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THE IMPACT OF GIBBERELLIC ACID AND DIFFERENT DECAPITATION METHODS ON SEED QUALITY OF BROCCOLI

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ABSTRACT

The present investigation was conducted during the *rabi* season of 2021-22 and 2022-23 in the Experimental farm, Department of Horticulture, College of Agriculture, Assam Agricultural University, Jorhat. The experiment was laid out in a Randomized Block Design (factorial) with three replications. The sixteen treatments comprised combinations of four different concentrations of GA_3 *viz.*, G_0 (0 ppm), G_1 (25 ppm), G_2 (50 ppm) and G_3 (75 ppm) and four different head decapitation methods *viz.*, D_1 (decapitation of the primary head at appearance), D_2 (decapitation of the primary head at the marketable stage), D_3 (decapitation of the secondary heads at appearance) and D_0 (control). GA_3 was applied as seedling root dip treatment for 24 hours before transplanting. The minimum number of days to second heading (81.18 days) was obtained under the G_2 (GA_3 50ppm). Among decapitation treatments, D_1 (decapitation of primary heads) was found to be the best for producing the minimum days to second heading (82.66), maximum secondary head yield per plant (87.07g), the maximum number of siliqua per plant (390.54), the highest number of seeds per siliqua (8.53), the highest seed yield per plant (4.19 g) and seed yield per hectare (1.98 q ha^{-1}). Therefore, it is suggested that decapitation of the primary head at appearance (D_1) can be recommended for commercial seed production of broccoli. The interaction effect of G_2D_1 (GA_3 @50 ppm and decapitation of the primary heads at appearance) recorded minimum days to second heading (81.18 days), the maximum secondary head yield (91.71g), the maximum number of siliqua per plant (340), the highest number of seeds per siliqua (9.17), highest seed yield per plant (5.42 g) and seed yield per hectare (235.49 kg).

***Key words*:** Gibberellic Acid, Seed Quality, Broccoli

Introduction

Broccoli (*Brassica oleracea* var. *italica* L) is a nutritious vegetable that belongs to the family Brassicaceae. In recent years, the cultivation of broccoli has gained momentum in India due to its numerous health benefits and increasing demand among consumers. Broccoli is gaining importance due to its nutritional value, including flavour, taste, carotenoids, and anticancerous properties. Isothiocyanate sulforaphane, which is present in broccoli in the form of glucosinolate glucoraphanin, which cancels out the free radicles, can potentially contribute to the prevention of cancer (Quiros, 2002). Quality seed is the main carrier of the genetic potential of an improved variety. The performance and efficacy of other inputs also depend on seed quality. It was reported that good-quality seeds of improved varieties can contribute to a 25-40% increase in the yield of crops (Kanwar *et al.*, 2010). The genetic purity of seeds of an improved variety can be maintained through practices like isolation, rouging, field inspection, etc., while physical purity can be upgraded through seed processing. However, the physiological quality of the seeds, *viz.*, germination and vigour can be improved through improved production practices. The climatic condition of Assam is suitable for the formation of compact heads, floral stock emergence, and seed production of broccoli. Due to the high cost of hybrid seeds, it is necessary to produce good-quality seeds of improved varieties locally so that farmers can get seeds at a reasonable price. Removal of either the axillary or terminal heads produced a higher seed yield compared to seed production when no buds were removed. Decapitation of broccoli (Mihov and Antonova, 2009)

Materials and Methods

The present investigation was conducted at the Experimental Farm, Department of Horticulture, College of Agriculture, Assam Agricultural University, Jorhat, during 2021-22 and 2022-23. The experimental area was located at 26 º472 N latitude and 94 º122 E longitude at an elevation of 86.8m above mean sea level, which was under Upper Brahmaputra Valley Agro Climatic Zone of Assam. The plot selected had a good slope and drainage. The variety used in the experiment was Pusa Broccoli KTS-1 which was developed by IARI Regional Station, Katrain. Pusa Broccoli KTS-1 is a medium maturing variety with medium plant growth. Foliage is waxy and dark green with a slightly wavy margin. The head is solid green with small buds and slightly raised at the center. Design of experiment was RBD. The number of treatments is 16 with three replications. The sixteen treatments comprised combinations of four different concentrations of GA_3 *viz.*, G_0 (0 ppm), G_1 (25 ppm), G_2 (50 ppm) and G_3 (75 ppm) and four different head decapitation methods *viz.*, D_1 (decapitation of the primary head at appearance), D_2 (decapitation of the primary head at the marketable stage), D_3 (decapitation of the secondary heads at appearance) and D_0 (control). GA_3 was applied as seedling root dip treatment for 24 hours before transplanting. Total number of plots were 48. Plot size was 2.4 m × 1.8 m. Spacing was 60 cm × 45 cm. The different decapitation methods include D_0- No decapitation, D_1- Decapitation of the primary head at appearance and harvesting seeds from secondary heads, D_2- Decapitation of the primary head at marketable stage and harvesting seeds from secondary heads and D_3- Removal of the secondary heads at appearance and harvesting of seeds from the primary head. Transplanting was done after 30 days of sowing seeds when the seedlings had attained a height of about 10-15 cm. Healthy vigorous seedlings were selected and transplanted in the evening hours at a spacing of 60 cm × 45 cm between and within rows. Gap filling was done within 7 days of planting. FYM @ 10 tha^{-1} was applied at the time of field preparation. Fertilizer in the form of urea, single super phosphate, and muriate of potash at the rate of 100 kg N, 75 kg P_2O_5, and 50 kg K_2O per hectare was applied. The total amount of P and K was applied as a basal dose, nitrogen in two split doses, and the remaining 50 per cent was applied one month after transplanting at the time of earthing up. As per treatment, the heads were harvested when they attained proper size, *i.e.* when the flower buds became bold before the opening of florets. After harvesting the heads, cull heads appear on the stump, and they are also harvested. When they attained a proper size and immediately fresh weight were taken as terminal heads. When 70% of the pod turned yellow, the seed stalks were cut and dried under shade. The seeds were then threshed, dried, and preserved in dry airtight glass containers. Harvesting of seed crops was done in the month of April 2022 and 2023.

Results and Discussion

Days to second heading

Significant variations were observed for the effect of head decapitation and GA_3 on number of days required for second heading. The minimum number of days required for second heading (81.86) was recorded under G_2 (GA_3 50ppm). On the other hand, G_0 (Control) recorded the maximum days required for heading (84.99 days). Gibberellic acid promotes stem elongation and cell division in plants. It encourages the growth of lateral buds or branches that may produce secondary heads. Similar findings were reported by Reza *et al.*, 2015 in broccoli. The main effect of decapitation revealed that the minimum days (82.66 days) required for the second heading were recorded under D_1(decapitation of the primary head at appearance) followed by D_2 (82.83 days). The apical bud at the tip of the main stem is the primary source of auxin hormones. When the apical bud is removed, the source of auxins is eliminated, allowing lateral buds to grow more vigorously (Seharawat *et al.*, 2003). While the maximum days were recorded under D_0 (83.79 days). The interaction effects of decapitation and GA_3 were also found to be significant. The combination of G_2D_3 (GA_3 50ppm and decapitation of the secondary head at appearance) resulted in a minimum (81.18 days) for the second heading followed by G_2D_2 (81.90 days). Whereas the combination of G_3D_3 ($GA_3$75ppm and decapitation of secondary heads at appearance) recorded the maximum days (86.08) for the second heading. Decapitation of the main head along with application of optimum levels of GA_3 removes apical dominance and

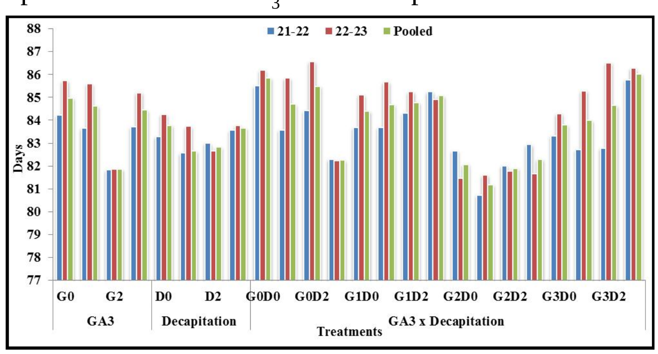

Fig. 1: Days to second heading.

thereby encourages the development of the secondary or lateral heads. Similar findings were reported by Mehta *et al.*, (2015) and Mihov and Antonova (2009) in broccoli.

Days to 50% flowering

The main effect of GA_3 on days to 50% flowering was significant (Fig. 2). A minimum of 134.67 days was recorded for 50% flowering under G_2 (GA_3 50 ppm) which is followed by 137.11 days in G_3 (GA_3 75 ppm). Whereas the maximum number of days required for 50% flowering was under G_1(147.74 days). Gibberellic acid can directly induce flowering in some plant species when applied at optimum levels. It can stimulate the production of flowering hormones and enzymes, which trigger the formation of flowers. Gibberellic acid can promote the formation of flower buds. It can stimulate the development of floral primordia, which are the initial stages of flower formation. Findings of Thapa *et al.*, (2013) in broccoli and Sawant *et al.*, (2010) and Lendve *et al.*, (2010) in cabbage have also exhibited similar results. The effect of decapitation on this character was also found significant. Minimum days (139.81) to 50% flowering was obtained when secondary heads were removed at appearance (D_3) which was significantly superior to other decapitation methods. However, a maximum day to 50% flowering (144.21) was obtained in D_2 *i.e.*, decapitation of primary head at the marketable stage. The removal of secondary heads increases flowering and overall plant productivity because it allows the plant to focus its energy and resources for producing central head. The individual effect of head decapitation methods showed that decapitation of secondary heads at appearance resulted in early flowering and subsequently early seed harvesting whereas pinching of the main head at formation or full marketable stage resulted in a delay in flowering and seed harvesting. (Seharawat *et al.*, 2003). The interaction effect revealed that the combination G_2D_3 (GA_3 50ppm with decapitation of secondary heads at appearance) resulted minimum number of days for 50% flowering (122.05 days) as pooled data over two years respectively. The maximum number of days (149.63 days) to 50% flowering was registered in G_0D_2(GA_3 0 ppm and decapitation of the primary head at maturity. Gibberellic acid can directly induce flowering and promote the formation of flower buds along with the removal of secondary heads allowing the plant to focus its energy and resources on flowering. Similar results were reported by Thakral *et al.*, (1991) and Menon and Khader (1997) in coriander and Sudarshan (2004) in fenugreek.

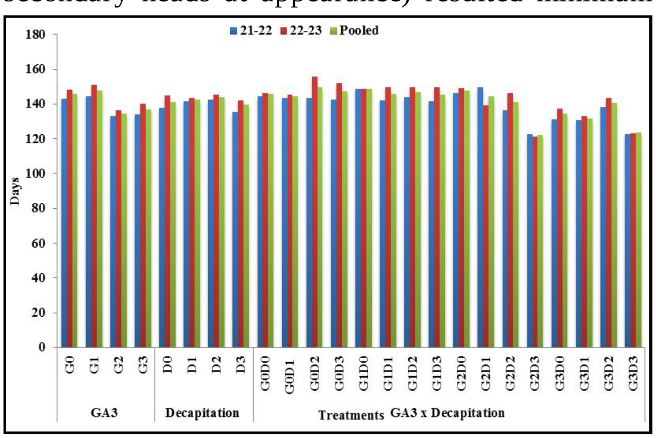

Fig. 2: Days to 50% flowering.

Secondary head yield per plant (g)

Significant variations were observed for the effect of head decapitation and GA_3 on secondary head yield per plant (Fig. 3). The effect of GA_3 treatment revealed that the maximum secondary head yield per plant of 88.39 g was recorded as pooled data over two years in G_2 (GA_3 at 50 ppm) which was found significantly superior to other treatments. While the lowest was recorded under D_0 (Control). This might be due application of optimum levels of GA_3 that induced more cell division, to more accumulation of carbohydrates by the maximum rate of photosynthesis (Thapa *et al.*, 2013). As a result, increase in secondary head yield. The individual effect of decapitation revealed that the highest secondary head yield (87.07g). When the main head is removed, the plant redirects its energy and nutrients towards the secondary head development. These secondary heads were initially suppressed by the main head's growth, but once it is removed, the plant can allocate more resources to these secondary shoots, allowing them to grow and develop into larger secondary heads (Mehta *et al.*, 2015). The interaction effect of GA_3 treatment and decapitation showed that the highest secondary head yield (91.71 g) was obtained under G_2D_1 (GA_3 50ppm and decapitation of the primary head at appearance) which is followed by 90.68 g in G_2D_1(GA_3 50ppm and decapitation of the primary head at appearance). The combined effect of GA_3 50 ppm along with the decapitation of the primary head at maturity may help in redirecting nutrients and

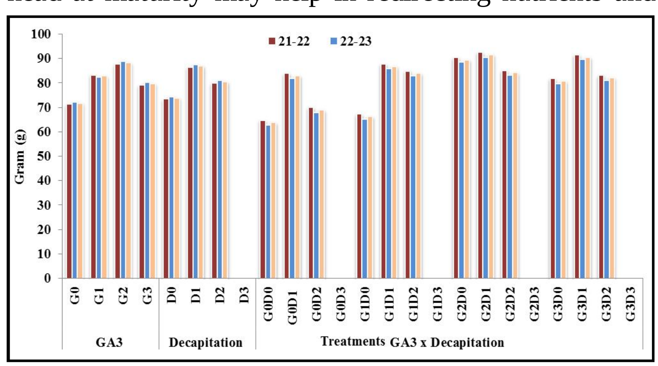

Fig. 3: Secondary head yield per plant (g).

food materials towards developing large-sized secondary heads (Elyazied *et al.*, 2007).

Number of siliqua per plant

Significant variations were observed due to GA_3 application and head decapitation on number of siliquas per plant (Fig. 4). The maximum number of siliquas (283.43) was obtained under G_2 (GA_3 50 ppm) which differs significantly among all other treatments. The lowest number of siliquas (140.42) was obtained under G_0 (Control). GA_3 can also influence the flowering process. It can induce flowering in some plants, which is a prerequisite for the development of siliques. When more flowers are formed, there is a higher potential to produce many siliquas. The effect of decapitation revealed that the highest number of siliquas per plant (390.54) was obtained in D_1 (decapitation of the primary head at appearance) which was followed by D_0 *i.e.*, control (251.90), and the lowest number of siliqua (138.32) was obtained in D_2 *i.e.*, decapitation of secondary heads at appearance. By removing the secondary heads, the plant redirects its energy to produce more flowers on the primary head. This leads to an increased number of siliquae as the primary head produces more flowers that eventually develop into seed pods. Similar results were confirmed by Ghimire *et al.*, (1993); Irwin and Aarseen (1996); Miguel *et al.*, (1998) and Venecez and Aarssen (1998). Interaction between GA_3 and head decapitation was also found significant for this character. The combination of G_2D_1(50ppm GA_3 and decapitation of the primary head at the appearance) resulted in the maximum number of siliquas per plant (340.00). Whereas the combination G_0D_2 ($GA_3$0ppm and decapitation of the primary head at maturity) gave the lowest number of siliquas per plant (101.46). Similar results were reported by Ghimire *et al.*, (1993); Irwin and Aarssen (1996); Miguel *et al.*, (1998), and Venecez and Aarssen (1998). They also reported that the removal of either the axillary or terminal head produced a higher number of siliques per plant than when no buds were removed.

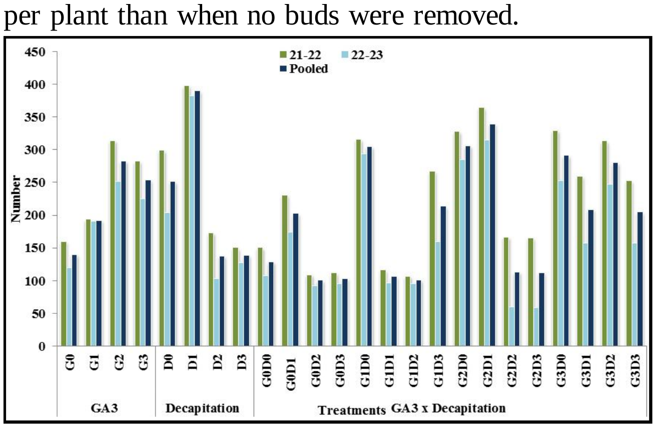

Fig. 4: No of siliqua per plant.

Table 1: Number of seeds per siliqua.

GA_3 treatment	21-22	22-23	Pooled
G_0	7.90	7.69	7.80
G_1	8.40	8.27	8.34
G_2	8.58	8.57	8.58
G_3	8.58	8.36	8.47
S Ed (±)	0.06	0.05	0.05
C.D at 5%	0.13	0.11	0.11
Decapitation treatment	**21-22**	**22-23**	**Pooled**
D_0	8.10	8.06	8.08
D_1	8.47	8.49	8.53
D_2	8.05	7.85	7.95
D_3	8.63	8.39	8.46
S Ed (±)	0.06	0.05	0.05
C.D at 5%	0.13	0.11	0.11
GA_3 × Decapitation	**21-22**	**22-23**	**Pooled**
G_0D_0	7.40	7.14	7.27
G_0D_1	8.33	8.10	8.22
G_0D_2	7.36	7.50	7.43
G_0D_3	8.49	8.43	8.46
G_1D_0	8.29	8.26	8.28
G_1D_1	8.35	8.09	8.22
G_1D_2	8.38	8.12	8.25
G_1D_3	8.57	8.61	8.59
G_2D_0	8.13	7.89	8.01
G_2D_1	9.28	9.06	9.17
G_2D_2	8.52	8.36	8.44
G_2D_3	8.68	8.49	8.59
G_3D_0	8.39	8.13	8.26
G_3D_1	9.16	8.90	9.03
G_3D_2	8.32	8.16	8.24
G_3D_3	8.42	8.23	8.33
S Ed (±)	0.10	0.10	0.10
C.D at 5%	0.21	0.21	0.20

Number of seeds per siliqua

Head decapitation and GA_3 alone as well as in combination were effective in exerting a significant influence on the number of seeds per siliqua (Table 1). The effect of GA_3 revealed that the highest number of seeds per siliqua 8.58 was obtained under G_2, while the lowest number of seeds (7.80) per siliqua was obtained under G_0 (Control). The main effect of head decapitation revealed that the highest number of seeds per siliqua (8.53) was obtained when primary heads were removed at appearance (D_1) which was found at par with D_3 (8.49) *i.e.*, decapitation of the secondary head at appearance. However, the lowest number of seeds per siliqua (7.95) was obtained in D_2 *i.e.*, decapitation of the primary head at the marketable stage. The interaction effect revealed that the combination of G_2D_1 ($GA_3$50 ppm and decapitation of the primary head at appearance) resulted

Table 2: Seed yield per plant (g).

GA_3 treatment	21-22	22-23	Pooled
G_0	4.05	2.33	3.19
G_1	4.21	2.98	3.60
G_2	5.09	3.40	4.24
G_3	4.83	2.64	3.73
S Ed (±)	0.12	0.11	0.13
C.D.at 5%	0.26	0.22	0.27
Decapitation treatment	**21-22**	**22-23**	**Pooled**
D_0	4.94	2.81	3.88
D_1	5.02	3.37	4.19
D_2	4.32	2.82	3.57
D_3	4.38	3.21	3.79
S Ed (±)	0.25	0.37	0.26
C.D.at 5%	0.52	0.76	0.53
GA_3 × Decapitation	**21-22**	**22-23**	**Pooled**
G_0D_0	4.38	3.91	4.14
G_0D_1	4.22	3.70	3.96
G_0D_2	4.22	3.01	3.61
G_0D_3	4.32	3.87	4.09
G_1D_0	4.12	3.33	3.72
G_1D_1	4.18	3.83	4.01
G_1D_2	4.81	3.09	3.95
G_1D_3	5.17	3.51	4.34
G_2D_0	5.12	3.73	4.42
G_2D_1	6.07	4.77	5.42
G_2D_2	4.52	2.86	3.69
G_2D_3	5.67	4.70	5.19
G_3D_0	4.09	4.06	4.07
G_3D_1	4.34	4.38	4.36
G_3D_2	4.95	4.72	4.84
G_3D_3	4.60	4.36	4.48
S Ed (±)	0.25	0.23	0.24
C.D at 5%	0.51	0.47	0.49

Table 3: Seed yield per hectare (q).

GA_3 treatment	21-22	22-23	Pooled
G_0	1.12	1.07	1.10
G_1	1.35	1.20	1.27
G_2	1.61	1.56	1.59
G_3	1.49	1.34	1.42
S Ed (±)	0.01	0.01	0.01
C.D at 5%	0.03	0.02	0.03
Decapitation treatment	**21-22**	**22-23**	**Pooled**
D_0	1.90	1.55	1.63
D_1	2.06	1.90	1.98
D_2	1.04	1.01	1.02
D_3	1.18	1.03	1.10
S Ed (±)	0.01	0.01	0.01
C.D at 5%	0.03	0.02	0.03
GA_3 × Decapitation	**21-22**	**22-23**	**Pooled**
G_0D_0	1.13	1.08	1.11
G_0D_1	1.44	1.29	1.37
G_0D_2	1.12	1.00	1.06
G_0D_3	1.27	1.06	1.17
G_1D_0	1.28	1.13	1.20
G_1D_1	1.69	1.55	1.62
G_1D_2	1.20	1.05	1.13
G_1D_3	1.37	1.21	1.29
G_2D_0	1.26	1.11	1.19
G_2D_1	2.43	2.28	2.35
G_2D_2	1.27	1.19	1.23
G_2D_3	1.41	1.36	1.39
G_3D_0	1.24	1.20	1.22
G_3D_1	2.27	2.12	2.19
G_3D_2	1.28	1.09	1.18
G_3D_3	1.91	1.75	1.83
S Ed (±)	0.02	0.03	0.02
C.D at 5%	0.05	0.05	0.05

in the maximum number of seeds per siliqua (9.17) and it was found at par (9.03) with G_3D_1(GA_3 75ppm and decapitation of the primary head at appearance. The highest number of seeds under G_2D_1 (GA_3 50ppm and decapitation of the primary head at appearance) might be due to the removal of the main head at appearance which results in the production of several numbers of secondary heads. These heads were produced around the main stem are not as compact as the main head and received more space which decreased competition among flower stalks and thus produced more seeds. Whereas the combination G_0D_0 (control) recorded the lowest number of seeds per siliqua (7.27). In the case of control plants without decapitation, the flower heads become overcrowded. They compete for resources like sunlight, water, and nutrients. This competition can lead to reduced seed production as the plants divert resources towards growing taller or spreading out. Besides, overcrowding can limit air circulation as well as improper pollination which can negatively impact seed production. (Elyazied, *et al.*, 2007 and Mehta *et al.*, 2015).

Seed yield per plant

From Table 2, it was evident that the effect of GA_3 on seed yield per plant was found to be significant. The maximum seed yield per plant (4.24 g) was obtained in G_2 (GA_3 50 ppm) which was significantly higher than all other treatments. However, the lowest seed yield per plant (3.19 g) was obtained under G_0 (Control). The main effect of head decapitation revealed that the maximum seed yield per plant (4.19 g) was obtained in D_1 *i.e.*, decapitation of the primary head at appearance which was found significantly superior to other treatments. However, the lowest seed yield per plant (3.59 g) was obtained in D_2 *i.e.*, decapitation of the primary head at full marketable stage (Table 2). Firoz *et al.*, (2000) and Khanal *et al.*, (2014) reported that head removal produced higher seed yield attributes and seed yield of broccoli as compared to those without head removal. The increase in seed yield and yield parameters of pinched plants was mainly because of the production of more side branches which ultimately resulted in a higher number of pods per plant, seeds per pod, and thus seed yield. These results conformed with the findings of Thakral *et al.*, (1991), Baboo and Rana (1995) in coriander, Venkatareddy *et al.*, (1997), Sajjan *et al.*, (2002) in okra. The interaction between G_2D_1 (GA_3 50ppm and decapitation of the primary head at the time of appearance) resulted in the highest seed yield per plant (5.42 g) which was followed by (5.19 g) in G_2D_3 (GA_3 50 ppm and decapitation of secondary head at appearance). More siliquas, more seeds per siliqua and high thousand seed weight etc. contribute to high seed yield per plant. While the lowest (3.61g) was observed under G_0D_2 (GA_3 50 ppm and decapitation of secondary head at appearance).

Seed yield per hectare (q)

The data presented in Table 3 showed that the maximum seed yield per hectare (1.58 q/ha) was obtained in G_2(GA_3 50 ppm) while the lowest (1.10 q/ha) was obtained in G_0 (control). The main effect of head decapitation revealed that the maximum seed yield per hectare (1.98 q/ha) was obtained in D_1 i.e., decapitation of the primary head at appearance. However, the minimum seed yield per hectare (1.02 q/ha) was obtained in D_2 (Decapitation of the primary head at marketable stage). The combined effect of head decapitation and GA_3 was also found significant on seed yield per hectare. The combination of G_2D_1 (GA_3 50ppm and decapitation of the primary head at appearance) resulted in the maximum seed yield per hectare (2.35 q/ha). Whereas the combination G_0D_2 (GA_3 0 ppm and decapitation of the primary head at the marketable stage) gave the lowest seed yield per hectare (1.06 q/ha). Verma and Sharma, 2000 reported that the decapitation methods significantly affect the quantity and quality of seed produced. Similarly in the cauliflower to facilitate bolting, different curd-cutting methods are recommended which have an impact on branching, seed yield, and seed quality (Kumar *et al.*, 2000). Rahman *et al.*, (1988) revealed that curd scooping had positive effects on the yield and the quality of cauliflower seeds. This might be because flower stalks produced from the scooped curd were not as compact as the no scooping and got more space which decreased competition among the flower stalks resulting in more seed yield.

Conclusion

The highest secondary head yield (150.21g) was obtained in G_2 (GA_3 50 ppm) and the lowest secondary head yield (135.17g) was obtained in G_0. The highest secondary head yield (193.22g) was obtained under D_1(Decapitation of the primary head at appearance) and no secondary head yield was recorded under D_3(Decapitation of the secondary head at appearance). Moreover, the interaction effect showed that the maximum secondary head yield was obtained of 218.69 g under G_2D_1 (GA_3 50ppm and decapitation of the primary head at appearance). The highest number of siliquas per plant (283.43) was obtained under G_2 (GA_3 50 ppm) and the lowest number of siliquas per plant (140.42) was recorded in G_0. The highest number of siliquas per plant (390.54) was observed in D_1 (decapitation of the primary head at appearance) and the lowest number of siliquas per plant (251.90) was recorded in D_3 (Decapitation of the secondary heads at appearance). The interaction effect showed that G_2D_1 (50ppm GA_3 and decapitation of the primary head at appearance) resulted in the highest number of siliquas per plant (340.00) and the lowest number of siliquas per plant (101.26) was observed in G_0D_2 (GA_3 0ppm and decapitation of the primary head at maturity). The highest number of seeds per siliqua (8.58) was obtained in G_2 (GA_3 50ppm) and the lowest number of seeds per siliqua (7.80) was obtained in G_0(Control). The highest number of seeds per siliqua (8.53) was obtained in D_1(decapitation of the primary head at appearance) and the lowest number of seeds per siliqua (7.25) was obtained in D_2 (Decapitation of the primary head at appearance). Moreover, the interaction effect showed that the maximum number of seeds per siliqua (9.17) was obtained in G_2D_1 (GA_3 50 ppm and decapitation of the primary head at appearance) and the lowest number of seeds per siliqua (7.27) was obtained in G_0D_0 (control). The highest seed yield per plant (4.24 g) was observed in G_2 (GA_3 50ppm) and the lowest seed yield per plant (3.19 g) was recorded under G_0 (Control). The highest seed yield per plant (4.19 g) was obtained in D_1(Decapitation of the primary head at appearance) and the lowest seed yield per plant (3.57 g) was obtained in D_2 (Decapitation of the primary head at maturity). Moreover, the interaction effect showed that the maximum seed yield per plant (5.42 g) was recorded in G_2D_1 (GA_3 50ppm and decapitation of primary head at the time of appearance) and the minimum seed yield per plant (3.61g) was obtained under G_0D_2 (GA_3 0ppm and decapitation of the primary head at maturity). The highest seed yield per hectare (158.61 kg/ha) was observed in G_2 (GA_3 50ppm) and the lowest seed yield per hectare

(109.53 kg/ha) was recorded under G_0 (Control). The highest seed yield per hectare (197.86 kg/ha) was obtained in D_1(Decapitation of the primary head at appearance) and the lowest seed yield per hectare (102.45 kg/ha) was obtained in D_2(Decapitation of the primary head at maturity). Moreover, the interaction effect showed that the maximum seed yield per hectare (235.49 kg/ha) was recorded in G_2D_1 (GA_3 50ppm and decapitation of the primary head at the time of appearance) and the minimum seed yield per hectare (105.90 kg/ha) was obtained under G_0D_2 (GA_3 0ppm and decapitation of the primary head at maturity).

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