RESEARCH ARTICLE

Volume 2, 2019

ISSN Print 2663-0141
ISSN Online 2663-015X

THE INTERNATIONAL JOURNAL OF GLOBAL SCIENCES (TIJOGS)

Investigation of the interactive effect of topping and plant spacing on growth, yield and quality of *Gossypium hirsutum* L.

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Article History
Received: 08 October 2018
Accepted: 11 February 2019
Published: 27 February 2019

How to Cite?
(Waseem *et al., 2019*)
H. M. Waseem, M. Usman Gani, Aamir Ali, Ahmad Ali, H. Ehtsham Ali, Abdur Rehman, Nasir Javaid, Ahmad Zunair Zaman, Ahmad Bilal.Investigation of the interactive effect of topping and plant spacing on growth, yield and quality of *Gossypium hirsutum* L. *The Int. J. Global.Sci*.2019, 2(1), 62-74(ISSN)26630141(print);ISSN2663015X(online).(http://www.rndjournals.com/)

ABSTARCT

The field trial was conducted to determine the effect of topping and different levels of plant spacing on growth, yield and quality of cotton (*Gossypium hirsutum* L.) at Agronomic research area, University of Agriculture Faisalabad, during kharif 2017. The experiment was laid out using randomized complete block design with factorial arrangement and replicated thrice. The experimental treatments were comprised of two factors which included four levels of topping viz, no topping (control), topping at 90 cm plant height, topping at 120 cm plant height and topping at 150 cm plant height; and three levels of plant spacing viz, 22 cm, 30 cm and 38 cm. All other agronomic practices were kept normal and same for all the treatments. Data on different phenological, morphological, agronomic and quality parameters were collected and analyzed statistically using Statistix program. Difference among treatments' means were compared using Fisher's protected Tukey Honestly Significance Difference (HSD) test at 5% probability level. Topping and plant spacing affected phenology, growth and yield of cotton differently. Plant spacing of 38 cm took minimum days to first flower and boll maturation period. The topping at 90 cm recorded minimum boll maturation period. Ginning out turn also affected by topping and plant spacing. Topping at 120 cm and plant spacing of 30 cm resulted less aborted sites, more total number of bolls and thus maximum seed cotton yield per hectare.

Key words: Topping, yield, growth, quality cotton, plant spacing

Introduction

Cotton (*Gossypium hirsutum* L.) is an important major cash crop mainly grown for fiber and oil in the world. The cotton plant is distinctive because it is a perennial with an indeterminate growth habit (Oosterhuis, 2001). It is also known as white gold due to reason that it is one of the most important commercial growing crops, playing an important role in economic, political and social affairs in the world (Kairon*et al.*, 2004). In spite of severe competition with synthetic fibres, cotton continues to enjoy a place of prime importance in the textile industry (Joshi, 1997; Kairon*et al.*, 2004). Cotton is grown chiefly for its fibre, used in the manufacture of cloth for the mankind (Singh, 1997). In other words, cotton lint is the most important seed fibre in the world today and is woven into fabrics either alone or combined with

other fibres (Purseglove, 1979). Increase in plant density in cotton above the optimal level caused the yield reduction due to decrease in plant height, number of opened bolls per plant and boll weight (El-Hindi *et al.,* 2006). Closer spacing interferes with the normal root and also plant development and results in more interplant competition, which finally results in yield reduction (Siddiqui *et al.,* 2007). Increasing plant spacing significantly increased the total number of sympodials per plant, total number of opened bolls per plant, individual boll weight and thus increased the seed cotton yield while plant height, nodes up to first sympodia, earliness percentage and lint percentage decreased and did not significantly affected the fiber properties (El-Shahawy and Hamoda, 2011). Increasing plant spacing in early sowing and decreasing plant spacing in late sowing is effective to manage infestation of CLCV (Iqbal and Khan, 2010).
Topping is the removal of main stem of the plant to modify the plant canopy for better penetration of solar radiations into the leaves closer to developing bolls and helpfull for the more efficient translocation of assimilates to the new developing bolls, which thus helps to increase the yields (Shwetha *et al.,* 2009).
Only 35-45% of bolls are produced by the developing buds under normal conditions (Metcalf and Elkins, 1980). Conditions responsible for shedding are moisture excess or deficiency, cloudiness, excessive temperature, nutrient imbalances or nutrient deficiency and damages due to insects and diseases (Purseglove, 1979; Metcalf and Elkins, 1980). The shedding starts from center of plant and moves towards the periphery and from base to top (Ustimenko- Bakumovsky, 1983). The main purpose of topping is to cause the redistribution of the plant agrowth and helpful to enhance the seed cotton yield (Dai *et al*., 2003). The most effective way of reducing the fruit bodies shedding is the de-topping or removal of the main stem tip, alone or together with main branches tips at least few weeks before boll splition (Arnon, 1972; Ustimenko-Bakumovsky, 1983). The present study was carried to investigate the interactive effect of topping and plant spacing on growth, yield and quality of cotton.

Materials and Methods

An experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, during kharif 2017.Randomized Complete Block Design (RCBD) with factorial arrangements having 3 replications was applied. Net plot size was 6m x 3m and seed was placed at 30 cm distance on one side of 75 cm apart ridges. There were four lines in each plot.
The experiment was comprised of the following treatments; Factor ATopping (T): T_0 = Control (No Topping), T_1 = Topping at 90 cm height, T_2 = Topping at 120 cm height, T_3 = Topping at 150 cm height; Factor BPlant spacing (S): S_1 = 22 cm, S_2 = 30 cm, S_3= 38 cm. Seedbed was prepared by cultivating one time with rotavator and two times with tractor mounted cultivator each followed by planking. Then 75 cm apart ridges were made by tractor mounted ridger. The crop was sown on sandy clay loam soil. Crop was sown on May 8, 2013 using 20 kg seed ha^{-1}. Seeds were placed on one side of ridges at distance of 30 cm.
Full dose of phosphorus (115 kg ha^{-1}) and potassium (95 kg ha^{-1}) and one third dose of nitrogen was applied at sowing while one third at 30-35 days after sowing and remaining nitrogen was applied at flowering. Weeds were controlled by one pre emergence herbicide {Dual Gold (S Metachlore) at the rate of 2000 ml $ha-^{1}$} sprayed 23 hours after sowing, two hoeing and one post emergence broad spectrum herbicide (Roundup (Glyphosate) at the rate of 3000 ml ha^{-1}) using shield. Insects were controlled by spraying proper insecticides (Imedacloprid) at proper time. Upper 3-4 cm portion of terminal bud of main stem was removed when plant height was 3-4 cm more as per treatment to maintain the height of plants as per treatment (70-100 days after sowing) by regular visits. All other agronomic practices were kept normal and uniform for all the treatments.
When seedlings were established, ten true representative plants were selected randomly from each plot and tagged to record data. Data on following parameters were recorded using standard procedures; Number of days from sowing to appearance of first flower, Boll maturation period (days), Number of monopodial branches per plant, Total number of bolls per plant, Seed index (g), Seed cotton yield per plant (g) and Seed cotton yield per ha (kg) and Ginning out turn (GOT) %. Data collected were statistically analyzed using Fisher's analysis of variance technique (Steel *et al*., 1997) and the treatments' means were compared by using Tukey's HSD (Honestly Significant Difference) test at 5% probability. Statistix software was used for statistical analysis and graphs were made by using Microsoft Excel Program.

RESULTS AND DISCUSSION

Number of days from planting to appearance of first flower:

Plant spacing significantly affected the number of days from planting to appearance of first flower (table 1). But number of days from planting to appearance of first flower were not significantly affected by topping and interaction of both plant spacing and topping. Plant spacing of 22 cm resulted in significantly more number of days taken from planting to appearance of first flower (61.77) followed by plant spacing of 30 cm which took 58.28 days to first flower. The minimum number of days for the appearance of first flower was observed when spacing of 38 cm was maintained (56.93) which is statistically at par with plant spacing of 30 cm. Wider spacing resulted in less plant population which caused the balanced availability of nutritive substances, better light penetration and aeration resulting in appearance of first flower in less number of days. Number of days to first flower appearance was not affected by topping because treatment of topping was applied later during the crop period.

Table 1: Effect of topping under different plant spacing on number of days from planting to appearance of first flower in cotton

A. Analysis of variance

SOV	DF	SS	MS	F Value
Replication	2	31.207	15.6036	
Plant Spacing (S)	2	150.061	75.0303	7.65*
Topping (T)	3	0.127	0.0423	0.004^{NS}
S x T	6	25.626	4.2710	0.44^{NS}
Error	22	215.682	9.8037	
Total	35	422.702		

* = Significant NS = Non-Significant

B. Comparison of treatments' means

Topping (T) / Plant Spacing (S)	T_0 = Control (No Topping)	T_1 = Topping at 90 cm height	T_2 = Topping at 120 cm height	T_3 = Topping at 150 cm height	Mean
S_1 = 22 cm	61.57	61.59	63.11	60.81	61.77 A
S_2 = 30 cm	57.62	57.67	57.96	59.85	58.28 B
S_3 = 38 cm	57.78	57.52	55.82	56.59	56.93 B
Mean	58.99	58.92	58.96	59.09	

Means not sharing a letter in common differ significantly at 5% probability.

Tukey HSD value (5%) for plant spacing means = 3.212

Boll maturation period:

Boll maturation period was significantly affected by plant spacing and topping treatments but the interaction of topping and plant spacing did not influenced the boll maturation period (table 2). Plant spacing of 22 cm required more time to mature bolls (38.01) compared with plant spacing of 30 cm (36.40) which showed lesser boll maturation period and is statistically at par with plant spacing of 22 cm. The shortest boll maturation period was shown by the plant spacing of 38 cm (34.90) which is statistically similar with the plant spacing of 30 cm (table 2).Closer spacing resulted in more dense plants which increased plant to plant competition within plant and more shading resulting in lack of boll formation and also delaying of boll maturation (Obasi and Msaakpa, 2005). Plant without topping treatment (no- topping) resulted in significantly more time (42.10) to boll maturation followed by the topping at 150 cm (38.09), topping at 120 cm (33.77) and topping at 90 cm (31.79). But the minimum time to boll maturation was observed in case of topping at 90 cm which is statistically at par with topping at 120 cm.Apical topping helps to break the apical dominance and causes the expansion of lateral branches and thereby increase in sites for fruit development (Sajjan*et al.,* 2002; Singh *et al*., 2011). Topping also modified the canopy architecture which helped the redistribution of assimilates to developing bolls causing earlier boll maturation.

Table 2: Effect of topping under different plant spacing on boll maturation period in cotton.

A. Analysis of variance

SOV	DF	SS	MS	F Value
Replication	2	30.599	15.299	
Plant Spacing (S)	2	58.089	29.045	4.14*
Topping (T)	3	571.154	190.385	27.17*
S x T	6	9.488	1.581	0.23^{NS}
Error	22	154.184	7.008	
Total	35	823.513		

* = Significant NS = Non-Significant

B. Comparison of treatments' means

Topping (T) / Plant Spacing(S)	T_0 = Control (No Topping)	T_1 = Topping at 90 cm height	T_2 = Topping at 120 cm height	T_3 = Topping at 150 cm height	Mean
S_1 = 22 cm	43.03	33.86	36.19	38.96	38.01 A
S_2 = 30 cm	42.33	31.85	33.04	38.37	36.40 AB
S_3 = 38 cm	40.92	29.67	32.08	36.93	34.90 B
Mean	42.10 A	31.79 C	33.77 C	38.09 B	

Means not sharing letter in common differ significantly at 5% probability.
Tukey HSD value (5%) for plant spacing means = 2.716
Tukey HSD value (5%) for topping means = 3.466

Number of monopodial branches per plant:

Number of monopodial branches per plant was affected significantly by topping, plant spacingand interactionof both topping and plant spacing (table 3). When we consider plant spacing of 22 cm, then maximum number of monopodial branches per plant obtained with topping at 120 cm (0.670) which was statistically at par with topping at 150 cm (0.647) and with no topping (0.547). But topping at 90 cm resulted in minimum number of monopodial branches per plant (0.243). When we focus on plant spacing of 30 cm then maximum number of monopodial branches per plant was obtained with topping at 120 cm (0.867) being at par with topping at 150 cm (0.830) and minimum number of monopodial branches per plant was obtained in 90 cm topped plants (0.333). With plant spacing of 38 cm, the topping at 120 cm resulted in significantly maximum number of monopodial branches per plant (2.33) while topping at 90 cm (0.483) resulted in minimum number of monopodial branches per plant (0.483) and is statistically samewith no topping treatment. It was reported that increase in number of monopodial branches per plant occurred under low plant populationdensity of cotton (Bednarz*et al.,* 2000).Lower planting density resulted in significant increase in number of monopodial per plant(Mahdi, 2007).Monopodial branches per plant decreased significantly in closer plant spacing comparedwith wider plant spacing (Iqbal et al., 2007).Iqbal and khan (2011) reported that monopodial branches per plantvaried significantly with different plant spacings. Topping treatments resulted in cutting of main stem to modify canopy architecture for better growth of the entire plant. Removal of uppermost part encouraged the establishment of lateral branches and resulted in more number of monopodial branches per plant. Fig.1 showed that relationship between number of monopodial branches per plant and seed cotton yield per plants is moderately strong and positive (R^2= 0.547).

Table 3: Effect of topping under different plant spacing on number of monopodial branches per plant in cotton

A. Analysis of variance

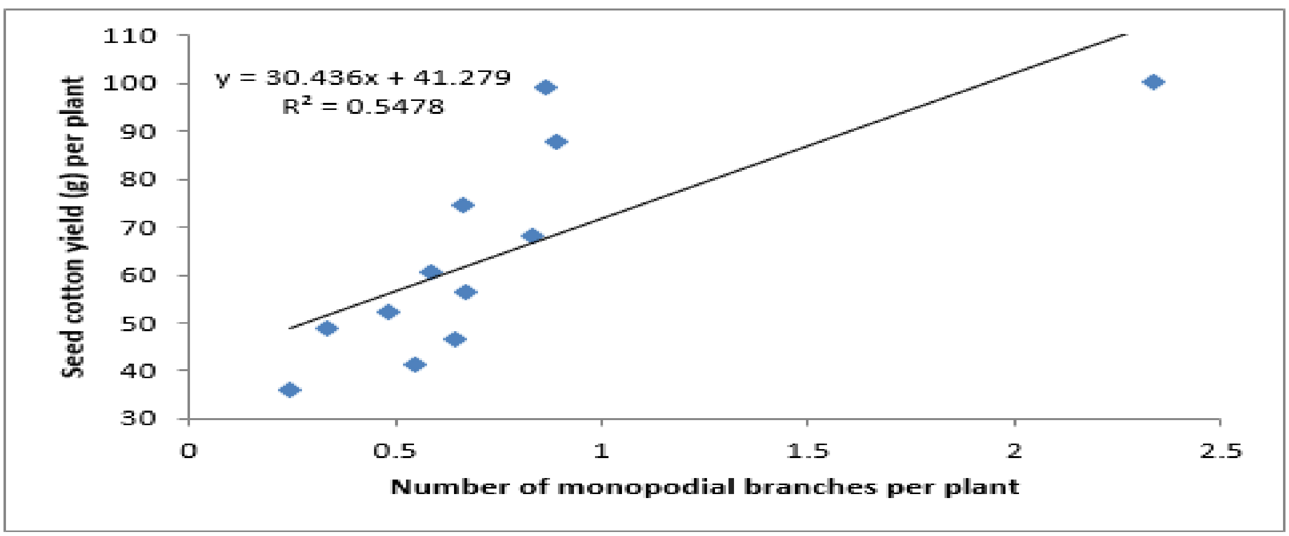
SOV	DF	SS	MS	F Value
Replication	2	0.01382	0.00691	
Plant Spacing (S)	2	2.12765	1.06382	116.64*
Topping (T)	3	4.25490	1.41830	155.51*
S x T	6	3.03788	0.50631	55.51*
Error	22	0.20065	0.00912	
Total	35	9.63490		

* = Significant

B. Comparison of treatments' means

Topping (T) / Plant Spacing (S)	T_0 = Control (No Topping)	T_1 = Topping at 90 cm height	T_2 = Topping at 120 cm height	T_3 = Topping at 150 cm height	Mean
S_1 = 22 cm	0.547 A	0.243B	0.670 A	0.647 A	0.527
S_2 = 30 cm	0.587 B	0.333 C	0.867 A	0.830 A	0.654
S_3 = 38 cm	0.667 CD	0.483 D	2.333 A	0.893 B	1.094
Mean	0.600	0.353	1.29	0.790	

Means not sharing a letter in common within row differ significantly at 5% probability.



Tukey HSD value (5%) for simple effect of topping on plant spacing (interaction) = 0.2150
Tukey HSD value (5%) for plant spacing means = 0.0980
Tukey HSD value (5%) for topping means = 0.1250

Fig. 1: Relationship between number of monopodial branches per plantvs seed cotton yield per plant

Total number of bolls per plant:

The total number of bolls per plant was affected significantly by topping, plant spacing and interaction of both topping and plant spacing (table 4). At spacing of 22 cm, the topping at 120 cm resulted in maximum number of bolls per plant (29.30) followed by topping at 150 cm (28.07) and no topping (27.40);all three were statistically same. But the topping at 90 cm resulted in significantly minimum number of total bolls per plant (19.07). At the plant spacing of 30 cm, the topping at 120 cm was resulted in maximum number of bolls per plant (39.70) which is statistically at par with topping at 150 cm and no topping treatment. But the significantly minimum total number of bolls per plant was obtained by topping at 90 cm (22.70). When the spacing of 38 cm is considered, the topping at 120 cm gave the significantly maximum total number of bolls per plant (45.07) and this treatment combination proved best in this regard. But significantly minimum total number of bolls per plant was given by topping at 90 cm (23.13). It was found that in cotton wider plant spacingresulted in increased total number of bolls per plant(Hussain*et al.,* 2000).Lower plant population density produced more number of total bolls per plant than the higher planting density(Rajakumar and Gurumurthy, 2008).Increasing the hill spacing resulted in moretotal number of bolls per plant(Emara and El-Gammaal, 2012). Closer spacing resulted in minimum number of bolls per plant (Nadeem*et al.,* 2010).Wider spacingresulted in more number of retended bolls per plants because of less inter-plant competition than the plants that are spaced narrowly (Iqbal *et al.,* 2012). De-topping resulted in maximum number of bolls per plant compared with no topping treatment (Shwetha*et al.,* 2010). It was also noted that de-topping and pruning resulted in reduction of total number of fruit sites but at the same time resulted in increase of total number of retained bolls probably due to reduction of abscised fruit sites (Yang *et al.,* 2008). Topping also resulted in increase in total number of bolls per plant (Obasi and Msaakpa, 2005). The value (R^2= 0.843) of regression coefficient indicated that the relationship between total number of bolls per plant and seed cotton

Table 4: Effect of topping under different plant spacing on total number of bolls per plant in cotton

A. Analysis of variance

SOV	DF	SS	MS	F Value
Replication	2	17.90	8.950	
Plant Spacing (S)	2	575.88	287.939	41.67*
Topping (T)	3	1316.22	438.741	63.49*
S x T	6	109.25	18.208	2.63*
Error	22	152.03	6.911	
Total	35	2171.28		

* = Significant

yield per plant is strong and positive (fig. 2).

Tukey HSD value for simple effect of topping on plant spacings = 5.919

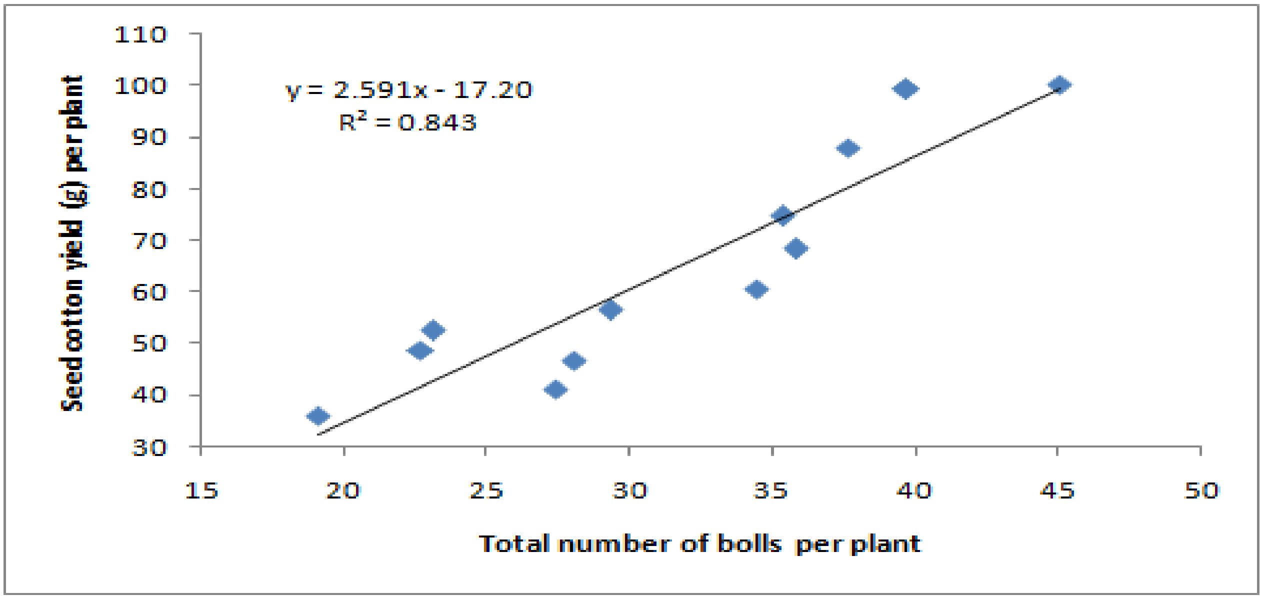
B. Comparison of treatments' means

Topping (T) / Plant Spacing (S)	T_0 = Control (No Topping)	T_1 = Topping at 90 cm height	T_2 = Topping at 120 cm height	T_3 = Topping at 150 cm height	Mean
S_1 = 22 cm	27.40 A	19.07 B	29.30 A	28.07 A	25.96
S_2 = 30 cm	34.43 A	22.70 B	39.70 A	35.83 A	33.17
S_3 = 38 cm	35.37 C	23.13 D	45.07 A	37.67 BC	35.31
Mean	32.4	21.63	38.02	33.86	

Means not sharing a letter in common within row differ significantly at 5% probability.

Tukey HSD value (5%) for plant spacing means = 2.697
Tukey HSD value (5%) for topping means = 3.442

Fig. 2: Relationship between total number of bolls per plantvs seed cotton yield per plant



Number of aborted sites per plant:

Significant effect of topping, plant spacing and their interaction was observed on number of aborted sites per plant(table 5).At the plant spacing of 22 cm, the maximum number of aborted sites per plant was observed with no topping treatment (42.50) which was however, at par with topping at 150 cm (40.00) and topping at 120 cm (38.00). The minimum number of aborted sites per plant was observed with topping at 90 cm (35.17). A plant spacing of 30 cm produced relatively less aborted sites than 22 cm plant to plant distance however, effect of topping treatment on the said parameter followed the same trend at both plant spacings.

Table 5: Effect of topping under different plant spacing on number of aborted sites per plant in cotton

A. Analysis of variance

SOV	DF	SS	MS	F Value
Replication	2	19.02	9.509	
Plant Spacing (S)	2	908.35	454.174	54.87*
Topping (T)	3	762.50	254.167	30.71*
S x T	6	127.04	21.174	2.56*
Error	22	182.09	8.277	
Total	35	1999.00		

* = Significant

B. Comparison of treatments' means

Topping (T) / Plant Spacing (S)	T_0 = Control (No Topping)	T_1 = Topping at 90 cm height	T_2 = Topping at 120 cm height	T_3 = Topping at 150 cm height	Mean
S_1 = 22 cm	42.50 A	35.17 B	38.00 AB	40.00 AB	38.92
S_2 = 30 cm	38.17 A	25.00 B	32.00 A	34.00 A	32.29
S_3 = 38 cm	35.00 A	19.00 C	21.33 BC	31.17 A	26.63
Mean	38.56	26.39	30.44	35.06	

Means not sharing a letter in common within row differ significantly at 5% probability.

Tukey HSD value (5%) for simple effect of topping on plant spacing (interaction) = 6.470
Tukey HSD value (5%) for plant spacing means = 2.951
Tukey HSD value (5%) for topping means = 3.767

At plant spacing of 38 cm, the maximum number of aborted sites per plant was given by no topping treatment (35.00) which was statistically at par with topping at 150 cm (31.17). Least number of aborted sites per plant was given by topping at 90 cm (19.00). Narrow plant spacing resulted in more dense plants resulting in more plant to plant competition, more requirement for nutrients and water and lesser translocation of assimilates to reproductive parts. This competition resulted in taller plants with more shedding of reproductive structures resulting in less boll formation and more number of aborted sites per plant (Obasi and Msaakpa, 2005).

Seed cotton yield per plant (g):

Topping, plant spacing and the interaction of topping and plant spacing significantly affected the seed cotton yield per plant (table 6). At plant spacing of 22 cm, topping at 120 cm resulted in maximum seed cotton yield (56.45 g) however, it was at par with topping at 150 cm (46.65 g) and no topping treatment (41.22 g). The topping at 90 cm resulted in minimum seed cotton yield (35.92 g). When plant spacing of 30 cm is considered, it is clear from table 4.16 that topping at 120 cm significantly out yielded (99.34 g) than other topping treatments. The topping at 90 cm resulted in minimum seed cotton yield per plant (48.71 g). Considering the plant spacing of 38 cm, the topping at 120 cm resulted in maximum seed cotton yield per plant (100.19 g) and was at par with topping at 150 cm (87.97 g). Again the topping at 90 cm plant height resulted in significantly minimum seed cotton yield (52.40 g). So results showed that maximum seed cotton yield per plant was obtained at plant spacing of 38 cm and topping at 120 cm but minimum seed cotton yield was obtained at plant spacing of 22 cm and topping at 90 cm. The decrease in yield with topping at 90 cm was due to earlier topping resulting in decreased plant height and hence less fruit bearing of the plants. The increase in yield at wider plant spacing was due to less dense plant, more air circulation and more light penetration resulting in more boll weight and more number of opened bolls per plant.

Table-6: Effect of topping under different plant spacing on seed cotton yield (g) per plant in cotton

Tukey HSD value (5%) for plant spacing means = 7.067
Tukey HSD value (5%) for topping means = 9.019

Seed index (100-seed weight):

A. Analysis of variance

SOV	DF	SS	MS	F Value
Replication	2	46.2	23.10	
Plant Spacing (S)	2	7258.8	3629.42	76.48*
Topping (T)	3	7473.0	2491.01	52.49*
S x T	6	1200.0	200.00	4.21*
Error	22	1044.0	47.45	
Total	35	17022.1		

* = Significant

B. Comparison of treatments' means

Topping (T) / Plant Spacing (S)	T_0 = Control (No Topping)	T_1 = Topping at 90 cm height	T_2 = Topping at 120 cm height	T_3 = Topping at 150 cm height	Mean
S_1 = 22 cm	41.22 AB	35.92 B	56.45 A	46.65 AB	45.06
S_2 = 30 cm	60.49 CD	48.71 D	99.34 A	68.29 BC	69.21
S_3 = 38 cm	74.69 B	52.40 C	100.19 A	87.97 AB	78.81
Mean	58.80	45.68	85.33	67.64	

Means not sharing a letter in common within row differ significantly at 5% probability.

Tukey HSD value (5%) for simple effect of topping on plant spacing (interaction) = 15.510

Plant spacing significantly affectedthe seed index but it was not significantly affected by topping and interaction of both topping and plant spacing (table 7).The plant spacing of 38 cm was resulted in maximum seed index (7.26 g) followed by plant spacing of 30 cm (7.03 g); both were statistically similar with each other. The minimum value of seed index was given by the plant spacing of 22 cm (6.73 g). Wider spacing resulted in maximum seed index (Shukla*et al*., 2013). Significantly maximum seed index was given by wider plant spacing and lower seed index was given by closer plant spacing (Nadeem*et al.,* 2010; Ali *et al.,* 2011).Heavy shading under increased plant population, by the upper leaves resulted in limitation of the photosynthates to the bolls and thus growth of bolls isreduced in that the part of the plant. But lower planting density resulted in increase in seed index due to more light penetration (Zakaria*et al.,* 2008). Proper planting pattern also resulted in increase in seed index (Hamoda*et al.,* 2013).

Table 7: Effect of topping under different plant spacing on seed index (100- seed weight) (g) in cotton

A. Analysis of variance

SOV	DF	SS	MS	F Value
Replication	2	1.4493	0.72464	
Plant Spacing (S)	2	1.7165	0.85823	4.42*
Topping (T)	3	1.0418	0.34727	1.79 NS
S x T	6	1.6115	0.26859	1.38 NS
Error	22	4.2713	0.19415	
Total	35	10.0904		

*** = Significant** **NS = Non-Significant**

B. Comparison of treatments' means

Topping (T) / **Plant Spacing (S)**	**T_0 = Control (No Topping)**	**T_1 = Topping at 90 cm height**	**T_2 = Topping at 120 cm height**	**T_3 = Topping at 150 cm height**	**Mean**
S_1 = 22 cm	6.54	6.56	7.03	6.79	6.73 B
S_2 = 30 cm	7.15	7.43	6.99	6.56	7.03 AB
S_3 = 38 cm	7.35	7.67	7.13	6.90	7.26 A
Mean	7.02	7.22	7.05	6.75	

Means not sharing a letter in common within row differ significantly at 5% probability.

Tukey HSD value (5%) for plant spacing means = 0.4520

Ginning out turn (GOT %):

Ginning out turn percentage was not affected significantly by topping and plant spacing and the interaction oftopping and plant spacing was also non-significant (table 8).

Ginning out turn percentage was not affected by different plant spacings (Hussain *et al.,* 2000). Ginning out turn is largely determined by the cultivar and is genetically controlled character. Plant spacing resulted in no effect on ginning out turn % (Ahmad *et al.*, 2009). Iqbal and Khan (2011) also found that there was no significant effect of plant spacing on ginning out turn.

Table 8: Effect of topping under different plant spacing on ginning out turn (GOT) % in cotton

A. Analysis of variance

SOV	DF	SS	MS	F Value
Replication	2	27.480	13.7400	
Plant Spacing (S)	2	23.736	11.8681	0.99 NS
Topping (T)	3	25.639	8.5462	0.71NS
S x T	6	64.531	10.7552	0.90NS
Error	22	264.325	12.0148	
Total	35	405.712		

NS = Non-Significant

B. Comparison of treatments' means

Topping (T) / Plant Spacing (S)	T_0 = Control (No Topping)	T_1 = Topping at 90 cm height	T_2 = Topping at 120 cm height	T_3 = Topping at 150 cm height	Mean
S_1 = 22 cm	41.25	41.15	41.97	39.25	40.90
S_2 = 30 cm	38.79	41.04	40.44	43.71	41.00
S_3 = 38 cm	40.81	45.70	41.79	42.39	42.67
Mean	40.28	42.63	41.40	41.78	

AUTHOR CONTRIBUTIONS: All authors contributed equally.
CONFLICTS OF INTEREST: The authors declare no conflict of interest.

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