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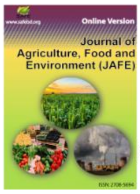

Research Article

Foliar application of gibberellic acid in combination with cow dung enhances growth and yield attributes of okra *(Abelmoschus esculentus)*

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ABSTRACT

A field experiment was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during March to July 2020 to investigate the results of various amount of cowdung and gibberellic acid (GA_3) on okra growth and production. The experiment comprised of Factor A: three doses of cowdung such as C_0 = 0 ton (Control), C_1 = 5 t ha^{-1}, C_2 = 10 t ha^{-1} and Factor B: four variable concentrations of GA_3 such as G_0 = Control (with no gibberellic acid), G_1 = 50 ppm gibberellic acid, G_2 = 100 ppm gibberellic acid and G_3 = 150 ppm gibberellic acid. Three replications of the experiment were set up using a Randomized Complete Block Design (RCBD). Most of the developmental and yield-contributing parameters of the okra tested significantly varied when various quantities of cowdung and varying amounts of gibberellic acid were used. The 10 t ha^{-1} cowdung (C_2) had the maximum yield (11.34 t/ha) as well as the amount of green pods (13.77) per plant. From a 0 t ha-^{1} cowdung (C_0) treatment, the fewest green pods (14.18), and lowest green pod production (5.98 t/ha), were produced. On the other hand, gibberellic acid with 100 ppm (G_2) showed the best performance on number of green pods (13.77), green pod output (10.51 t/ha) and the lowest performance on number of green pods (10.05), green pod produce (6.47 t/ha) from control (G_0) treatment (without gibberellin). Okra's development and yield-contributing characteristics were greatly impacted by the interaction of cowdung and gibberellic acid. The integration of 10 t ha^{-1} cowdung (C_2) and 100 ppm gibberellic acid performed the best on the number of green pods (15.91), green pod yield (13.47 t/ha) tremendously non-identical from the combination of treatment of 0 t ha^{-1} (C_0) with no gibberellic acid applied plants in the same parameters viz. number of green pods (7.72), green pod yield (4.13 t/ha). The finding of this study suggested that application of 10 tons cowdung per hectare combine with 100 ppm gibberellic acid to be recommended for okra cultivation.

Introduction

Okra (*Albelmoschus esculentus* L.) belongs to Malvaceae family, a well-known tropical vegetable. In many parts of the world, especially in underdeveloped nations, it is consumed as a vegetable. Okra possibly originated from east Africa, as it has been grown there for 4000 years (Tindall, 1988). For its fresh pods, it is frequently grown in tropical or Mediterranean climates. It thrives best in hot climate (Temperature above 26°C). Bangladesh, India, Nigeria, Pakistan, Ghana and Egypt are the top okra producers in the world. In Bangladesh, the year-round demand for vegetables is high to meet the growing population but vegetable production is very low. Okra is a nutritious vegetable which has a great role in food security, earning money, solving extreme poverty, creating jobs and having as a medicinal value. Therefore, selection of proper variety and application of proper plant growth regulators are very effective to increase the production of okra and meet up the increasing demand for nutrition. Okra is added to soups, salads, and stews either raw, cooked, or chemically. Due to ease of storage, fresh okra is preserved mainly by freezing or, in some countries; the fruit is dried for later use. Okra contains a variety of vitamins, nutritional fiber, minerals, and energy (Elkhalifa *et al.*, 2021). It grows in Bangladesh as an important and popular vegetable in both summer and winter. Vitamin A and C are present in modest amounts in the edible section of the pod (100 g), along with calcium (90 mg), phosphorus, and potassium. The pods have some medical benefit as well as a mucilaginous preparation made via the pod can be used as a blood volume expander or to substitute plasma. (Farinde *et al.*, 1993).Vegetable production varies year-round in Bangladesh. Okra was grown on 18122.98 hectares of land in the 2018–2019 growing season, yielding a total of roughly 56 thousand metric tons, which is extremely low compared to other developed nations where yields can reach up to 7.0–12.0 t/ha (Yamaguchi, 1998). The low production of okra in our nation has also been attributed to a lack of knowledge on cultural practices including judicious application of manures and fertilizers, lack of good producing cultivars, poor quality seeds, and indiscriminate use of various agrochemicals, including plant growth regulators.

The ongoing deterioration of land and water resources, as well as decreased productivity brought on by the widespread use of agrochemicals; pose a danger to the viability of traditional agriculture in Bangladesh. After the Green Revolution, there was a significant increase in the use of chemical fertilizers and pesticides in agricultural production (Goutam *et al.*, 2011). The excessive use of chemical fertilizers has a harmful influence on the environment, and practicing organic farming may help to mitigate that impact (Aksoy, 2001; Chowdhury, 2004). Organic fertilizers improve soil quality, water-holding capacity, high cation exchange capacity, low bulk density, and the diversity of beneficial microorganisms in the soil (Bulluck *et al.*, 2002). Plant growth regulators are widely used to cope with biotic and abiotic stresses, to enhance flowering, fruiting, and crop productivity (Roy *et al.*, 2018; Rahman *et al.*, 2015; Karim *et al.*, 2015). One of the most important plant growth regulators is gibberellin, play significant roles in breaking seed dormancy, stem elongation, enhancing vegetative growth, reducing genetical and physiological dwarfism, induction of flowering and increased fruiting (Bhai and Singh, 1998). A class of plant hormones known as gibberellins includes the natural growth hormone GA_3, or GA for short. GA_3 encourages a variety of beneficial benefits, including increased plant height, uniform flowering, shortened flowering time, and larger and more numerous and larger flowers. It also promotes cell division and a number of plant development mechanisms (Ayyub *et al.*, 2013). Gibberellin and cowdung play an important role in okra growth and yield. Gibberellin treatment to leaves also altered plant development and pod attributes (Singh *et al.*, 1999). However, okra production technology in Bangladesh is still not standardized with different dosages of cow dung and different concentrations of gibberellin. Yield of okra can be boosted through judicious use of cowdung and gibberellic acid. With the aforementioned information in mind, the current study was conducted to examine the impacts of various cowdung doses on the growth and production of okra as well as the effects of various gibberellic acid concentrations (GA_3) to determine the ideal cowdung dose with the highest GA_3 concentration for maximizing okra production.

2. Materials and Methods

2.1 Experimental site, soil and climate

The experiment was conducted at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during the period from March to July 2020 in order to study the effects of cowdung and gibberellic acid (GA_3) on growth and yield of okra. The experiment was carried out on high ground in the alluvial zone of the former Brahmaputra flood plain (UNDP, 1988) and within the framework of agro-ecological zone 9.The soil texture was silty loam with pH 6.7. Soil samples of the experimental plot were collected from a depth of 0 to 30 cm before conducting the experiment and analyzed in the Humboldt Soil Testing Laboratory, Department of Soil Science, Bangladesh Agricultural University, Mymensingh. The experimental area is under the sub-tropical climate, which is characterized by heavy rainfall. The amount of total rainfall of the experimental site was acceptable for Okra cultivation in Bangladesh.

2.2 Plant material used in the experiment

BARI Dherosh-1 was taken as a planting stuff. Okra seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

2.3 Treatments, design and layout of the experiment

The experiment included of two factors, Factor A: Factor A: Three doses of cowdung *viz.*, C_0 = 0 ton (Control, no cowdung), C_1 = 5 t ha^{-}1 cowdung, C_2 = 10 t ha^{-}1 cowdung; Factor B: Four different concentrations of gibberellin viz., G_0 = Control (Control, no gibberellic acid), G_1 = 50 ppm gibberellic acid, G_2 = 100 ppm gibberellic acid, G_3 = 150 ppm gibberellic acid. The two-factor experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. An area of 306 m^2 was divided into three equal blocks, representing the replications, each containing 12 plots in the form of raised bed was 2.4 m x 2 m (4.8 m^2). A distance of 0.5 m between two plots and 1m between the blocks were kept to facilitate various intercultural activities.

2.4 Preparation of land

The selected experimental plot was first opened on 1 March 2020 by ploughing and was thoroughly prepared by several cross ploughing followed by laddering. The soil was pulverized to obtain proper tilth for sowing the seeds. The soil was ultimately ready by removing weeds after the application of basal doses of cowdung and synthetic fertilizers. Channels for drainage and irrigation were created all around the experimental plots.

2.5 Application of manures and fertilizers

The doses of fertilizers and manures were practiced to the okra production plots as the following doses (FRG, 2012). Urea 150 kg/ha (72 g/plot), triple super phosphate (TSP) 100 kg (48 g/plot), muriate of potash (MoP) 150 kg (72 g/plot) were used in the experiment. During the last stage of land preparation, full applications of TSP and cowdung were made to the soil. At 2, 4, and 6 weeks after sowing (DAS), urea and MoP were applied as a side dressing (ring placement) in three equal installments.

2.6 Seed sowing

Seeds of okra were sown on 10 March 2020 at a depth of about 1.5 cm of elevated bed in rows. Row to row and plant to plant spacing were maintained 60 cm and 40 cm, respectively. Three seeds were sown in each pit and the seeds were covered with fine soil by land.

2.7 Preparation and application of GA_3 solution

By dissolving 50, 100, and 150 mg of GA_3 per liter of water, respectively, the GA_3 solution with 50, 100, and 150 ppm was created. A couple of drops of ethanol had been added to the GA_3 solution during preparation in order to ensure appropriate dissolution. The control solution was distilled water (0 ppm). Gibberellic acid was administered using a hand sprayer at 25, 40, and 55 days after sowing (DAS).

2.8 Intercultural activities

For healthy plant growth and development, intercultural activities are conducted throughout the agricultural season. One healthy plant is left to grow in each site for five to six days following germination, and the rest are removed. Weeding and mulching were done regularly whenever necessary to keep the experimental plots free from weeds and to pulverize the soil. Irrigation was done when the moisture level of the soil became lower. Standing water was effectively evacuated during heavy rains. Diazinon 60 EC @ 3.5 ml/L was used for spraying at intervals of 15 days beginning soon after the development of the infestation to suppress the shoot and fruit borer. Nogos @ 0.02% had been sprayed seven days apart during fruit setting to suppress Jassid (Anonymous, 2019).

2.9 Parameters measured

At 40, 70, and 100 DAS during the experiment, data on different pre-harvest parameters, including plant height (cm) and leaf count per plant, were collected from the sample plants. Other metrics from the specimen plant at various DAS, such as dates to first blooming and the quantity of nodes prior to flowering, were recorded. Each sample plant's leaves were counted individually. A meter scale was used to measure the plant's height from the ground up to the growth point's tip. For each unit plot, the median value of the 10 randomly selected plants was determined and represented in centimeters (cm). The selected plants' petioles were measured in centimeters (cm) at 55 and 100 DAS using a meter scale.

The overall number of green pods per plant, the length of a green pod, the width of a newly harvested pod, the quantity of branches per plant, the weight of a single green pod, the yield of green pods per plot, and the yield of green pods per hectare were all measured during harvesting. The diameter of the freshly plucked pod was measured with a slide caliper, and the total length of the green pod was weighed in centimeters by a scale at 70 DAS from the carefully chosen plants of each plot. Green pod production per plot and individual weights of fresh green pods were tallied in kilograms. The average green pod yield per plot was converted to determine the green pod yield (metric ton/ha).

2.10 Statistical analysis

Data collected from experimental plants per plot regarding various characteristics were compiled and tabulated in a form suitable for statistical analysis. The mean of all treatments was calculated and analysis of variance for most of the characters considered was performed using the "F" test of variance. The significance of the difference between pairs of means was assessed using the least significant difference (LSD) test at the 1% probability levels (Gomez and Gomez, 1984).

3. Results and Discussion

3.1 Plant height

The height of plant was recorded at various growing stage i.e. at 40, 70 and 100 days after sowing (DAS). Different doses of cowdung had significant influence on plant height. The highest height of plant was obtained from C_2 (10 t ha^{-1}) 147.17 cm at 100 DAS and the lowest height 130.27 cm was gained from C_0 (Control) (Figure 1). This study's findings also supported those findings of Akande, 2003. According to Adamu *et al.* (2022), the Clemson cultivar with 10 kg (V_2 l00) of cow manure had a significant plant growth in comparison to all other treatments, with an average result of (41.33 cm). Through increased soil composition, increased infiltration rates, and improved soil water holding capacity, cowdung additionally supports cropping systems. The height of plants of the okra at 40, 70, and 100 DAS was considerably impacted by the treatment of various gibberellic acid concentrations. Gibberellic acid at 100 ppm produced the tallest plant (147.23 cm) whereas 0 ppm gibberellin produced the shortest plant (128.28 cm) (Figure 2). Singh *et al.* (1999) reported that GA_3 increased plant height of okra. Similarly, Ayyub *et al.* (2013); Mehraj *et al.*, (2015); Chowdhury *et al.* (2014) found maximum increase in plant height in their experiment.

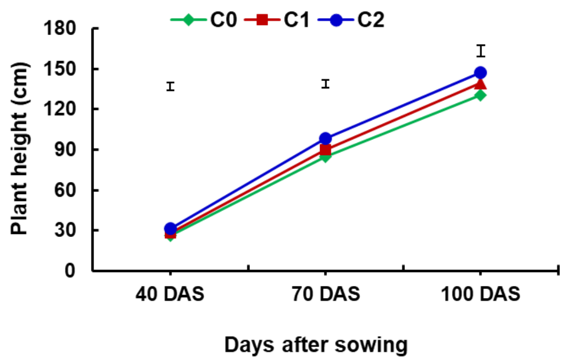

Figure 1. Effect of different doses of cowdung on the plant height of okra at different DAS. Vertical bars indicate LSD at 1% level of probability. C_1 = 0 ton; C_1 = 5 t ha^{-1} and C_2 = 10 t ha^{-1} cowdung

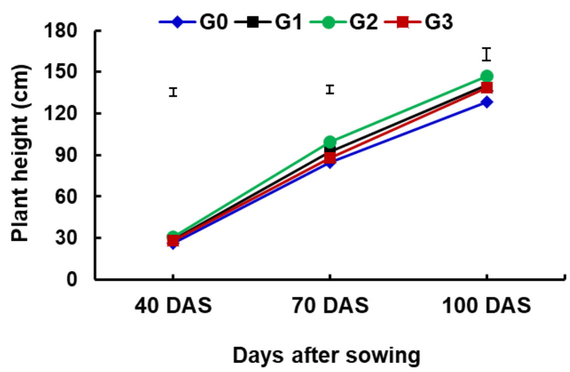

Figure 2. Effect of different doses of gibberellic acid on the okra plant height at various DAS. LSD is represented as vertical bars with a 1% level of chance. G_0 = 0 ppm, G_1 = 50 ppm, G_2 = 100 ppm, G_3 = 150 ppm

The growth of plant was shown strong impact by the interaction outcome of various doses of cowdung and different concentrations of gibberellic acid. The combined application of C_2G_2 resulted in the height plant growth

(154.67 cm) at 100 DAS, and the interaction effect of C_2G_0 resulted in the lowest plant growth (119.06 cm) (Table 1).

3.2 Number of fresh leaves per plant

Different doses of cowdung had a big impact on how many leaves a plant produced. The highest number of leaves per plant (29.36) was obtained with 10 t ha^{-1} (C_2). The minimum number of leaves (13.16) was found 0 t ha^{-1} (C_0) (Figure 3). According to Elhag *et al.* (2014), it might be caused by an increase in the activities of other bacteria that are aided by organic amendments. Leaves number per plant was also influenced notably by gibberellic acid. Number of leaves gradually increased upto100 ppm gibberellin but decreased with 150 ppm. The highest number of leaves per plant (30.19) was obtained in 100 ppm gibberellin while the lowest (24.55) was obtained in 0 ppm gibberellic acid (Figure 4). Mehraj *et al.* (2015) and Chowdhury *et al.* (2014) also noticed indistinguishable results.

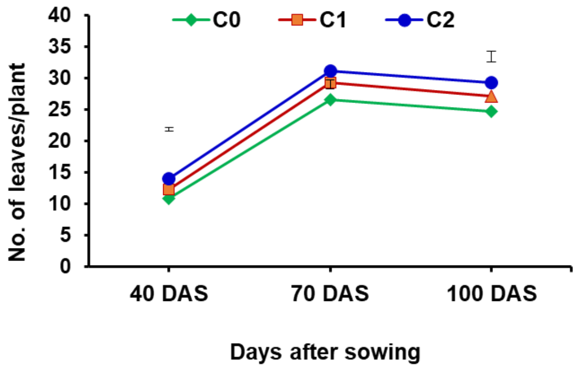

Figure 3. Effect of different doses of cowdung on plant leaf count at various DAS. Vertical bars indicate the level of probability of LSD at 1%. C_1 = 0 ton; C_1 = 5 t ha^{-1} and C_2 = 10 t ha^{-1}cowdung.

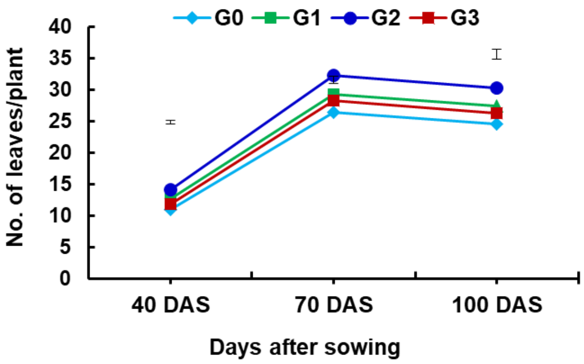

Figure 4. Effect of different doses of gibberellic acid on the quantity of okra leaves per plant at several DAS. Vertical bars represent LSD at 1% level of probability. G_0 = 0 ppm, G_1 = 50 ppm, G_2 = 100 ppm, G_3 = 150 ppm.

The merged interaction of variable doses of cowdung and gibberellic acid was remarkably affected on the leaves number of single plant. The maximum leaves number/plant (32.47) was observed in combined treatment of C_2G_2 whereas the minimum number of leaves/plant (22.70) was obtained from C_0G_0 (Table 1).

Table 1. Effect of varying cowdung doses and gibberellic acid concentrations combined on the height and quantity of plants and leaves in okra plants at various DAS.

Treatment combinations	Plant height (cm)			Number of leaves per plant		
	40 DAS	70 DAS	100 DAS	40 DAS	70 DAS	100 DAS
C_0G_0	24.31	78.72	119.06	9.50	24.12	22.70
C_0G_1	26.56	84.61	132.43	11.28	26.96	25.05
C_0G_2	27.64	93.76	139.45	12.50	29.78	27.67
C_0G_3	25.53	82.53	130.16	10.43	25.76	23.75
C_1G_0	26.27	82.67	128.23	10.71	26.31	24.56
C_1G_1	28.63	92.72	141.19	12.44	29.55	27.43
C_1G_2	31.07	98.72	147.56	14.35	32.76	30.42
C_1G_3	27.65	85.67	139.84	11.77	28.51	26.36
C_2G_0	28.72	92.23	138.44	12.71	28.67	26.37
C_2G_1	31.63	99.10	148.73	14.50	31.34	29.81
C_2G_2	33.67	105.09	154.67	15.29	34.38	32.47
C_2G_3	30.57	96.35	146.83	13.50	30.36	28.74
$LSD_{(0.05)}$	0.51	0.53	0.75	0.51	1.08	1.44
$LSD_{(0.01)}$	0.70	0.72	1.02	0.69	1.47	1.95
Level of significance	**	**	**	**	**	**

** = Significant at 1% level of probability, C_0 = 0 ton (Control), C_1 = 5 t ha^{-1}, C_2 = 10 t ha^{-1}, G_0 = Control (no gibberellic acid), G_1 = 50 ppm gibberellic acid, G_2 = 100 ppm gibberellic acid, G_3 = 150 ppm gibberellic acid

3.3 Days to first flowering

The results on effect of different doses of cowdung on days to first flowering have been presented in Table 2. The C_2 (10 t ha^{-1}) gave first flowering at the shortest time (36.67 days). On the other had C_0 (Control) took the longest time (38.84 days). Days required to first flowering was significantly influenced by different concentrations of gibberellic acid. Longer time (38.45 days) was required for flowering in case of 0 ppm gibberellin. On the other hand, shorter time (36.60 days) was recorded in case of plants treated with 100 ppm gibberellin presented in (Table 3). The combined effect of cowdung and gibberellic acid was significantly influenced on the days to first flowering. The combined therapy of C_2G_2 was shown to have the quickest first flowering period (35.65 days). The lengthiest amount of time (3.74 days) was needed for the initial blooming, according to the C_0G_0 (Table 4) treatment combination.

3.4 Number of nodes per plant at first flowering

Different cowdung doses had a substantial impact on the quantity of nodes per plant. Using C_2 (10 t ha-1), the greatest number of terminals on plant (4.48) was attained. For C_1 (5 t ha-1), the smallest number of limbs (3.08) was discovered (Table 2). Gibberellic acid has a considerable impact on the amount of branches every plant. Number of branches gradually increased with increased concentration up to 100 ppm gibberellin and decreased at 150 ppm. The highest number of branches per plant (4.26) was obtained in 100 ppm gibberellin while the lowest (3.31) was obtained 0 ppm gibberellin (Table 3). The total quantity of nodes for each plant was dramatically impacted by the combined effects of cow manure and gibberellic acid. The mixed combination of C_0G_2 was determined to have the most branches (5.10). The mixed treatment of C_0G_0 produced the plant with the fewest nodes (2.73) (Table 4).

3.5 Number of branches per plant

The various cowdung doses had a substantial impact on the number of branches per plant. The maximum number of branches per plant (2.53) was obtained with 10 t ha^{-1} (C_2). The smallest quantity of limbs (2.11) was discovered from C_0 (Control) (Table 2). From Adamu *et al.* (2022), V_2 10 has the largest branch size, followed by C_2 15 and V_2 L10, which are recorded as statically smiling. Based on the findings, there was less branching and less organic manure needed for vegetable growth and development. Its poor performance may be caused by the slow mineralization of some organic substances. Gibberellic acid has a significant impact on how many branches a plant produces. Number of branches gradually increased with increased concentration upto100 ppm gibberellic acid and decreased at 150 ppm. The highest number of branches per plant (2.60) was obtained in 100 ppm gibberellic acid while the lowest (2.03) was obtained 0 ppm gibberellic acid (Table 3). Mehraj *et al.* (2015) observed the same findings. The combined effect of different doses of cowdung and different concentrations of gibberellic acid was significantly influenced on the number of branches per plant. The number of shoots per plant was considerably impacted by the interaction of various cowdung doses and various gibberellic acid concentrations. The use of the pair of C_2G_2 resulted in the greatest number of branches (2.80). The administration of the pair of C_0G_0 resulted in the fewest branches (1.81) per plant (Table 4).

3.6 Number of pods per plant

Marked influence was found in case of number of pods per plant (Table 2) as a result of different doses of cowdung. Number of pods per plant (14.18) was recorded maximum from 10 t ha^{-1} (C_2). Alternatively, minimum number of pods (9.46) per plant was observed in C_0 (0 t ha^{-1}) treatment. Adamu *et al.* (2022) observed the same findings. Sanwal *et al.* (2007) also found similar findings in turmeric (curcuma longa). This increment of fruit of okra occurred due to organic manure application that could be associated with easy solubilization of plant nutrient and improving nutritional status. The influence of gibberellic acid on the number of pods has been shown gibberellic acid. The number of pods per plant was recorded higher with 100 ppm gibberellic acid and the number was minimum in 0 ppm gibberellic acid. The interaction effect of different levels of cowdung and gibberellic acid was statistically significant on the number of pods per plant. The combination of C_2G_2 resulted in the maximum number of pods (15.91) and the number of pods per plant (7.72) was found minimum from the combination of C_0G_0. Chowdhury *et al.* (2014) and Uddin *et al.* (2014) found maximum number of pods by treating the seeds with 100 ppm GA_3.

Table 2. Main effect of different doses of cowdung on okra yield and development.

Cowdung	No. of days of first flowering	No. of nodes at first flowering	No. of branches at last edible pod harvest	No. of green pods per plant
C_0	38.84	3.68	2.11	9.76
C_1	37.46	3.08	2.31	12.27
C_2	36.67	4.50	2.48	14.18
$LSD_{(0.05)}$	0.65	0.11	0.13	0.11
$LSD_{(0.01)}$	0.88	0.15	0.18	0.15
Level of significance	**	**	**	**

** = Significant at 1% level, C_0 = 0 ton (Control), C_1 = 5 t ha^{-1}, C_2 = 10 t ha^{-1}

Table 3. The primary impact of various gibberellic acid concentrations on okra yield and growth.

Concentrations of gibberellin	No. of days of first flowering	No. of nodes at first flowering	No. of branches at last edible pod harvest	No. of green pods per plant
G_0	38.45	3.31	2.03	10.05
G_1	37.58	3.83	2.36	12.50
G_2	36.60	4.26	2.60	13.77
G_3	38.00	3.60	2.20	11.95
$LSD_{(0.05)}$	0.75	0.13	0.15	0.13
$LSD_{(0.01)}$	1.02	0.17	0.21	0.18
Level of significance	**	**	**	**

** = Significant at 1% level, G_0 = Control (no gibberellin), G_1 = 50 ppm gibberellin, G_2 = 100 ppm gibberellin, G_3 = 150 ppm gibberellin

3.7 Green pod length

Green pod length differed significantly with different doses of cowdung. Pod with the highest length was recorded from C_2 treatment and C_0 (Control) treatment (Table 5) resulted the lowest pod length (11.32 cm). Similarly, Dash and Mishra (2003) found the significant effect of cowdung on pod length. Results regarding main effect of gibberellic acid on the length of pods have been shown in Table 6. Length of individual pod per plant was attained maximum (13.95 cm) from 100 ppm gibberellic acid application and minimum length of individual pod was observed (12.11 cm) with no gibberellic acid (Table 5). Uddin *et al.* (2014), Mehraj *et al.* (2015) and Chowdhury *et al.* (2014) found same findings. Combination of different doses of cowdung and gibberellic acid was varied significantly on the pod length per plant. The maximum length of pods (16.02 cm) was obtained from the combination of C_2G_2 and the minimum pod length (10.51 cm) was recorded in C_0G_0 (Table 7).

3.8 Green pod diameter

Different doses of cowdung had significant influences on diameter of green pod. The green pod diameter (1.82 cm) was obtained maximum at 10 t ha^{-1} (C_2) treatment and minimum (1.39 cm) at C_0 (0 t ha^{-1}) (Table 5). Dash and Mishra (2003) also found the significant effect of cowdung on pod diameter. As well as, the highest pod diameter was found 1.68 cm in 100 ppm gibberellic acid treated plant and it was found the lowest (1.48 cm) in 0 ppm gibberellic acid applied (Table 6). Mehraj *et al.* (2015); Uddin *et al.* (2014) and Chowdhury *et al.* (2014) observed similar findings. The combined effect of different doses cowdung and different concentrations of gibberellic acid was significantly influenced on pod diameter. The maximum diameter of pods (1.92 cm) was observed from the combination of C_2G_2 and the minimum diameter of pods (1.28 cm) was recorded in C_0G_0 (Table 7).

3.9 Individual pod weight

The fresh weight of pod was differed significantly due to the effect of different doses of cowdung. The fresh weighty of pod (19.67g) was obtained maximum by the 10t ha^{-1} (C_2) treatments and minimum (14.33 g) was observed in C_0 (0 t ha^{-1}) (Table 5). There was significant variation was found of using different concentrations of gibberellic acid for weight of fresh green pod per plant. Fresh green pod weight was found maximum due to the treatment of 100 ppm gibberellic acid. The weight of fresh green pod (14.98) was found minimum in pods with no gibberellin (Table 6). Munda *et al.* (2000) found that GA @ 100 ppm used for treating seeds was most suitable for weight of pod. The combination of cowdung and gibberellic acid was significant on pod fresh weight. The fresh weight of pod per plant (21.43 g) was found maximum due to the combination of C_2G_2 and the lowest (12.82 g) was obtained from C_2G_0 (Table 7).

Table 4. Combined effect of different doses of cowdung and different concentrations of gibberellic acid on growth, yield contributing characters of okra at various DAS.

Treatment	No. of days of first flowering	No. of nodes at first flowering	No. of branches at last edible pod harvest	No. of green pods per plant
C_0G_0	38.23	3.23	1.81	7.72
C_0G_1	37.41	3.76	2.17	10.25
C_0G_2	36.37	4.23	2.42	11.19
C_0G_3	37.83	3.48	2.02	9.86
C_1G_0	39.78	2.73	2.06	10.16
C_1G_1	38.74	3.07	2.35	12.69
C_1G_2	37.77	3.45	2.59	14.20
C_1G_3	39.06	3.06	2.22	12.02
C_2G_0	37.35	3.98	2.22	12.26
C_2G_1	36.58	4.67	2.56	14.57
C_2G_2	35.65	5.10	2.80	15.91
C_2G_3	37.11	4.25	2.35	13.97
LSD (5%)	1.30	0.22	0.27	0.23
LSD (1%)	1.77	0.30	0.36	0.31
Level of significance	**	**	**	**

** = Significant at 1% probability level, C_0 = 0 ton (Control), C_1 = 5 t ha^{-1}, C_2 = 10 t ha^{-1}, G_0 = Control (without gibberellic acid), G_1 = 50 ppm gibberellic acid, G_2 = 100 ppm gibberellic acid, G_3 = 150 ppm gibberellic acid

Table 5. Main impact of various cowdung doses on the growth and output of okra.

Cowdung	Green pod length (cm)	Pod diameter (cm)	Green pod wt. (g)	Pod yield per plot (kg)
C_0	11.32	1.38	14.54	2.88
C_1	12.51	1.52	16.12	3.99
C_2	15.06	1.81	19.66	5.46
$LSD_{(0.05)}$	0.22	0.05	0.25	0.15
$LSD_{(0.01)}$	0.30	0.07	0.34	0.21
Level of significance	**	**	**	**

** = Significant at 1% probability level, C_0 = 0 ton (Control), C_1 = 5 t ha^{-1}, C_2 = 10 t ha^{-1}

3.10 Green pod yield per plot

The effect of cowdung on the pod yield per plot at harvest differed significantly. The highest pod yield (6.44 kg) per plot (4.8 m^2) was filed from 10 t ha^{-1} (C_2) and the lowest (2.87 kg) per plot was obtained in C_0 (0 t ha^{-1}) treatment (Table 5). Senjobi *et al.* (2007) reported that the higher performance of crop is associated with the availability of nutrients and vice-versa. The fresh pod production per plot varied significantly because of gibberellic acid application. Fresh pod yield per plot (5.02 kg) was obtained maximum from 100 ppm gibberellic acid and minimum (3.10 kg) was obtained from 0 ppm gibberellic acid foliar application (Table 6). The combination of different levels of cowdung and different concentrations of gibberellic acid were significant on yield of fresh pod per plot. Fresh pod yield (6.44kg) was found maximum with the treatment combination of C_2G_2 and the lowest one (1.98 kg) was found in C_0G_0 (Table 7).

Table 6. The main impact of various gibberellic acid concentrations on okra production and development.

Concentrations of gibberellin	Green pod length (cm)	Pod diameter (cm)	Green pod wt. (g)	Pod yield per plot (kg)
G_0	12.11	1.48	15.16	3.10
G_1	13.07	1.59	17.08	4.28
G_2	13.95	1.68	18.44	5.03
G_3	12.72	1.54	16.41	4.02
$LSD_{(0.05)}$	0.25	0.06	0.29	0.18
$LSD_{(0.01)}$	0.35	0.08	0.39	0.24
Level of significance	**	**	**	**

** = Significant at 1% level of probability, G_0 = Control (no gibberellic acid), G_1 = 50 ppm gibberellic acid, G_2 = 100 ppm g gibberellic acid, G_3 = 150 ppm gibberellic acid

Table 7. The combined effect of various cowdung dosages and varying gibberellic acid concentrations on the yield and quality-contributing traits of okra at various DAS.

Treatment (cowdung× gibberellic acid)	Green pod length (cm)	Pod diameter (cm)	Green pod wt. (g)	Pod yield per plot (kg)
C_0G_0	10.51	1.28	12.82	1.98
C_0G_1	11.38	1.39	14.83	3.07
C_0G_2	12.19	1.49	16.11	3.61
C_0G_3	11.20	1.35	14.38	2.85
C_1G_0	11.43	1.43	14.54	2.95
C_1G_1	12.59	1.54	16.36	4.14
C_1G_2	13.65	1.62	17.78	5.05
C_1G_3	12.37	1.50	15.80	3.83
C_2G_0	14.39	1.73	18.13	4.37
C_2G_1	15.23	1.83	20.04	5.64
C_2G_2	16.02	1.92	21.43	6.44
C_2G_3	14.59	1.77	19.05	5.38
LSD (5%)	0.44	0.11	0.49	0.31
LSD (1%)	0.60	0.15	0.67	0.42
Level of significance	**	**	**	**

** = Significant at 1% level of probability, C_0 = 0 ton (Control), C_1 = 5 t ha^{-1}, C_2 = 10 t ha^{-1}, G_0 = Control (zero gibberellic acid), G_1 = 50 ppm gibberellic acid, G_2 = 100 ppm gibberellic acid, G_3 = 150 ppm gibberellic acid

3.11 Pod yield per hectare

The different doses of cowdung were found to significantly influence the yield of pod per hectare at harvest. The production of pod (11.34 t/ha) per hectare was maximum in 10 t ha^{-1} (C_2) and minimum (5.98 t/ha) per hectare was obtained in C_0 (0 t ha^{-1}) (Figure 5). According to Elhag *et al.* (2014), organic manure application improved better supply of nutrients to the plants at the same time increased higher yield response of crops. The effect of gibberellic acid on fresh pod yield per hectare was statistically significant. There was wide difference among three variations. Fresh pod yield (10.51 t/ha) was obtained maximum due to the treatment of 100 ppm gibberellin. Alternatively, the lowest fresh pod yield (6.47) t/ha) was filed in 0 ppm gibberellic acid treated plants (Figure 6).

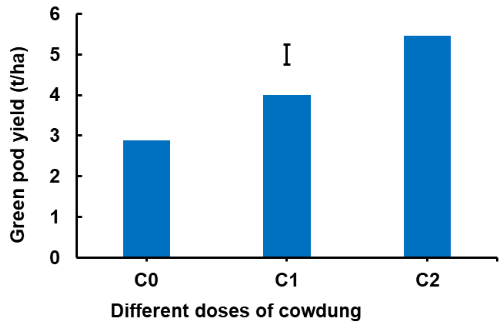

Figure 5. Effect of varying cowdung doses on the yield of green pods per okra plot. The vertical bar reflects the possibility of LSD at 1%. C_0 = 0 t ha^{-1} cowdung (Control), C_1 = 5 t ha^{-1} cowdung, C_2 = 10 t ha^{-1} cowdung.

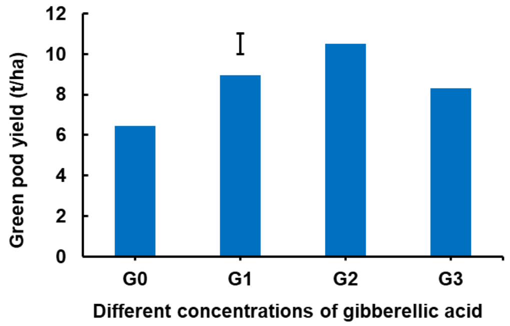

Figure 6. Impact of multiple concentrations of gibberellic acid on green pod yield per okra plot. The vertical line indicates the possibility of LSD at 1%. G_1 = 50 ppm gibberellic acid, G_2 = 100 ppm gibberellic acid, G_3 = 150 ppm gibberellic acid.

On the newly harvested pod yield per hectare, the combined impacts of various cowdung dosages and various gibberellic acid concentrations were significant. The integrated treatment of C_2G_2 produced its greatest freshly pod yield (13.47 t/ha) whereas C_0G_0 produced the least amount (4.13 t/ha) (Figure 7). Mehraj *et al.* (2015); Chowdhury *et al.* (2014); Vijayaraghavan (1999) and Surendra *et al.* (2006) reported that GA3 gave the highest fruit yield.

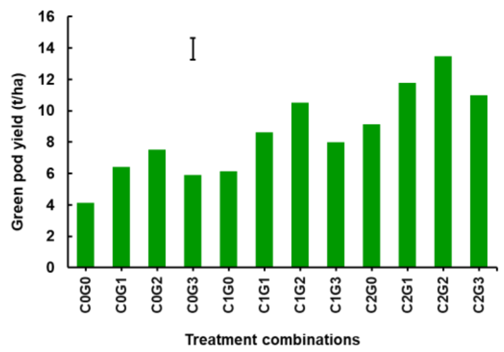

Figure 7. Integrated effect of different doses of cowdung and different concentrations of gibberellic acid on green pod yield per ha of okra. Vertical bar represents LSD at 1% level of probability. C_0 = 0ton cowdung (control), C_1 = 5 t ha^{-1}, C_2 = 10 t ha^{-1}, G_0 = control (without gibberellic acid), G_1 = 50 ppm gibberellic acid, G_2 = 100 ppm gibberellic acid, G_3 = 150 ppm gibberellic acid.

Conclusion

Different doses of cowdung and different concentrations of gibberellic acid played an important role on yield contributing characters and okra production. The outcomes showed that development of okra and yield performance increased in case of cowdung and 10 t ha^{-1} cowdung performed better than other doses. It improves fertility of the soil through microbial activity, increases plant meristem elongation, and releases nutrients gradually and steadily over an extended period of time. These effects provide traits that contribute to superior growth and performance. Another conclusion that can be drawn is that foliar application of gibberellin produced good results in terms of growth, development, and yield performance. Among four concentrations, gibberellic acid with 100 ppm showed the topmost development and production. The experiment's findings showed that 10 t ha-1 of 10 ppm gibberellic acid application resulted in the greatest vegetative growth and the highest yield. So, it may be recommended that cultivation of okra using 10 t ha^{-1} cowdung with 100 ppm gibberellin is good for maximum growth and yield performance. The overall work concluded that an effective combination strategy of using different doses of cowdung and different concentrations of gibberellic acid may be salutary of increasing the yield of okra.

Conflict of interest: The authors conducted this research and wrote this article and have no conflicts of interest with anyone else.

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