# Effect of topping under different plant spacing on earliness and yield of cotton

**Short Title:** Topping and plant spacing in cotton

Abdul Shakoor[1,2,*], Muhammad Farrukh Saleem[1], Umm e Hani[1,3], Ali Raza[1], Tayyub Hussain[4], Ifra Saleem[5], Amina Iftkhar[1], Qudsia Nazir[5], Samman Gul Vaseer[2], Khunsa Khakwani[6], Shabbir Hussain[1]

[1]*Department of Agronomy, University of Agriculture Faisalabad, Pakistan*

[2]*Wheat Program, Crop Sciences Institute, National Agricultural Research Centre, Islamabad*

[3]*Department of Botany, University of Agriculture, Faisalabad*

[4]*Maize, Sorghum and Millet Program, Crop Sciences Institute, National Agricultural Research Centre, Islamabad*

[5]*Institute of Soil Chemistry and Environmental Sciences, Ayub Agricultural Research Institute, Faisalabad*

[6]*Cotton Research Station, Ayub Agricultural Research Institute, Faisalabad*

**ABSTRACT**

An experiment was laid out to study the dynamics of plant spacing and topping height with the objective to hasten maturity and enhance seed cotton yield and yield components. The experiment was conducted at Agronomic Research Area, University of Agriculture Faisalabad. Experiment was laid out in Randomized Complete Block Design (RCBD). Treatments' structures were factorial and replicated three times. Treatments were comprised of three plant spacing's viz. $S_1$ (22 cm), $S_2$ (30 cm) and $S_3$ (38 cm) and four topping heights viz. $T_0$ (Control/No topping), $T_1$ (Topping at 90 cm height), $T_2$ (Topping at 120 cm height) and $T_3$ (Topping at 150 cm height). Plant spacing of 38 cm took significantly lesser number of days from sowing to first floral bud initiation and appearance to first flower and boll opening. Topping effect remained non-significant for first two parameters. Whereas, no topping took significantly highest number of days to first boll opening and minimum duration was observed with topping at 90 cm height. Highest number of sympodial branches per plant were recorded with 38 cm plant spacing and with topping at 120 cm height. Significantly more earliness index was exhibited by plant spacing of 30 cm and topping at 120 cm height. Topping at 120 cm height depicted higher number of monopodial branches, opened bolls, boll weight, seed cotton yield per plant and per hectare at each plant spacing treatment. Minimum boll weight was observed for no topping at each plant spacing. Minimum seed cotton yield per plant and per hectare was manifested by topping at 90 cm height at each plant spacing treatment. As concluding remarks, topping at 120 cm height depicted highest seed cotton yield and other yield attributes at each plant spacing treatment. However, highest earliness index was recorded for 30 cm plant spacing and topping at 120 cm height.

***Keywords*****:** Canopy; Maturity; Plant height; Boll weight; Sympodial; Monopodial; Cotton

## INTRODUCTION

Cotton earliness can be defined in different ways. It may be defined as, early appearance of first flower, early boll formation; early boll opening/splition and early closure of crop (Chaudhry and Guitchounts, 2003). 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; Javaid *et al*., 2014). Closer spacing interferes with the normal root and also plant development and results in more interplant competition, which finally consequences in yield reduction (Siddiqui *et al*., 2007). Increasing plant spacing considerably increased the total number of sympodia per plant, total number of opened bolls per plant, individual boll weight and thus improved the seed cotton yield while plant height, nodes up to first sympodia, earliness index/percentage and lint percentage diminished 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 cope infestation of CLCuV (Iqbal and Khan, 2010).

In certain growing areas of cotton, pruning of vegetative branches, removal of main stem node mechanically and spray of growth regulators are used to control lodging and extreme growth, to increase early maturity, to make mechanical harvesting easy and to boost yield (Abou-El-Nour *et al*., 2001). Increased number of fruiting sites and rotted bolls, decreased number of aborted sites and increased average boll weight and number of bolls and ultimately high seed cotton yield was recorded when topped at 120 cm plant height (Obasi and Msaakpa, 2005). There was superior seed cotton yield, lint percentage, fiber length and minor aphid, jassid and thrips population due to topping (Shwetha *et al*., 2009; Khan *et al*., 2014).

In cotton, more vegetative growth can compete successfully with fruiting points for total available assimilates and level of these assimilates alongside the plant axis was lowest close to the central position of the plant (Singh and Sanyal, 1972). Topping and pruning is the removal of main stem of the plant that modifies 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, thus helps to increase the yields (Shwetha *et al*., 2009).

The main purpose of topping is to cause the redistribution of the plant nutritive substances that helps to strengthen reproductive growth and also reduces the vegetative growth and helpful to enhance the seed cotton yield (Dai *et al*., 2003; Wajid *et al*., 2014). In cotton topping at 120 cm height with the application of nitrogen at 200 kg ha$^{-1}$ was most beneficial to get maximum seed cotton yield (Saleem *et al*., 2016). The most effective way of reducing the fruit bodies shedding topping or removal of the main stem tip, alone or together with main branches tips at least few weeks before boll splition (Ustimenko-Bakumovsky, 1983).

## MATERIALS AND METHODS

An experiment was conducted to study the effect of topping under different levels of plant spacing on earliness and yield of Bt. cotton at Agronomic Research Area, University of Agriculture Faisalabad. Seed of cultivar IR-3701 obtained from NIAB Faisalabad Pakistan. andomized Complete Block Design (RCBD) with factorial arrangements having 3 replications was applied. Net plot size was 6 m × 3 m and seed was placed manually at 30 cm distance on one side of 75 cm apart ridges. There were four lines maintained in each plot. The experimental treatments comprised three plant spacings viz. $S_1$ (22 cm), $S_2$ (30 cm) and $S_3$ (38 cm) and four topping levels viz. $T_0$ Control (No Topping), $T_1$ (Topping at 90 cm height), $T_2$ (Topping at 120 cm height) and ($T_3$ Topping at 150 cm height.). Seedbed was prepared to fine tilth. Then 75 cm apart ridges were made by tractor mounted ridger. The crop was sown on May 08, 2013 using 20 kg seed ha$^{-1}$. 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 35 days after sowing and remaining nitrogen was applied at flowering (65 days after sowing). To control weeds, a herbicide {Dual Gold (S Metachlore) at 2000 ml ha$^{-1}$} was sprayed 23 hours after sowing followed by two hoeings, and then a post emergence broad spectrum herbicide (Roundup (Glyphosate) at 3000 mL ha$^{-1}$ ) was sprayed using shield. Insects were controlled by spraying proper insecticides (Imidachloprid at the rate of 250 g per acre) 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 according to treatments (70-100 days after sowing) by consistent visits. All other husbandry practices were kept uniform for entire experiment. Ten true representative plants were randomly tagged in each plot and following parameters were recorded.

**Number of days from sowing to first floral bud initiation (squaring)**

Time period from sowing to squaring was noted which were selected in every plant.

**Number of days from sowing to appearance of first flower**

First flower initiation days was recorded from the representative plants when yellowish and white flowers appeared in 50% tagged plants.

**Number of days from sowing to first boll opening**

Boll splition period was observed from sowing of crop till the cracked boll lint was appearing.

**Earliness index (%)**

For calculation of earliness index (%) following formula was used (Singh, 2004).

$$\text{Earliness index (\%)} = \frac{\text{Weight of seed cotton from first pick}}{\text{Total seed cotton weight from all the picks}} \times 100$$

**Number of sympodial branches per plant**

These were counted from tagged plants in each plot and then averaged.

**Number of monopodial branches per plant**

Noted the monopodials per plant from tagged plants before first picking.

**Number of opened bolls per plant**

Opened bolls were counted at first and second picking of guarded plants.

**Boll weight (g)**

It was obtained by dividing seed cotton yield per plant with respective number of opened bolls per plant.

**Seed cotton yield per plant (g)**

Seed cotton yield per plant was calculated by weighing the seed cotton yield from the selected plants of each plot of all the picks in grams by electrical balance and then the average of the selected plants was taken.

**Seed cotton yield per ha (kg)**

Seed cotton yield per plot was converted into seed cotton yield per hectare.

Data collected were statistically analyzed using Fisher's analysis of variance (Steel *et al*., 1997) and means were compared by using Tukey's HSD (Honestly significant difference) test at 5% probability.

**RESULTS AND DISCUSSIONS**

Number of days from planting to first floral bud initiation and first flower were significantly affected by plant spacing but remained unaffected by topping height and their interaction (Table 1).

Plant spacing of 22 cm took significantly more days to first floral bud initiation (44.69) and first flower (61.77). Minimum numbers of days were depicted by plant spacing of 38 cm for floral bud initiation and appearance of first flower (Table 2).

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.

Significant effect of topping and plant spacing was observed on the number of days from sowing to first boll opening, earliness index and number of sympodial branches per plant. All these attributes were not affected significantly by interaction of both topping and plant spacing (Table 1).

More number of days to first boll opening (87.88) was manifested by plant spacing of 22 cm. Plant spacing of 22 cm was at par with plant spacing of 30 cm

(86.66) which was statistically at par with plant spacing of 22 cm. The minimum number of days to first boll opening (84.46) was observed in case of plant spacing of 38 cm which was statistically similar with plant spacing of 30 cm (Table 2).

Narrow plant spacing resulted in more number of days to first boll opening because narrow plant spacing resulted more plant to plant competition causing more need of water, nutrients and sunlight. The result of this competition was delay in boll formation and boll opening (Obasi and Msaakpa, 2005). Generally, movement of air around the plant and penetration of light to the plants causes earlier boll opening (Zakaria *et al*., 2008). Topping is the removal of main stem of the plant to modify the plant canopy for better penetration of solar radiations into the leaves and is helpful for more efficient translocation of assimilates to the new developing bolls (Shwetha *et al*., 2009). Control (no- topping) exhibited significantly highest number of days to first boll opening (92.96). Topping at 150 cm height (88.06) and topping at 120 cm height (84.56) were statistically similar. Topping at 90 cm took minimum number of days to first boll opening (79.75) (Table 2). Plants in control treatment required more days from planting to first boll opening compared with plants on which topping treatment was applied (Obasi and Msaakpa, 2005).

Highest earliness index was exhibited by plant spacing of 30 cm (56.26%) against the minimum (48.06%) with plant spacing of 38 cm. Relatively more earliness index at spacing of 30 cm was due to optimum plant population while minimum earliness index at plant spacing of 38 cm was due to low plant population (Table 3).

Earliness was indirectly correlated with the plant population density because maximum penetration of light and movement of air around the plants results in earlier boll opening and hence more earliness index (Alfageih *et al*., 2001; Zakaria *et al*., 2008).

Topping at 120 cm depicted significantly maximum earliness index (58.45). It was followed by topping at 150 cm (54.23) and no topping (49.35). But topping at 90 cm was manifested minimum earliness index (47.00) which is statistically similar with no topping (control) (Table 2).

The maximum earliness index at topping of 120 cm was due to topping at optimum level causing modification of canopy architecture and maximum penetration of light, which resulted in earlier boll opening and earlier maturity hence increase in earliness index. The lowest earliness at topping of 90 cm was due to earlier topping which resulted in less number of bolls per plant so decreased earliness index.

The plant spacing of 38 cm depicted significantly maximum number of sympodial branches per plant (33.25). Both lesser spacings were statistically similar (Table 2).

Increasing hill spacing resulted in increased number of sympodial branches per plant because narrow hill spacing resulted in dense stand and increased plant to plant competition, less light penetration and more requirement of nutrients thus decreased number of sympodial branches per plant (Obasi and Msaakpa, 2005). Increasing plant spacing significantly increased the total number of sympodials per plant (El-Shahawy and Hamoda, 2011). Decrease in plant population resulted in increased number of sympodial branches per plant (Hamed, 2006). It was found that lower planting density resulted in significant increase in number of fruiting branches per plant (Mahdi, 2007; El-Shahawy and Hamoda, 2010).

Topping at 120 cm resulted in significantly more number of sympodial branches per plant (34.39) followed by topping at 150 cm (30.72) and no topping (29.78). Topping at 150 cm was statistically at par with no topping treatment while topping at 90 cm resulted in significantly minimum number of sympodial branches per plant (25.17) (Table 2).

Topping resulted in more sympodial bearing capacity of plant (Shwetha *et al*., 2010). Topping resulted in increased number of sympodial branches per plant (Obasi and Msaakpa, 2005).

Topping, plant spacing and interaction of topping and spacing were significant for number of monopodial branches per plant, opened bolls per plant, boll weight, seed cotton yield per plant and seed cotton yield per hectare (Table 1).

At plant spacing of 22 cm, maximum number of monopodial branches per plant was 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). Whereas, topping at 90 cm resulted in minimum number of monopodial branches per plant (0.243). At plant spacing of 30 cm, 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). 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). Topping at 90 cm (0.483) resulted in minimum number of monopodial branches per plant (0.483) and was statistically same with no topping treatment (Table 3).

Lower planting density resulted in significant increase in number of monopodials per plant (Mahdi, 2007). Monopodial branches per plant decreased significantly in closer plant spacing compared with wider plant spacing (Iqbal *et al*., 2007). Iqbal and khan (2011) reported that monopodial branches per plant varied 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.

Considering the spacing of 22 cm, maximum number of opened bolls per plant was produced by topping at 120 cm (20.65) followed by topping at 150 cm (18.41) and no topping (17.60); all three were statistically at par with each other. At the plant spacing of 30 cm, topping at 120 cm resulted in significantly maximum number of opened bolls per plant. Topping at 120 cm was at par with topping at 150 cm. Significantly minimum number of opened bolls per plant was recorded with topping at 90 cm. At 38 cm plant spacing, significantly highest number of opened bolls per plant was depicted by topping at 120 cm height. Whereas, significantly lowest number of opened bolls per plant was recorded at 90 cm topping (Table 3).

Increasing hill spacing resulted in increase in total number of opened bolls per plant (El-Sayed and El-Menshawi, 2005) because wider spacing resulted in more penetration of light, more availability of water and nutrients and lesser plant to plant competition which resulted in better growth (Obasi and Msaakpa, 2005). Increasing plant spacing significantly increased the total number of opened bolls per plant (El-Shahawy and Hamoda, 2011). Wider plant spacing resulted in more number of opened per plant than narrow plant spacing (Bhalerao *et al*., 2010). Decreasing plant density resulted in increased number of opened bolls per plant (Zakaria *et al*., 2008). It was noted that topping and pruning resulted in reduction of total number of fruit sites but at the same time resulted in increased total number of retained bolls probably due to reduction of abscised fruit sites. Though production of total dry matter was reduced, but there was more allocation of dry matter to reproductive parts resulting in increased total number of opened bolls per plant by de-topping and pruning treatments (Yang *et al*., 2008).

Performance of 22 cm and 38 cm spaced plants was similar under different topping treatments; with maximum average boll weight at 120 cm topping closely followed by topping at 90 cm plant height. In case of 30 cm plant spacing all topping treatments differed significantly in average boll weight with highest values recorded when topping was performed at 120 cm plant height. Average boll weight remained at the bottom in all spacings at no topping (control) (Table 3).

De-topping at proper time resulted in increase in boll weight because of control of apical growth, reproductive growth initiation and carbohydrates diversion to developing bolls (Shwetha *et al*., 2010). The wider plant spacing resulted in more boll weight and narrow plant spacing resulted in lowest boll weight (Ali *et al*., 2011). The decreased boll weight in higher plant population may be due to minimum availability of the carbohydrates to developing bolls (Rajakumar and Gurumurthy, 2008). Increasing plant spacing significantly increased the individual boll weight (El-Sayed and El-Menshawi 2005; El-Shahawy and Hamoda, 2011).

At plant spacing of 22 cm, topping at 120 cm resulted in maximum seed cotton yield however, it was closely followed by topping at 150 cm. When plant spacing of 30 cm is considered, it is clear from Table 3 that topping at 120 cm significantly out yielded than other topping treatments. Considering the plant spacing of 38 cm, again the topping at 120 cm resulted in maximum seed cotton yield but was at par with topping at 150 cm. At all spacing treatments, the topping at 90 cm plant height resulted in significantly minimum seed cotton yield. 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. It is also reported that increasing hill spacing resulted in increased number of sympodial branches per plant, opened bolls per plant and also the seed cotton yield per plant (Emara and El-Gammaal, 2012). Wider plant spacing resulted in increased number of opened bolls per plant and seed cotton yield per plant (Bhalerao *et al*., 2010). Decreasing the plant population resulted in increase in number of sympodial branches per plant, boll weight, total number of opened bolls per plant and also the seed cotton yield per plant (Hamed, 2006).

Pruning as well as topping increases seed cotton yield mostly due to readjustments in the assimilate distribution in the plant, that strengthens reproductive growth and inhibits plant vegetative growth. Both the inhibition of plant vegetative growth and strengthening of reproductive growth help to increase seed cotton yield (Xu *et al*., 2001; Dai *et al*., 2003). It is reported that topping at proper time resulted in significantly higher seed cotton yield as compared to no topping. This increase in yield was because of control of apical growth, reproductive growth initiation and carbohydrates diversion for components of yield (Shwetha *et al*., 2010).

**REFERENCES**

Abou-El-Nour, M.S., O.M. M. Wassel and S.M. Ismail. 2001. Response of Giza 80 cotton cultivar to some cultural practices to control excessive vegetative growth. Egyp. J. Agric. Res. 79: 191-204.

Alfageih, F.M., A.S. Baswaid and K.B. Atroosh. 2001. Effect of plant density on some agronomic characters and growth development of medium-staple cotton. Uni. Aden J. Natur. Appl. Sci. 5: 35-44.

Ali, H., M. N. Afzal, F. Ahmad, S. Ahmad, M. Akhtar and R. Atif. 2011. Effect of sowing dates, plant spacing and nitrogen application on growth and productivity on Cotton Crop. Inter. J. Sci. Eng. Res. 2: 111-118.

Bhalerao, P.D., B.R. Patil, P.U. Ghatol and P.P. Gawande. 2010. Effect of spacing and fertilizer levels on seed cotton yield under rain fed condition. Indian J. Agric. Res. 44: 74-76.

Chaudhry, M.R. and A. Guitchounts. 2003. Cotton Facts. International Cotton Advisory Committee. First edi. pp: 14.

Cheema, M.S., M. Akhter, L. Ali and M. Jamil. 2004. Effect of plant density on seed cotton yield of different varieties. J. Agric. Res. 42: 3-4.

Dai, J., W. Zheng and J.S. Yang. 2003. Review on growth and application of cotton monopodial branches. China Cotton. pp 30: 2-5.

El-Hindi, M.H., E.M. Said, M.H. Ghonema and A.E. Khalifa. 2006. Studies on the effect of some cultural practices on the growth and the yield of Egyption cotton. J. Agric. Sci. 31: 4087-4095.

El-Sayed, E. and M. El- Menshawi. 2005. Response of the promising hybrid cotton Giza 89 × 86 to hill spacing and nitrogen fertilizer level. J. Agric. Res. Tanta Univ. 31: 436-456.

El-Shahawy, M.I. and S.A.F. Hamoda. 2010. The proper agricultural management practices for the new promising hybrid cotton (Giza 77 × Pima S6). J. Agric. Sci. Mansoura Univ. 31: 4087-4095.

El-Shahawy, M.I.M. and S.A.F. Hamoda. 2011. The proper agricultural management practices for the new promising hybrid cotton. J. Plant. Prod. 2: 1551-1561.

Emara, M.A. and A.A. El-Gammaal. 2012. Effect of plant distribution and nitrogen fertilizer levels on new promising hybrid cotton (Giza 89 × Giza 86). J. Agric. Res. Kafer El-Sheikh Univ. pp: 38.

Hamed, F.S. 2006. Response of cotton cultivar Giza 90 to population density and nitrogen levels. Assuit. J. Agric. Sci. 37: 173-184.

Iqbal, M. and M.A. Khan. 2010. Management of cotton leaf curl virus by planting time and plant spacing. Adv. Agric. Bot. Bioflux 2: 25-33.

Iqbal, M. and M.A. Khan. 2011. Response of cotton genotypes to planting date and plant spacing. Frontiers. Agric. China. 5: 262-267.

Iqbal, M., K. Hayat and N. Islam. 2007. Cotton response to mepiquate chloride and nitrogen under ultra-narrow plant spacing. Asian. J. plant. Sci. 6: 87-92.

Javaid, A., F.M. Azhar, I.A. Khan and F.S. Awan. 2014. Biometrical analysis of variability in plant height and seed cotton yield in gossypium hirsutum under water stress conditions. Pak. J. Agri. Sci. 52: 309-315.

Khan, M.A., A. Ali, M. Aslam, Z. Tahir, M.M. Khan and I. Nadeem. 2014. The role of morphological and chemical plant traits imparting resistance in *Bt* cotton genotypes against thrips, *Thrips tabaci* (lind.). Pak. J. Agri. Sci. 51: 725-731.

Mahdi, A.H. 2007. Study the contribution of some agronomic factors to cotton variation in Fayoum region. M. Sc. Thesis, Fac. Agric. El-Fayoum Univ. Egypt.

Obasi, M.O. and T.S. Msaakpa. 2005. Influence of topping, side branch pruning and hill spacing on growth and development of cotton (*Gossypium barbadense* L.) in the Southern Guinea Savanna location of Nigeria. J. Agric. Rural dev. Trop. Subtrop. 106:155-165.

Rajakumar, D. and S. Gurumurthy. 2008. Effect of plant density and nutrient spray on the yield attributes and yield of direct sown and poly bag seedling planted hybrid cotton. Agric. Sci. Digest. 28: 174-177.

Saleem, M.F., M. Ahmad, S.A. Anjum, M.A.S. Raza and A. Shakoor. 2016. Effect of topping under different nitrogen levels on earliness and yield of cotton. Pak. J. Agric. 29: 110-118.

Shwetha, N.S., A.S. Halepyati and B.T. Pujari. 2009. Effect of de-topping, removal of monopodial and plant spacing's on nutrient uptake, quality parameters and economics of Bt cotton (*Gossypium hirsutum* L.). Karnataka J. Agric. Sci. 22: 892-893.

Shwetha, N.S., A.S. Halepyati and B.T. Pujari. 2010. Studies on the manipulation of growth as a means of increasing productivity of Bt cotton (*Gossypium hirsutum* L.). Karnataka J. Agric. Sci. 23: 334-336.

Siddiqui, M.H., F.C. Oad and U.A. Buriro. 2007. Plant spacing effects on growth, yield and lint of cotton. Asian J. Plant. Sci. 6: 415-418.

Singh, M.P. and P. Sanyal. 1972. Effect of topping on cotton. Field. Crop. Abstr. 25. pp: 118.

Singh, P. 2004. Cotton breeding. Kalyani Publishers Ludhiana New Dehli Nodia (U.P.) Hyderabad Chennei Kolkata Cuttack India. pp. 118-295.

Steel, R.G.D, J.H. Torrie and D. Dickey. 1997. Principles and procedure of statistics. A biometrical approach. 3rd Eds. McGraw Hill Book Co. Inc., New York. pp. 352-358.

Ustimenko-Bekumovsky, G.V. 1983. Plant growing in tropics and sub-tropics. Mir Publisher, Moscow. pp: 391.

Wajid, A., A. Ahmad, M. Hussain, M.H.U. Rahman, T. Khaliq, M. Mubeen, F. Rasul, U. Bashir, M. Awais, J. Iqbal, S.R. Sultana and G. Hoogenboom. 2014. Modeling growth, development and seed-cotton yield for varying nitrogen increments and planting dates using DSSAT. Pak. J. Agri. Sci. 51: 641-649.

Xu, L.H., G.F. Li, X.H. He and D.Y. Yang. 2001. Regularity of accumulation and distribution of dry matter in monopodial branches retained cotton plants. J. Agric. Sci. 17:153-157.

Yang, Y., Z. Ouyang, Y. Yang and X. Liu. 2008. Simulation of the effect of pruning and topping on cotton growth using COTTON2K model. Field Crops. Res. 106: 126-137.

Zakaria M.S., M.H. Mahmoud and A.H. Fahmy. 2008. Cotton (*Gossypium barbadense* L.) yield and fiber froperties as affected by plant growth retardants and plant density, J. Crop Improv. 21: 171-189.

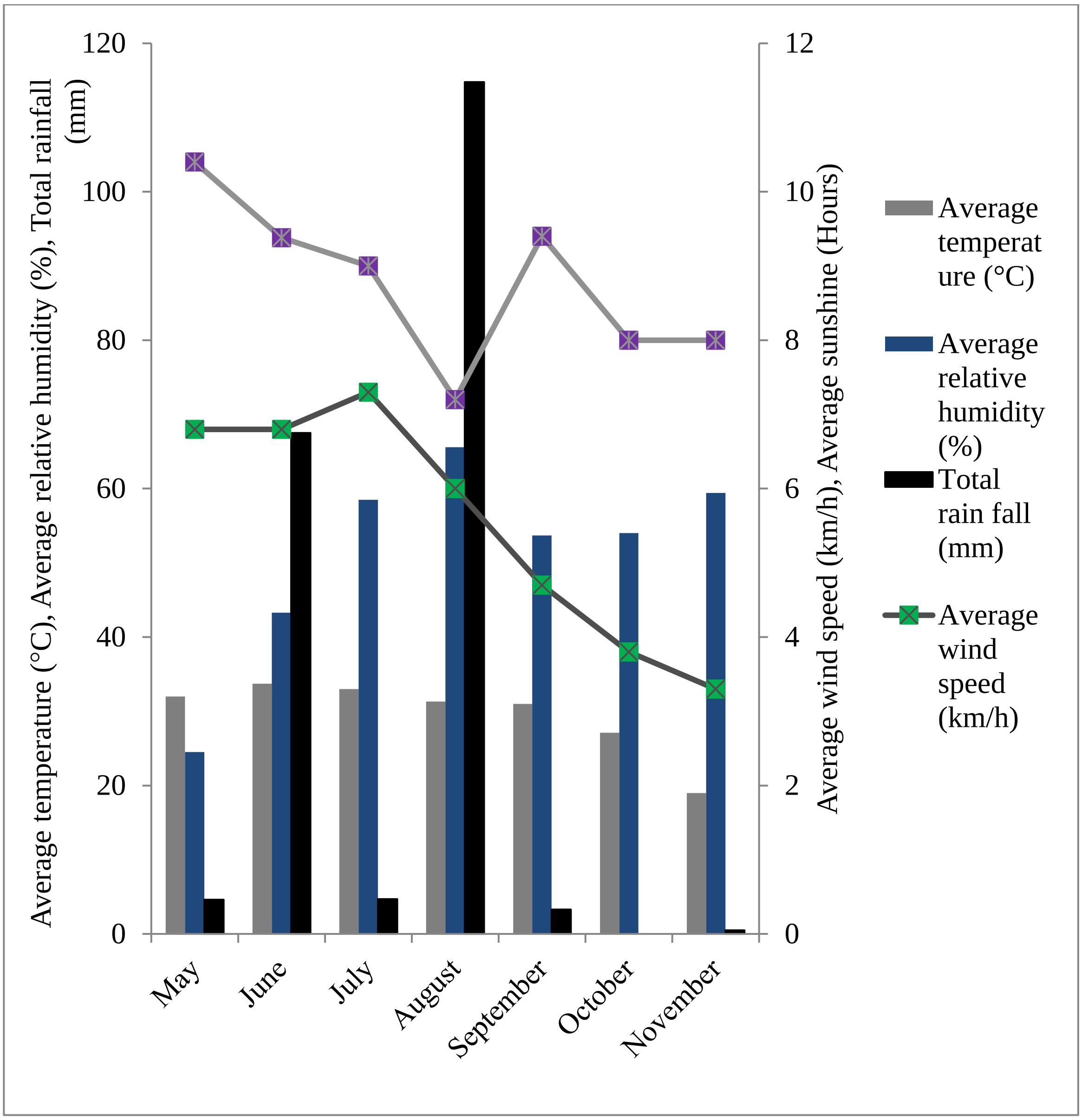


**Figure 1: Weather conditions during cotton growing period**

**Table 1. Mean sum of square for topping and plant spacing on earliness and yield related traits in cotton**

| Parameters | Source of variation | | | |
|---|---|---|---|---|
| | **Plant spacing (S)** | **Topping (T)** | **S × T** | **Error** |
| Days to first square | 193.405* | $0.004^{NS}$ | $0.025^{NS}$ | 9.233 |
| Days to first flower | 75.0303* | $0.0423^{NS}$ | $4.2710^{NS}$ | 9.8037 |
| Days to first boll opening | 35.984* | 280.161* | $1.554^{NS}$ | 8.625 |
| Number of monopodial branches | 1.06382* | 1.41830* | 0.50631* | 0.00912 |
| Number of sympodial branches | 110.007* | 129.581* | $11.525^{NS}$ | 7.714 |
| Earliness index | 202.080* | 234.866* | $0.672^{NS}$ | 6.862 |
| Number of opened bolls | 350.271* | 330.300* | 19.742* | 6.952 |
| Boll weight | 0.13310* | 1.11287* | 0.01611* | 0.00459 |
| Seed cotton yield per plant | 3629.42* | 2491.01* | 200.00* | 47.45 |
| Seed cotton yield per hactare | 1213940* | 3952786* | 200098* | 76899 |

Where:
* = Significant, NS = Non-significant

**Table 2. Effect of topping and plant spacing on earliness and phenological traits in cotton**

| Treatments | DFS | DFF | FBO | NSB |
|---|---|---|---|---|
| **Plant spacing (cm)** | | | | |
| 22 ($S_1$) | 44.69 A | 61.77 A | 87.88 A | 27.25 B |
| 30 ($S_2$) | 40.82 B | 58.28 B | 86.66 AB | 29.54 B |
| 38 ($S_3$) | 36.66 C | 56.93 B | 84.46 B | 33.25 A |
| HSD ($\leq$ 0.05) | 3.117 | 3.212 | 3.013 | 2.849 |
| **Topping levels** | | | | |
| No topping ($T_0$) | 40.73 | 58.99 | 92.96 A | 29.78 B |
| Topping at 90 cm height ($T_1$) | 40.69 | 58.92 | 79.75 C | 25.17 C |
| Topping at 120 cm height ($T_2$) | 40.74 | 58.96 | 84.56 B | 34.39 A |
| Topping at 150 cm height ($T_3$) | 40.72 | 59.09 | 88.06 B | 30.72 B |
| HSD ($\leq$ 0.05) | NS | NS | 3.845 | 3.636 |
| HSD ($\leq$ 0.05) for interaction | NS | NS | NS | NS |

Means not sharing a common letter within a column differ significantly at 5% probability level.
NS = Non-significant, DFS = Days to first square, DFF = Days to first flower
FBS = Days to first boll opening, NMB = Number of sympodial branches

**Table 3. Effect of topping and plant spacing on earliness and yield related traits in cotton**

| Treatments | EI | NMB | BW | OBPP | SCYPP | SCY |
|---|---|---|---|---|---|---|
| **Plant Spacing (cm)** | | | | | | |
| 22 ($S_1$) | 52.45 B | 0.527 | 3.01 | 17.35 | 45.06 | 2628.5 |
| 30 ($S_2$) | 56.26 A | 0.654 | 3.11 | 25.16 | 69.21 | 3035.1 |
| 38 ($S_3$) | 48.06 C | 1.094 | 3.22 | 27.69 | 78.81 | 2408.2 |
| HSD ($\leq 0.05$) | 2.687 | 0.0980 | 0.0695 | 2.705 | 7.067 | 284.47 |
| **Topping levels** | | | | | | |
| No topping ($T_0$) | 49.35 C | 0.600 | 2.64 | 22.44 | 58.80 | 2436.0 |
| Topping at 90 cm height ($T_1$) | 47.00 C | 0.353 | 3.30 | 15.70 | 45.68 | 1983.9 |
| Topping at 120 cm height ($T_2$) | 58.45 A | 1.290 | 3.45 | 30.23 | 85.33 | 3552.9 |
| Topping at 150 cm height ($T_3$) | 54.23 B | 0.790 | 3.06 | 25.19 | 67.64 | 2789.6 |
| HSD ($\leq 0.05$) | 3.430 | 0.1250 | 0.0887 | 3.452 | 9.019 | 363.05 |
| **Interaction** | | | | | | |
| **$S_1$ (22 cm)** | | | | | | |
| **$S_1 \times T_0$** | 49.55 | 0.547 a | 2.43 c | 17.60 ab | 41.22 ab | 2404.7 bc |
| **$S_1 \times T_1$** | 46.96 | 0.243 b | 3.27 a | 12.65 b | 35.92 b | 2095.1 c |
| **$S_1 \times T_2$** | 59.20 | 0.670 a | 3.39 a | 20.65 a | 56.45 a | 3292.7 a |
| **$S_1 \times T_3$** | 54.09 | 0.647 a | 2.97 b | 18.41 ab | 46.65 ab | 2721.4 ab |
| **$S_2$ (30 cm)** | | | | | | |
| **$S_2 \times T_0$** | 53.13 | 0.587 b | 2.65 d | 24.21 b | 60.49 cd | 2621.3 cd |
| **$S_2 \times T_1$** | 51.27 | 0.333 c | 3.28 b | 16.55 c | 48.71 d | 2255.3 d |
| **$S_2 \times T_2$** | 62.56 | 0.867 a | 3.44 a | 32.56 a | 99.34 a | 4304.5 a |
| **$S_2 \times T_3$** | 58.08 | 0.830 a | 3.06 c | 27.32 ab | 68.29 bc | 2959.3 bc |
| **$S_3$ (38 cm)** | | | | | | |
| **$S_3 \times T_0$** | 45.36 | 0.667 cd | 2.85 c | 25.52 c | 74.69 b | 2282.1 b |
| **$S_3 \times T_1$** | 42.79 | 0.483 d | 3.37 a | 17.90 d | 52.40 c | 1601.1 c |
| **$S_3 \times T_2$** | 53.59 | 2.333 a | 3.52 a | 37.48 a | 100.19 a | 3061.4 a |
| **$S_3 \times T_3$** | 50.50 | 0.893 b | 3.16 b | 29.85 bc | 87.97 ab | 2688.0 ab |
| HSD ($\leq 0.05$) | NS | 0.2150 | 0.1530 | 5.937 | 15.510 | 624.40 |

Means not sharing a letter in common within a row differ significantly at 5% probability.
NS = Non-significant, NSB = Number of monopodial branches, EI = Earliness index (%), OBPP = Opened bolls per plant, BW = Boll weight (g), SCYPP = Seed cotton yield per plant (g), SCY = Seed cotton yield per hactare (kg)