11.22	1.083	1073	10.41
SEm ±	0.76	0.12	0.013	24	0.23
CD at 5%	NS	0.34	0.037	70	0.66
B. Plant growth regulators					
G_1	86.20	9.54	0.872	9.04	9.09
G_2	92.07	9.75	1.060	993	9.43
G_3	91.48	11.00	1.115	1040	9.97
G_4	95.47	11.52	1.116	943	10.51
G_5	93.47	11.61	0.988	1052	10.00
G_6	98.01	11.71	1.422	1068	10.49
G_7	93.60	10.06	1.087	1051	10.06
SEm ±	1.17	0.18	0.019	37	0.35
CD at 5%	3.34	0.52	0.056	107	1.01
C. Interaction					
D × G	NS	Sig	Sig	Sig	Sig
Control	93.32	9.83	1.163	889	8.17
Rest	91.94	10.74	1.054	1007	9.94
SEm ±	1.46	0.23	0.024	47.14	0.44
CD at 5%	NS	NS	0.071	NS	1.26
CV (%)	3.77	5.17	5.64	11.25	10.78

ber of pods per plant i.e. 72.33 (Table 3), number of seeds per pod i.e. 6.75 (Table 3) and the highest in weight of 1000 seeds i.e. 38.79 (Table 3). This showed that decapitation treatment at 75 DAS, significantly affected most of the yield parameters. This might be due to checking of the vegetative growth phases and diversification of photosynthetic materials towards the source i.e. pods and seeds at optimum growth phase (Jauvenile growth stage) and developed favorable environmental conditions for development of reproductive organs. However, it was noted yield reduction in cluster bean when decapitated 15 cm from the top of the main shoot at 55, 70 and 85 DAS.

Similar trend was also observed for seed yield per plant (Table 3), seed yield per hectare (Table 4) as well as harvest index (Table 4). Significantly, the maximum seed yield per plant (6.64 g), seed yield per hectare (981.69 kg) as well as harvest index (25.49) were recorded under decapitation treatment D_3 (Decapitation at 75 DAS) and exhibited its superiority over other treatments.

Germination (%) was found to be non-significant. Where, seedling length was significantly the higher in treatment D_3 (Decapitation at 75 DAS) i.e. 11.21 cm (Table 4). While higher trend was also observed in dry weight of seedling i.e. 1.0838 g by D_3 treatment (Table 4). Similarly, vigor index-1 and II were also the higher with D_3 treatment i.e. 1073.10 and 10.41 (Table 4). This might be due to early clipping adversely affected the vegetative growth and shortened the reproductive period and thus more adverse effect was observed at early clipping. Satodiya et al. [2] also recorded similar trend in cluster bean.

Effect of PGR's

The effect of different plant growth regulators treatments for growth parameters viz. plant height (Table 1) and number of leaves per plant (Table 1) at 60 DAS was found non-significant. However, it was found significant at 75 DAS and harvest stage. The highest plant height was registered under the treatment G_5 (GA_3 40 mg/l) i.e. 82.86 cm at 75 DAS and 87.87 cm at harvest (Table 1). Similarly, the treatment G_5 (GA_3 40 mg/l) also recorded the maximum number of leaves per plant at 75 DAS i.e. 56.94 (Table 1). This might be due to synergistic effect of GA_3 in stimulation of cell division and cell elongation, which ultimately affected overall growth of plant and stimulated auxiliary buds from apical dominance and increased plant height and number of leaves per plant. These results are in accordance with the findings of Hoque and Haque [3] in mung been, Rai et al., [4] in French bean and Panday et al. [5] in garden pea.

Results of various physiological parameters viz. LA, LAI, and dry weight of plant showed non-significant differences at 60 DAS (Table 1 and 2). However,

Table 5. Interaction effects between decapitation and PGR's on number of leaves per plant at 75 DAS, leaf area (cm^2) at 60 and 75 days after sowing and leaf area index at 75 days after sowing.

Treatments	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
G_1	61.53	42.70	45.53	1410.39	900.66	815.34	1.043	0.670	0.453
G_2	62.86	45.43	53.70	1562.42	864.11	952.61	1.160	0.640	0.703
G_3	56.50	52.43	48.86	1321.28	977.29	1180.26	0.980	0.723	0.873
G_4	66.86	49.10	50.40	1637.96	960.72	1130.92	1.096	0.710	0.840
G_5	68.53	49.56	52.73	1477.26	1061.68	1537.43	1.213	0.786	1.120
G_6	66.36	53.20	49.13	1540.56	1034.84	1121.40	1.143	0.766	0.830
G_7	62.56	48.90	51.20	1343.07	1284.14	1401.47	0.996	0.950	1.036
SEm ±		2.06			86.11			0.076	
CD at 5%		5.90			245.85			0.218	
CV (%)		7.82			12.39			14.99	

LA, LAI, CGR and dry weight of plant were found significant at 75 DAS (Table 1 and 2). The maximum LA (1352.12 cm^2), LAI (1.040), CGR (1.6511) and dry weight (54.43 g) of plant were found at 75 DAS, and was recorded under the treatment G_5 GA_3 40 mg/l). In the later stage of crop, all PGR's treatments nullified their synergistic effects for growth and development due to maturation stage. Plant growth regulators play vital role in physiological forms and functions. GA_3 treatments trigger or stimulate cell elongation and cell expansion, which ultimately increased the size of leaf. Thus, initiate the bio chemical processes, which ultimately lead to increase the size/organ or other growth and development processes governed under plant level.

Moreover, LA, LAI and CGR had significant and positive correlation with bio-chemical and physiological processes that increased size of photosynthetic area, which contributed for better biological yield, number of pods per cluster and number of clusters per plant as well as seed yield. This might be due to activation of enzymatic system during its juvenile growth phases and stimulated various physiological forms and functions going at tissues level and ultimately on growth. These findings are in accordance with the reports of Ganiger et al. [6] in cowpea for LA, Mohandoss and Rajesh [7] for LAI and dry weight production in cowpea and Burman et al. [8] for dry matter accumulation in cluster bean.

Significant defences were also observed in yield attributing parameters (number of pods per clusters, number of pods per plant and weight of 1000 seeds) among the various PGR's treatments (Table 3). Significantly, the higher number of pods per cluster i.e. 5.62 (Table 3), number of pods per plant i.e. 78.39 (Table 3), while the maximum number of cluster per plant i.e. 14.27 (Table 3) and weight of 1000 seeds i.e. (38.59 g) (Table 3) were recorded under the treatment G_6 (Thiourea 500 mg/l) and proved its superiority and ranked on top among the all the PGR's treatments. Similar

Table 6. Interaction effects between decapitations and PGR's on crop growth rate (g/cm^2 /day) and number of seeds per pod.

Treatments	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
G_1	0.704	0.691	1.646	4.36	4.86	4.96	5.30	5.56	7.20
G_2	1.281	1.516	1.033	4.50	4.60	5.60	6.26	6.63	6.73
G_3	1.033	1.380	1.160	4.40	5.53	4.56	6.30	6.66	6.46
G_4	1.463	1.103	1.176	4.70	4.90	5.00	6.13	6.46	6.96
G_5	2.056	1.393	1.503	4.37	4.70	5.60	6.83	6.33	6.00
G_6	1.756	1.283	1.743	5.53	5.23	6.10	7.16	6.93	7.26
G_7	1.416	0.806	1.170	4.46	4.76	5.26	6.70	6.50	6.63
SEm±		0.124		0.25			0.26		
CD at 5%		0.355		0.73			0.76		
CV (%)		16.44		9.07			7.15		

Table 7. Interaction effects between decapitations and PGR's on weight of 1000 seed (g) at harvest, seedling length (cm) and seedling dry weight (g).

Treatments	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3
G_1	35.64	36.84	38.02	9.05	9.93	9.65	0.936	0.656	1.023
G_2	39.93	39.52	38.11	9.25	10.63	9.36	1.046	1.170	0.963
G_3	35.91	36.78	40.36	10.15	11.70	11.16	1.050	1.180	1.116
G_4	36.69	40.50	38.02	10.53	10.53	13.51	1.140	1.083	1.126
G_5	39.26	38.28	38.94	12.86	10.53	11.23	0.900	0.966	1.100
G_6	38.08	40.58	40.11	10.91	10.66	13.55	1.090	1.150	
G_7	38.56	38.55	37.96	10.48	9.65	10.06	1.067	1.126	1.070
SEm ±		0.89			0.31			0.034	
CD at 5%		2.55			0.91			0.098	
CV (%)		4.03			5.17			5.64	

results were also obtained for seed yield (Table 3) and harvest index (Table 3) due to various PGR's treatments. The maximum seed yield was recorded by the treatment G_6 i. e. 973.78 kg/ha, which was remained at par with treatment G_5 (GA_3 40 mg/l). However, in case of harvest index, G_5 recorded the highest value (26.69) and remained at par with G_2 (24.65) and G_4 (24.63). This might be due to exogenous application of plant growth regulators, which stimulated and enhance the enzymatic activities through its effect of natural occurring hormones that accelerated the growth and development of plants. Similar results were also reported by Yadav et al. [9] and Burman et al [10] in cluster bean.

Seed quality parameters showed significant differences due to application of different PGR's treatments. Germination percentage was recorded the higher in treatment G_6 (98.46 (%) and 98.01 (%)) (Table 4). Treatments G_4 (GA_3 20 mg/l), G_5 (GA_3 40 mg/l) and G_7 (Thiourea 1000 mg/l) remained at par with each other.

Seedling length was also the highest in the treatment G_6 (11.71 cm) (Table 4). Similarly, the Seedling dry weight was significantly the higher in treatment G_6 (1.142 g). This might be due to beneficial effect of thiourea on seed germination, seedling growth, biomass production and better dry matter partitioning Sharma et al. [11].

Vigor index-I showed significant differences and treatment G_6 recorded the highest vigor index-I i.e. 1068.78 (Table 4). Which was statistically at par with G_5 (1052.62) and G_7 (1051.45).

While, vigor index-II was the highest in treatment G_4 (GA_3 20 mg/l) i.e. 10.51 and it was found statistically at par with treatment G_6 (10.49) (Table 4). This might be due to higher germination and seedling dry weight through the activation of synthetic activities by growth regulators i.e. thiourea and GA_3 during seedling growth. Similar results were also reported by Sharma et al. [11] in cluster bean.

Interaction effect

Interaction effects between clipping and PGR's were found non-significant for plant height at 60, 75 and harvest time, number of leaves per plant at 60 DAS, leaf area at 60 DAS, LAI at 60 DAS, dry weight of plant 60 and 75 DAS, number of cluster per plant, number of pod per plant, number of pods per cluster, number of seeds per pods, harvest index and seed yield per plant.

Whereas, in the case of number of leaves per plant the interaction D_1G_5 (Without decapitation + GA_3 40 mg/l) recorded the highest number of leaves per plant (68.53) at 75 DAS (Table 5). Results showed that as the age of plant increased the number of leaves per plant decreased due to senescence effect of GA_3 at higher concentration with decapitation.

Interaction effects between decapitation and PGR's treatments on leaf area showed significant differences at 75 DAS (Table 6). Interaction D_1G_4 (Without decapitation + GA_3 20 mg/l) registered the maximum LA i.e. 1637.96 cm^2, which was statistically at par

Table 8. Interaction effect between decapitation and PGR's on vigor index-I and II.

Treat-ments	D_1	D_2	D_3	D_1	D_2	D_3
G_1	791.03	858.23	1063.80	6.67	10.57	10.04
G_2	825.71	1052.02	1101.80	7.30	10.18	10.81
G_3	898.02	1147.78	1025.23	9.06	10.50	10.29
G_4	866.23	1000.59	965.16	10.42	10.28	10.86
G_5	873.30	1023.99	1260.58	10.17	9.95	9.89
G_6	1035.65	1027.60	1143.09	10.64	9.98	10.87
G_7	1030.05	1222.24	902.06	9.90	10.17	10.13
SEm ±		65.16			0.61	
CD at 5%		186.03			1.75	
CV (%)		11.25			10.78	

with D_1G_2 (without decapitation + NAA 20 mg/l) and D_1G_6 (without decapitation + Thiourea 500 mg/l). This might be due to synergistic effect of GA_3 at early stage and thiourea at later stage that stimulates cell elongation and expansion of leaf. These results are in accordance with the findings of Ganiger et al. [6] in cowpea and Chavan and Lad [12] in chickpea.

Interaction effects of decapitation and PGR's were found significant for yield parameters likes number of pods per cluster, number of seeds per pod, seed yield per hectare (kg) and weight of 1000 seeds (Table 7). Significantly, the higher number of pods per cluster (6.10) was recorded under D_3G_6 (Decapitation at 75 DAS + Thiourea 500 mg/l) combination similarly, the highest numbers of seeds per pod (7.26) was also recorded under D_3G_6 (Decapitation at 75 DAS + Thiourea 500 mg/l) combination (Table 3). Seed yield per hactare (kg). While weight of 1000 seeds was higher in D_2G_6 (Decapitation at 60 DAS + Thiourea 500 mg/l) i.e. 40.58 (Table 3). These might be due to interaction effects of decapitation and thiourea, which stimulated enzymatic activities and diversification of food materials toward source i.e. number of pods per cluster, number of seeds per pod, seed yield per hectare (kg) and weight of 1000 seeds. Similar results were also reported by Yadav et al. [9] in cluster bean.

Interaction effect of decapitation and PGR's for test weight of 1000 seeds (g) character treatment D_2G_4 (40.50 g) significantly higher. For seedling length (13.55 cm) and seedling dry weight (1.86 g) character treatment D_3G_6 is superior over the all treatment. For vigor index-I treatment D_2G_7 (1222.24) is significant over all the treatment.For vigor index-II treatment D_3G_4 (10.86) is best over all the treatment (Table 8). This might be due to diversification of food synthesis towards source i.e. seeds, by the decapitation treatments and accumulation of growth promoters in seeds. Similar findings were also observed Sharma and Singh [13] in cluster bean.

Conclusion

In the light of results obtained from present investigation, it may be inferred that for securing the maximum seed yield and good quality seed of cluster bean cv Pusa Navabahar, it is advisable to spray thiourea @ 500 mg/l or GA_3 40 mg/l at flowering stage as well as applied decapitation treatment at 75 DAS under middle Gujarat agro-climatic conditions.

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