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Responses of Gibberelic Acid (GA_3) on Growth and Yield of Cowpea cv. BARI Falon-1 (*Vigna unguiculata* L.)

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Abstract

An experiment was carried out at the research farm of Patuakhali Science and Technology University (PSTU) during the period from November 2010 to April 2011 to study on growth and yield performance of cowpea cv. BARI Falon-1 under different treatment of GA_3 as foliar spray to investigate the responses and most optimum level of gibberelic acid regarding growth and yield of Falon that are suitable to cultivate in coastal region of Bangladesh. Among the GA_3 treatments, 33.33 ppm GA_3 produced significantly the tallest plant (61.07 cm), maximum leaves and branches plant^{-1} (28.50 and 19.73, respectively), higher LAI (1.10) and higher TDM plant^{-1} (81.95 g) comparatively than that of other GA_3 levels while control had lower on the above characters. Growth characters such as CGR, RGR and NAR had also higher (0.99 and 1.65 gm^{-2} day^{-1} for CGR, 0.43 and 0.72 gm^{-2} day^{-1} for RGR and 0.027 and 1.275 mg cm^{2} day^{-1} for NAR) in 33.33 ppm GA_3 at the stage between 30 to 60 DAS and 60 to 90 DAS, respectively Yield contributing characters Among other observation of yield and yield contributing characters, 33.33 ppm GA_3 further registered the maximum pods plant^{-1} (11.50), longest pod (17.05 cm), higher weight fresh (3.78 g) and dry pod (1.99 g), higher weight of 100–seed (12.25), seed yield (18.57 g plant^{-1} and 2986.72 kg ha^{-1}) and higher HI (22.45%). These results also showed that GA_3 up to 33.33 ppm signifciantly developmend morpho–physiological, growth, yield and yield contributing characters and thereafter all the data decreased due to its destructive effect of higher GA_3 levels. So, considering the above observation it could be suggested that GA_3 @ 33.3 ppm would be appropriate doses of GA_3 for obtaining the better produciton of BARI Falon-1 under resion.

Key words: Cowpea, GA_3, Growth, Yield

Introduction

Cowpea (*Vigna unguiculata* L, Walp.) is locally known as Falon which was grown as a grain legume crop in *rabi* season and fodder in *kharif* season in the tropics and sub-tropics covering Asia, Africa, Southern Europe, Southern United States and Central and South America (Ullah *et al*., 1995). Cowpea is probably of American origin from the fact that the plant was an important source of hay for cows in the United States and first found in literature in 1978. It was also called as “pease” and later “corn field pease”, because of planting it between the rows of field corn. It is now called as “Southernpeas”, “Blackeyed peas”, “Field peas”, “Pinkeyes”, and “Crowders” etc. Cowpea is a hardy crop well adapted to relatively dry environments. In Bangladesh, the area under cowpea production is about 16 thousand hectares where the yield is 632 Kg ha^{-1} and the production quantity 6000 tons (BBS, 2010). Cowpea fodder is an excellent source of essential nutrients with an average digestibility co-efficient of 74.35 % of the whole plant, 78.06 % of crude protein, 72.42 of crude fiber, 76.98 % of nitrogen free extract (soluble carbohydrate) and 71.81 % of ether extract. The green pod of cowpea contains 51.40 % water, 22.5 % protein, 10.1 % crude fiber, 56.29 % soluble carbohydrate, 2.10 % fat and 9.0 % minerals (Rahman *et al*., 1992). In Bangladesh, the number of livestock is decreasing due to the lack of green grasses in grazing fields. Recently the dairy farms surrounding the urban areas have increased due to the growing need of milk and milk products for the urban people. So to sustain the dairy industries it is essential to increase fodder production where cowpea could be a potential crop. However, growth regulators especially auxins have been reported to enhance the vegetative growth of many crops including legumes (Roy *et al*., 1990). For normal growth and development, gibberellic acid (GA_3) is a phytohormone that is needed in small quantities at low concentration to accelerate plant growth and development. GA_3 enhances growth activities to plant, stimulates stem elongation and increases dry weight and yield (Deotale *et al.,* 1998). The challenge is to find ways of improving cowpea productivity, where varital improvement modified cropping systems and use of plant growth regulators (PGRs) any improve cowpea yield (Emongor, 2007). Mukhtar and Singh (2006) reported that GA_3 stimulated an increase in growth, flowering, pod maturity and grain yield of cowpea. Therefore, application of plant growth regulators such as gibberellins may promote elongation of internodes and hence increase yield. Moreover growth regulators are used in appropriate concentrations, these substances influence the plant architecture in a typical fashion and improve the yield potential. Therefore, the current research work undertaken to evaluate the effect of various concentrations of GA_3 on growth and yield of Cowpea and to find out the most appropriate doses of GA_3.

Materials and Methods

A field experiment was conducted at the research farm of PSTU during the period from November 2010 to April 2011. Geographycally, the research farm is located at $22^0 37'$ N latitude and $89^0 10'$ E longitudes. The area is named as Gangetic Tidal Floodplains and falls under Agroecological Zone "AEZ- 13". The area lies at 1.5 metre above mean sea level. The soil of the experimental field was silty caly loam having pH value of 7.00. The organic matter content found 1.53% in most cases. Deficiency of nitrogen is acute and widespread. Status of exchangeable potasium is almost satisfactory. Phosphorus, sulphur and other characterstics of soil status are also optum for its cultivation. Climatic conditions are also favourable for its cultivation. The variety cv. BARI Falon-1 was used as planting materails and five different levels of Gibberelic Acid (GA_3) including control were applied as treatment *viz.* T_0 = Control (without GA_3), T_1 = 25 ppm, T_2 = 33.3 ppm (recommended dose by Yon Longping high-tech. Agriculture Company Ltd.), T_3 = 50 ppm and T_4 = 100 ppm. A 100 ppm solution of GA_3 was prepared by dissolving 100 mg of GA_3 in 1 L of distilled water. The distilled water was added to make the volume 1 liter to get 100 ppm solution which was used as treatment T_4. Similarly another volume (T_1, T_2 and T_3) of GA_3 was prepared. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of each unit plot was 2.0 m × 2.0 m where line to line and seed to seed distances were 30 and 15 cm, respectively, in each plot. The land of the experimental site was first opened on December 20, 2010 with a tractor and then the land was ploughed and cross-ploughed to obtain good tilth. All the weeds and stubbles were removed from the experimental field. The soil was treated with insecticides at the time of final ploughing. Insecticides Furadan 5G was used @ 8 kg ha^{-1} to protect young plants from the attack of mole cricket, ants, and cutworms. Fertilizers such as urea @ 8 kg, TSP @ 6 g and MoP 20 g were applied for each plot during final plot preparation. The seeds of Falon (cowpea) were sown in the research field on January 3, 2011. The distances between row to row and seed to seeds were 40 and 15 cm, respectively. Matured and viable 2 seeds were placed in each hole at 2-3 cm depth from the soil surface. Thinning out, gap filling, weeding, irrigation and disease and pest management operation were also done as intercultural operation for maximizing the yield. Continuous monotoring of growing seedlings and GA_3 spraying was also done as per treatment. The first crop sampling was done on 30 days after sowing (DAS) and it was continued up to physiological maturiety on 90 DAS at an interval of 30 days. Harvesting of the cowpea was done after 110 days of sowing. Data were collected when the foliage turned pale yellow. Data were recorded for 5 individual plants per plots in each replication. Yield data were also collected after harvest. The plants were separated into leaf, stem and roots and then their dry weight were recorded after drying them in an oven at $80 \pm 2^{O}C$ for 72 hours. The data obtained from the experiment on various parameters were statistically analyzed by MSTAT-C computer program and the mean were adjusted by DMRT where at 5 % levels of probability.

Results and Discussion

Morphological characters

Plant height

At the early stage of growth up to 60 DAS, the growth of plants of the cowpea genotype was slow after that the plant was growing fast compared to 30 and 60 DAS (Table 1). Among the five levels of GA_3, significantly the tallest plant (17.25, 45.33 and 61.07 cm respectably) was observed in 33.3 ppm GA_3 at 30, 60 and 90 DAS, respectively while it was shortest (13.55 and 55.07 cm, respectively) in 100 ppm at 30 and 90 DAS and in control (33.67 cm) at 60 DAS. The present findigns was similar to Hoque and Haque (2002) who also found signficiant variation in plant height in mungbean. (Castro *et al.*, 1989) also found a significant increase in plant height in rapes induced by different levels of GA_3. A gradual increase in plant height was noticed up to 50 ppm. Further increase in concentration (75 ppm GA_3) had resulted in reduced plant height.

Leaves plant^{-1}

A highly significant variation was found to be the effect of different levels of GA_3 at differnet DAS in respect of leaves plant^{-1}. Among the treatments, foliar spray of GA_3 at 33.3 ppm showed the maximum leaves plant^{-1} (8.33, 25.50 and 28.50) at 30, 60 and 90 DAS, respectively followed by GA_3 at 25 ppm at 30 DAS (8.17) and 50 ppm at 60 and 90 DAS (24.17 and 26.00, respectively). On the other hand, the minimum leaves plant^{-1} (7.50) was found in both GA_3 levels at 50 and 100 ppm at 30 DAS while without GA_3 (control) had minimum at 60 and 90 DAS (20.83 and 23.50, respectively). Similar finding was also found by Hoque and Haque (2002) who found that GA_3 at 50 ppm increase the number of leaves of mungbean and thereafter it decreased.

Branches plant^{-1}

Branches plant^{-1} was also significant due to GA_3 levels at different DAS in this study where foliar spray of 33.3 ppm GA_3 showed significantly the maximum branches plant^{-1} (4.60, 9.67 and 19.73) at 30, 60 and 90 DAS, respectively (Table 1). On the other hand, the minimum branches plant^{-1} was found in 100 ppm GA_3 (3.33 and 15.87) at 30 and 90 DAS, respectively and control treatment (6.17) at 60 DAS.

Table 1. Effect of different levels of GA_3 on plant height, leaves plant^{-1} and branches plant^{-1} at different DAS

GA_3 levels (ppm)	Plant height (cm)			Number of leaves per plant			Number of branches per plant		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
0 (control)	14.03 c	33.67 c	58.18 bc	7.83 b	20.83 d	23.50 c	3.67 bc	6.17 d	16.00 c
25	16.00 b	36.18 c	59.22 ab	8.17 ab	22.50 c	25.50 b	4.17 ab	7.42 bc	17.45 b
33.3	17.25 a	45.33 a	61.07 a	8.83 a	25.50 a	28.50 a	4.60 a	9.67 a	19.73 a
50	16.03 b	40.95 ab	56.47 cd	7.50 b	24.17 b	26.00 b	3.95 b	8.00 b	17.75 b
100	13.55 d	38.02 bc	55.07 d	7.50 b	21.17 d	23.67 c	3.33 c	6.75 cd	15.87 c
CV (%)	**2.52**	**9.46**	**2.70**	**8.47**	**2.96**	**3.05**	**11.22**	**8.08**	**2.82**
$LSD_{(0.05)}$	**0.4698**	**4.455**	**1.832**	**0.8191**	**0.8191**	**0.9427**	**0.05370**	**0.7448**	**0.5930**

Leaf area (LA)

Leaf area data due to GA_3 foliar application were significant at all the data recording stages whereas it increased particularly from initial stage up to 90 DAS. The highest leaf area (102.04 and 477.99 cm^2 plant^{-1}) was recorded in 33.3 ppm GA_3 at 30 and 60 DAS, respectively while leaf area had higher (2462.20 cm^2 plant^{-1}) in 100 ppm GA_3 at 90 DAS wehreas statistically similar LA at 60 DAS (460.81) and 90 DAS (2419.40) were obtained by 50 and 25 ppm GA_3. Similarly, the lowest LA was recorded in 100 ppm GA_3 (81.21 cm^2 plant^{-1}) at 30 DAS, 25 ppm (347.94 cm^2 plant^{-1}) at 60 DAS and control treatment (1918.74 cm^2 plant^{-1}) of 90 DAS (Table 2).

Leaf area index (LAI)

Foliar application of GA_3 showed significant variation in respect of LAI at different days after sowing where the highest LAI (0.71, 1.13 and 1.10) was obtained in 33.3 ppm GA_3 at 30, 60 and 90 DAS, respectively while 50 and 25 ppm GA_3 showed statistically similar LAI at 30 DAS (0.70 and 0.68, respectively) and signifciantly differed from other treatments at 60 and 90 DAS. However, the lowest LAI (0.658 and 0.92) was found in control treatment at 30 and 60 DAS but it was statistically similar to 100 ppm GA_3 at 30 DAS (0.66) and statistically similar to 25, 50 and 100 ppm GA_3 at 60 DAS. LAI of 90 DAS had lower (0.87) in 100 ppm GA_3 which was also statistically similar to 25, 50 and 100 ppm GA_3 (Table 2).

Total dry matter (TDM)

Effect of GA_3 had significant on TDM where TDM increasing gradually up to 60 DAS and increasing rapidly at 90 DAS. The highest TDM (81.95, 32.47 and 81.95 g plant^{-1}) was recorded in 33.3 ppm GA_3 at 30, 60 and 90 DAS, respectively which was statistically close to 50 ppm GA_3 at 30 DAS (2.85). GA_3 at 100 ppm showed the lowest TDM (2.79 and 60.61 g plant^{-1}) at 30 and 90 DAS, respectively but control treatment (24.69 g) at 60 DAS (Table 2). Similarly, Doijode (1975) also found that 30 ppm GA_3 foliar spray showed higher plant dry weight at flowering stage in gardenpeas.

Table 2. Effect of different levels of GA_3 on leaf area plant^{-1}, Leaf area index and total dry matter weight at different DAS

GA_3 levels	Leaf area per plant (cm^2 plant^{-1})			Leaf area index (LAI)			Total dry matter (g plant^{-1})		
(ppm)	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
0 (control)	87.62 c	415.04 b	1918.74 b	0.66 c	0.92 b	0.89 b	2.83 b	24.69 e	64.31 c
25	83.56 cd	347.94 c	2419.408 a	0.68 ab	0.98 b	0.94 b	2.80 b	26.24 d	70.29 b
33.3	102.04 a	477.99a	2050.92 b	0.71 a	1.13 a	1.10 a	2.90 a	32.47 a	81.95 a
50	94.87 b	460.81 a	2013.82 b	0.70 ab	0.95 b	0.93 b	2.85 ab	30.83 b	69.89 b
100	81.21 d	407.28 b	2462.20 a	0.66 bc	0.97 b	0.87 b	2.79 b	28.28 c	60.61 d
CV (%)	**4.52**	**6.05**	**6.73**	**3.07**	**5.00**	**3.89**	**2.04**	**2.78**	**2.34**
$LSD_{(0.05)}$	**4.928**	**30.94**	**177.30**	**0.03836**	**0.1085**	**0.07671**	**0.06921**	**0.9597**	**1.972**

Growth characters

Crop growth rate (CGR)

Crop growth rate (CGR) data revealed that the significant variation was found due to GA_3 where significantly the highest CGR (0.99 and 1.65 cm^2 day^{-1}) was noticed in 33.3 ppm GA_3 reatments at the stage between 30 to 60 DAS and 60 to 90 DAS, respectively. However, the lowest CGR (0.73 and 1.08 cm^2 day^{-1}) was recorded in control treatment at 30 to 60 DAS and foliar spray at 100 ppm GA_3 at 60 to 90 DAS, respectively (Fig. 1). Similar findings were also observed (Ganapathi, 2006) who reported that the application of RDF+ GA_3 (40 ppm) recorded significantly higher crop growth between 40 to 60 DAS and between 60 DAS to harvest over other treatments.

Relative growth rate (RGR)

Five levels of GA_3 showed significant difference on RGR at both stages of data recording where the RGR range was 0.32 to 0.43 cm^2 day^{-1} at 60 DAS and 0.47 to 0.72 cm^2 day^{-1} at 90 DAS. Among the GA_3 treatments, the foliar spray at 33.3 ppm of GA_3 produced the maximum RGR (0.43 and 0.72 cm^2 day^{-1}) at 30 to 60 DAS and 60 to 90 DAS, respectively whereas the lowest RGR (0.32 and 0.47 cm^2 day^{-1}) was recorded in control treatment at 60 DAS and 100 ppm GA_3 at 90 DAS (Fig. 1).

Net assimilation rate (NAR)

Effect of foliar spray application of GA_3 showed significant variation at the stages of 30 to 60 DAS and 60 to 90 DAS in respect of NAR. Among the GA_3 applications, 33.3 ppm GA_3 produced the maximum NAR (0.027 and 1.275) at the stages between 30 to 60 DAS and 60 to 90 DAS, respectively wheras the minimum NAR (0.019 and 0.897) was recorded in control treatment at 60 DAS and 100 ppm GA_3 at 90 DAS (Fig. 1).

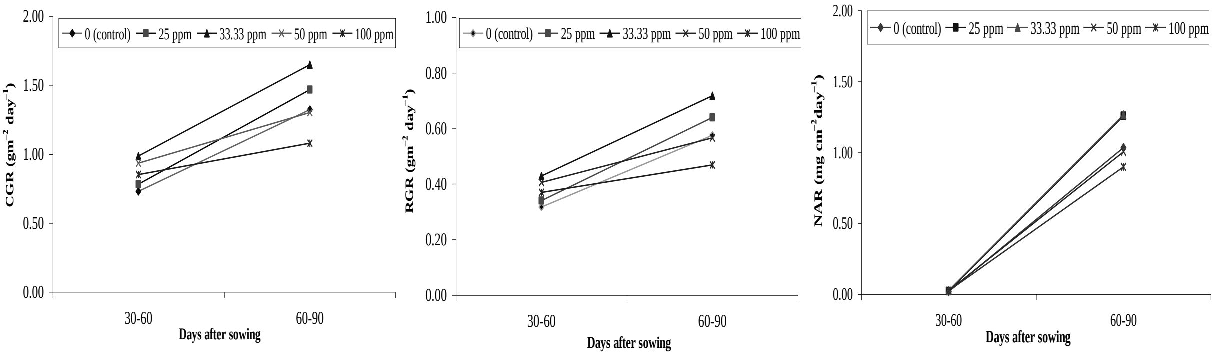

Fig. 1. Effect of GA_3 on CGR (A), RGR (B) and NAR (C) at different days after sowing

Yield parameters

Flower plant^{-1}

Number of flowers plant^{-1} differed significantly among the treatments of GA_3 (Fig. 2). Number of flowers plant^{-1} was maximum (18.30) in 33.3 ppm GA_3 which was statistically identical to 50 ppm GA_3 (17.53). The minimum flowers plant^{-1} (14.77) was recorded in 100 ppm GA_3 which was also statistically similar to control (14.95). The findings of Upadhyay (2002) results was also similar with the present study who noticed that NAA (20, 30 ppm) and GA_3 (20, 30 ppm) increased the number of flowers compared to control in chickpea.

Seeds pod^{-1}

A significant variation was also recorded by the effect of GA_3 levels in respect of seeds pod^{-1}. The number of seeds pod^{-1} was maximum (16.23) in 33.33 ppm GA_3 and the minimum (11.95) in 100 ppm GA_3. Rest of the foliar spray treatment of GA_3 (control, 25 and 50 ppm GA_3) produced the statistically more or less similar seeds pod^{-1} (14.15, 14.33 and 14.27, respectively) (Fig. 14). Upadhyay (2002) noticed that NAA (20, 30 ppm) and GA_3 (20, 30 ppm) increased number of grains per pod. Srikant (2003) also reported that significantly highest seeds plant^{-1} (8.3) was found in GA_3 at 40 ppm in cluster bean.

Pods plant^{-1}

Number of pods plant^{-1} showed distinct significant difference among all the levels of GA_3. The maximum pods plant^{-1} (11.50) was obtained in 33.3 ppm GA_3 and the lowest (7.67) was found in 100 ppm GA_3 which was statistically identical to control (8.33) (Table 3). The range of pods plant^{-1} 8.33 to 11.50 where the mean data showed increasing capability from control to 33.3 ppm spray of GA_3 and there after it was decrease. It was observed that the GA_3 at 33.3 ppm was resistant for growth and yield after that it was tolerant. The 1500 ppm of KNap was found influential to produce more pods per plant as reported by Islam *et al*. (2006) in lentil. Zaky *et al*. (2006) found that application of humic acids as foliar application (1 g L^{-1}), gave a significant superior effect over non-treated plant on number of pods plant^{-1}, total pod yield plant^{-1} and average pod fresh weight of common bean.

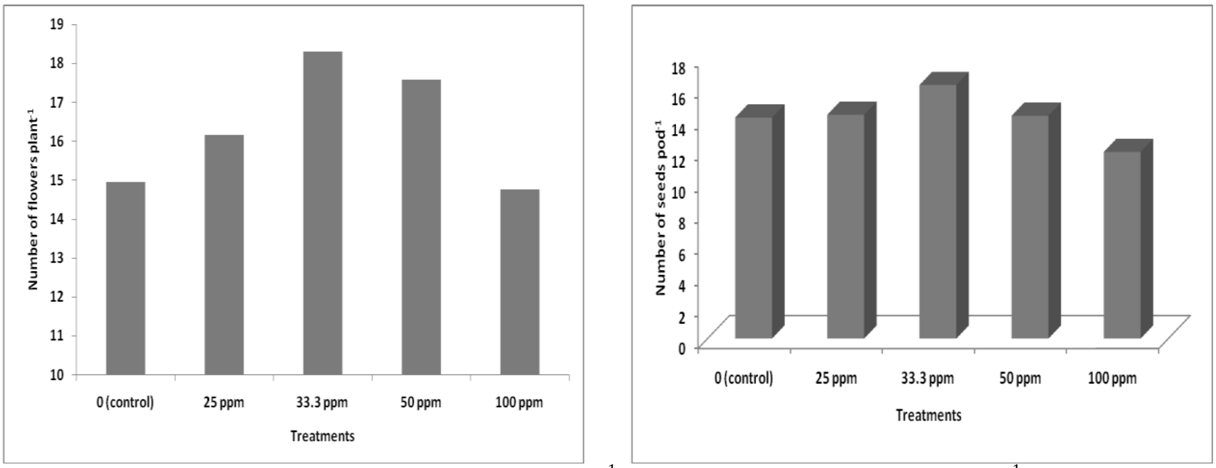

Fig. 2. Effect of GA_3 on number of flowers plant^{-1} at flowering stage (A) and seeds pod^{-1} at harvest

Length of pod

Different levels of GA_3 showed significant variation in respect of length of pod (Table 3). The length of pod range was 13.77 cm to 17.05cm where significantly the longest pod (17.05 cm) was obtained from the foliar spray of 33.3 ppm GA_3 and the shortest pod (13.77 cm) was found in 100 ppm GA_3.

Fresh weight of pod

Significant difference was found to be the effect of GA_3 in relation to fresh weight of pod where it was found that the highest fresh weight of pod (3.784 g $plant^{-1}$) was observed in 33.3 ppm GA_3 while foliar spray of GA_3 at 25 and 50 ppm produced statistically similar weight of pod (3.462 and 3.463 g $plant^{-1}$, respectively). On the other hand, the lowest fresh pod weight (3.358 g $plant^{-1}$) was noticed in 100 ppm GA_3 which was also statistically smilar to control (3.362 g $plant^{-1}$). Hoque and Haque (2002) reported that the GA_3 at 50 ppm increase fresh and dry weight of pod in mungbean.

Dry weight of pod

Weight of dry pod had highest (1.993 g $plant^{-1}$) was found in 33.33 ppm GA_3 and the lowest (1.687 g $plant^{-1}$) was observed in 100 ppm GA_3. It was also observe that the application of GA_3 at different levels increase in pod dry weight up to 33.3 pm GA_3 thereafter it was decreased. The induction in pod dry weight was affected by GA_3 which produced lower results by the high rate (100 ppm) of GA_3. As a result, 100 ppm GA_3 produced the lowest result then control treatment (Table 3).

Hundred-seed weight

Significant variation was recorded on 100-seeds weight by the effect of GA_3 (Table 3). The highest 100-seeds weight (12.25 g) was found in 33.3 ppm GA_3 and the lowest 100-seeds weight (10.63 g) was observed in 100 ppm GA_3 while statistically similar lower weight of 100-seeds was found in control (10.82 g). Another foliar spray at 25 and 50 ppm GA_3 also gave the statistically similar results i.e., 11.33 and 11.62 g, respectively.

Seed Yield

Different levels of GA_3 were significantly affected on seed yield at both g $plant^{-1}$ and kg ha^{-1} where the highest yield (18.57 g $plant^{-1}$ or 2986.72 kg ha^{-1}) was produced in 33.3 ppm GA_3 and the lowest yield (12.04 g $plant^{-1}$ or 1987.25 kg ha^{-1}) was recorded in control treatment which was statistically similar to 100 ppm GA_3 (12.32 g $plant^{-1}$ or 2061.85 kg ha^{-1}). Similar study was also observed by Srikant (2003) who reported the the significantly highest seed yield $plant^{-1}$ (7.33 g) with GA_3 at 40 ppm in cluster bean. Upadhyay (2002) also noticed that GA_3 (20 and 30 ppm) increased seed yield in chickpea. Similarly, Srikant (2003) reported significantly highest seed yield ha^{-1} (542.6 kg) with GA_3 at 40 ppm in cluster bean.

Harvest Index (HI)

The data on harvest index indicated that the foliar spray application of GA_3 showed significant variations among themselves (Table 3). The foliar spray at 33.3 ppm GA_3 having the maximum harvest index (22.45%) and it was statistically identical to 50 ppm GA_3 (22.07%) whereas the lowest harvest index (18.76%) was noticed in without foliar spray of GA_3.

Table 3. Effect of different levels of GA_3 on yield and yield contributing characters at harvest

GA_3 levels (ppm)	No. of pods $plant^{-1}$	Length of pod (cm)	Fresh weight of pod (g)	Dry weight of pod (g)	100- seed weight (g)	Seed yield (g $plant^{-1}$)	Seed yield (kg ha^{-1})	Harvest Index (%)
0 (control)	8.33 c	14.12 c	3.36 c	1.74 c	10.82 c	12.04 d	1987.25 d	18.76 c
25	9.67 b	14.87 b	3.46 b	1.77 c	11.32 b	13.28 c	2210.00 c	18.89 c
33.3	11.50 a	17.05 a	3.78 a	1.99 a	12.25 a	18.57 a	2986.72 a	22.45 a
50	9.50 b	15.28 b	3.46 b	1.85 b	11.62 b	15.44 b	2545.60 b	22.07 a
100	7.67 c	13.77 c	3.36 c	1.69 d	10.63 c	12.32 d	2061.85 d	20.54 b
CV (%)	**7.17**	**3.50**	**1.08**	**1.88**	**3.05**	**4.01**	**5.24**	**5.63**
$LSD_{(0.05)}$	**0.8119**	**0.6382**	**0.03836**	**0.3836**	**0.1414**	**0.6968**	**134.50**	**1.401**

Conclusions

In view of the above results observation and discussion, it was concluded that the foliar spray at 33.3 ppm GA_3 had higly effective and more significant due to its advantageous effect on morpho–physiological growth and yield of cowpea which ensure the greater yield of cowpea.

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