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Influence of sowing time and plant population on seed cotton yield

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ABSTRACT:

The present study was conducted to evaluate yield performance of cotton under various plant spacing by keeping normal to maximum plant population under four sowing dates. FH-NOOR cotton variety was sown in triplicate split-plot design having a net plot size measuring 5.45×3.78m, while keeping sowing dates as main-plot and plant populations as sub-plots. The results indicated that there was a significance difference among sowing dates, plant spacing and interaction between sowing dates and spacing for round all studied traits of cotton. It was found that the higher performance of cotton genotype was recorded for 24 inch plant spacing and six inch plant spacing for most of the studied traits under early and late sowing dates as compared with intermediate sowing dates. The highest plant population was recorded under six inch plant spacing and second date of sowing. The good fibre quality was found under 18 to 24 inch plant spacing under intermediate sowing dates. It was concluded from our study that the sowing date and plant spacing affects cotton yield and quality of fibre, so there is a need to grow cotton plants under optimum agronomic practices.

Keywords:

Gossypium hirsutum, Seed cotton, Sowing times, Plant population, Fibre strength.

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is known as the world's best trading crop because it plays a significant role in uplifting country`s economy. More than fifty countries of the world are growing cotton in tropical areas. In Pakistan, cotton gained importance due to its contribution with 1.5% in Gross Domestic Product (GDP) and 7.1% in agriculture (Anonymous, 2016). Pakistan is known to be the 4th producer and 3rd consumer of cotton in the world. In Pakistan, Punjab and Sindh contribute 80% and 20% production of cotton respectively (Anonymous, 2016). Cotton is a cash crop which provides fibre, oil, fuel wood and contributes a major part in the income of farmers of Pakistan. Cotton textile sectors play an important role in the national economic stream and proved to reduce poverty (Cororaton and Orden, 2008). Textile industry depends upon raw material provided by local grown cotton, about 63% need for edible oil in Pakistan is met by its seed (Iqbal *et al*., 2012a). Cotton is also used in pharmaceutical products like tarpaulin, cordage and belting.

Demand depends upon quality. Quality product can support textile industry and can be exported to other countries which results increase in income, reduces poverty and support the nation's economy. Condition of yield can get poor due to many biotic and abiotic factors such as weed infestation, insect pest, sowing too early or too late, improper use of genotypes according to the existing environment (Arshad *et al*., 2007; Abbas *et al*., 2016ab; Zia-ul-Hassan *et al*., 2014). Cotton yield reduction in Pakistan is due to many problems like improper nutrition, attack of insect and pests, reduced plant population, irrigation, poor germination but two agronomic practices cause major reduction if not managed properly, sowing time and plant population. Sowing time is the most important factor of yield reduction because if crop is not sown on proper time, it will not get suitable environment. Cotton seed needs warm soil condition and sowing should be started as the temperature is warm enough to support germination requirement. Cotton is very responsive to environment because it is a perennial crop which is sown annually (Shakeel *et al.*, 2009). Early plant sowing can cause poor germination and get attacked by insect and pests which results in reduced growth, reduced flowers, less boll formation and ultimately distinct loss in yield. Early sown cotton has more vegetative growth than yield (Iqbal *et al*., 2012a). It also reaches to early reproductive plant growth during hot months of the year causes serious yield loss (Rahman *et al*., 2007).

Late sowing have more negative effects on plant like burning of seedlings due to hot weather (heat stress), stunted growth which results in poor vegetation, reduction in sympodial branches, reduced flowering and hence reduction in bolls per plant ultimately. Plant won't get enough time to complete its phases and will try to complete with rapid speed and shorten its growth and reproductive stages. Late sowing also causes flowering and maturity in cold season which harms the yield (Elayan *et al*., 2015). Karavina *et al*. (2012) stated that sowing time severely affects the management of insect/ pest. Interaction of cultivar with sowing time is an important strategy to determine yield and quality in a specific environment (Campbell and Jones, 2005). Yield potential and fibre quality of cotton genotypes can be evaluated through sowing under different dates. Selection of genotype and proper sowing time increase vegetative growth, buds, nodes, flowers, bolls per plant and ultimately these factors will increase yield to a great extent and quality of product like fibre, oil etc. (Abbas *et al.,* 2015; Deho *et al*., 2012).

Plant population severely affects the yield. Optimum population of plants not only provide better yield but it also save inputs (Nadeem *et al.,* 2010). Plant population also affects the quantity and quality of fibre (Wrather *et al.,* 2008). Bednarz *et al.* (2006) reported about the problems like boll rot, increase plant height and delay maturity, fruit shedding and flower shedding

Table 1. ANOVA Table for plant population and cotton planting date and their effects on cotton seed yield and fibre quality

Source	df	Days taken to 1st bud	Days taken to 1st flower	1st Boll opening	Sympodial branches	Monopodial branches	Number of bolls	Boll weight (g)	Plant height (cm)	CLCV %	Plant population/ha	Seed cotton yield (kg)/ha	Fibre length (cm)	Fibre fineness
Replication	2	0.14583^{ns}	0.0625^{ns}	0.14583^{ns}	0.896^{ns}	0.20828^{ns}	28.77^{ns}	0.00180^{ns}	1104.77^{ns}	1.0208^{ns}	1.637E+07^{ns}	691217^{ns}	0.04206^{ns}	0.00141^{ns}
Days	3	2.05556*	23.2500*	5.07639*	135.333*	2.55419*	1072.13*	0.82602*	1529.81*	41.8611*	6.077E+07*	9402426*	2.03006*	0.20456*
Spacing	3	0.38889^{ns}	1.4722^{ns}	9.29861*	7.222*	2.13332*	322.91*	0.33065*	787.14*	2.3611*	3.440E+09*	3164103*	2.54183*	0.06308*
D×S	9	0.66667*	2.5648*	0.42824*	2.778*	0.26208^{ns}	93.11*	0.24124*	209.60^{ns}	2.4352*	9.804E+07*	322616*	2.80217*	0.06412*
Error	30	0.70139	0.9292	0.72361	4.407	0.15946	31.59	0.00061	169.50	0.5097	2.758E+07	173978	0.02918	0.00150
Grand mean		29.871	48.769	82.811	22.571	1.571	37.412	4.431	114.371	1.127	39216	3211	29.843	6.021
Standard error		0.2352	1.2056	1.0965	0.8652	0.0082	0.9756	0.0545	2.3412	0.0652	2.8732	1.2343	1.0072	0.7612

*=significant (P 0.05); ns=non-significant

caused by extra dense population. Proper management of plant population can provide maximum bolls per plant which results better lint production as well as great impact on quality (Siebert *et al*., 2006). Keeping in view the importance of relation between sowing time with suitable plant population, present study was planned to attain following objectives:

- To determine the optimum sowing time for a specific cultivar.
- To explore the potential yield of cultivar by sowing them at different densities.
- To investigate the impact of sowing date and plant density on seed cotton yield.

MATERIALS AND METHODS

The present study was conducted to evaluate yield performance of cotton under various plant spacing by keeping normal to maximum plant population under four sowing dates.

Experimental details

The experiment replicated thrice and was laid out according to split-plot design having a net plot size measuring 5.45×3.78m. The sowing dates were randomized as main-plots and plant populations as sub-plots. FH-NOOR was used as an experimental material.

Crop husbandry

Slight irrigation was applied to create favourable condition for seedbed preparation. At field capacity, field was cultivated with tractor mounted cultivator along with planking. FH-NOOR was sown on four different dates (15-April, 1-May, 15-May and 1-June) with different spacing (24, 18, 12 and 6 inches). The crop was sown on beds with hand chopa by using 20kg/ha fuzzy seed. Slight irrigation was applied in order to have successful germination. The crop was fertilized at 150-100-50 kg NPK/ha. All other agronomic and entomological practices were kept uniform and normal. The yield data recorded was analysed by using analysis of

Table 2. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (days taken for 1st bud)

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	29.667^{abc}	30.000^{abc}	29.667^{abc}	29.333^{bc}	29.667^{AB}
2	D_2	29.667^{abc}	29.667^{abc}	29.333^{bc}	28.667^{c}	29.333^{B}
3	D_3	30.000^{abc}	30.000^{abc}	29.667^{abc}	30.667^{ab}	30.083^{A}
4	D_4	31.000^{a}	29.667^{abc}	30.000^{abc}	30.333^{ab}	30.250^{A}
5	Mean	30.083^{A}	29.833^{A}	29.667^{A}	29.750^{A}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016; D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

variance technique (Steel, 1997).

RESULTS AND DISCUSSION

The results presented in Table 1 show the significant effect of sowing date on 1st bud emergence. Interaction of sowing date with plant spacing had significantly promoted 1st bud emergence of cotton. The significant effects of sowing date on formation of 1st flower of cotton were recorded while plant spacing had no significant effect on 1st flower formation. Interaction of sowing date and plant spacing significantly affected the formation of 1st flower of cotton. It was found from the results that maximum 31.00 days were taken to 1st bud under sowing date and plant spacing of 01-June at 24 inch. Significantly least value was recorded as 28.66th sowing date (1 May) and plant spacing (6 inch) were used. Plant spacing had no significant effect on 1st bud emergence (Table 2). As early sown varieties affect sympodial branches it ultimately affects early emergence of 1st bud which was also confirmed by the findings of Farrukh *et al.* (2009) and Deho *et al*. (2012).

Significantly a maximum of 50.00 (1st flower) data was recorded when sowing date and plant spacing was used as 01-June at 12 and 6 inch both. Significantly a less data of 44.66 (1st flower) was recorded which was statistically in par with 46.00 when sowing date and plant spacing were used as 15-April at 6 inch and 15-April at 18 inch respectively. Early sown cultivar with proper spacing promote early bud formation which ultimately produce early flowering and hence initiates early boll formation and opening thus can prevent 25% shedding (Table 3). These conclusions are similar to the findings of Farrukh *et al.* (2009), Deho *et al*. (2012), Khan *et al*. (2015) and Ullah *et al.* (2012).

The Table 4 presented data about 1st boll opening of cotton. Date of sowing had significant effect on 1st boll opening. Significantly maximum value 83.25 was recorded when sowing date was 01-May. Significantly least value 81.83 was recorded by using sowing date as 01-June which was statistically in par with 82.41 at 15-May. Plant spacing also significantly affects the 1st boll opening. Significantly maximum value was at-

Table 3. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (1st flower)

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	48.333^{bcd}	46.000^{ef}	47.000^{de}	44.667^{f}	46.500^{C}
2	D_2	48.667^{abc}	48.667^{abc}	50.000^{a}	48.667^{abc}	49.000^{AB}
3	D_3	48.000^{cd}	48.333^{bcd}	48.000^{cd}	48.667^{abc}	48.250^{B}
4	D_4	49.333^{abc}	49.667^{ab}	50.000^{a}	50.000^{a}	49.750^{A}
5	Mean	48.583^{A}	48.167^{A}	48.750^{A}	48.000^{A}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016; D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

Table 4. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (1st boll opening)

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	82.333^{bcde}	82.333^{bcde}	82.667^{abcde}	80.333^{g}	81.917^{B}
2	D_2	84.000^{a}	83.333^{abc}	83.667^{ab}	82.000^{cdef}	83.250^{A}
3	D_3	82.000^{cdef}	83.000^{abcd}	83.333^{abc}	81.333^{efg}	82.417^{B}
4	D_4	81.667^{defg}	82.333^{bcde}	82.667^{abcde}	80.667^{fg}	81.833^{B}
5	Mean	82.500^{A}	82.750^{A}	83.083^{A}	81.083^{B}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing S_4=6 inch plant spacing; D_1=15-04-2016; D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

tained as 83.08 which were statistically in par with 82.50 when spacing was used as 12 and 24 inch respectively. The least significant results were recorded as 81.08 when 6 inch spacing was used. Interaction of sowing date and plant spacing had no significant effect on 1st boll opening of cotton. Plant spacing and sowing date trigger 1st boll opening which may be due to early sown the variety reached to its physiological maturity early by getting more suitable temperature, environment and optimum plant to plant space which supports the plant to express its growth without any disturbance as compared to the late and narrow sown varieties. These results are similar with the findings of Iqbal *et al*. (2012b) and Deho *et al*. (2012).

The results from Table 5 show about the significant effect of sowing date on sympodial branches of cotton. Significantly a maximum data of 23.50 (sympodial branches) was recorded when date of sowing was used as 15-April. Least significant value was recorded as 15.50 while using sowing date as 01-June. Interaction of sowing date and plant spacing had no significant effect on sympodial branches of cotton, even when we use plant spacing as a sole factor, it had no significant response as well. These results are confirmed by the findings of the following researchers. Elongated plant height allows more sympodial branches to grow as compared to short statured plants, when subjected to early sowing condition. Khan *et al*. (2015) reported that sympodial branches are boll bearing branches, so more the sympodial branches there will be more bolls per plant which contributes in yield enhancement. This phenomena is applicable for same cultivars. Sympodial branches and boll bearing also depends upon genetic makeup which is different in different cultivars and time of sowing and have no impact (Deho *et al*., 2012; Batool *et al.,* 2010).

Results from table 6 show that date of sowing had significant effect on monopodial branches. Significantly maximum value was achieved as 1.62 when crop was sown at 15-April which was statistically at par with 1.31 where sowing date was 01-May. Significantly least value of monopodial was achieved at 0.69 which was

Table 5. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (sympodial branches)

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	23.000^{abc}	24.333^{a}	23.333^{ab}	23.333^{ab}	23.500^{A}
2	D_2	20.000^{bcde}	19.667^{cde}	22.667^{abc}	21.667^{abcd}	21.000^{B}
3	D_3	18.333^{def}	18.333^{def}	20.333^{bcde}	20.333^{bcde}	19.333^{B}
4	D_4	15.667^{fg}	14.000^{g}	15.333^{fg}	17.000^{efg}	15.500^{C}
5	Mean	19.250^{A}	19.083_{A}	20.417^{A}	20.583^{A}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016; D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

Table 6. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (Monopodial branches)

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	1.7733^{abc}	1.8633^{ab}	1.7733^{abc}	1.1067^{de}	1.6292^{A}
2	D_2	1.1600^{cde}	1.9967^{a}	1.4433^{abcd}	0.6633^{efg}	1.3158^{A}
3	D_3	0.3300^{fg}	1.4400^{abcd}	0.6633^{efg}	0.3300^{fg}	0.6908^{B}
4	D_4	1.2200^{bcde}	0.8833^{def}	0.7733^{ef}	0.0000^{g}	0.7192^{B}
5	Mean	1.1208^{B}	1.5458^{A}	1.1633^{B}	0.5250^{C}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016; D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016.

statistically in par with 0.71 when date of sowing was used as 15-May and 01-June respectively. Data in given table also showed significant results of plant spacing on monopodial branches. Significantly a maximum value 1.54 was achieved at 18 inch spacing, while least significant value was achieved as 0.52 at 6 inch plant spacing. Interaction of sowing date and plant spacing had no significant effect on the monopodial branches. Monopodial branches are greatly affected by the sowing time because early sown varieties are subjected to that temperature and solar duration that physiologically affected the monopodial branches in a positive manner. On the other hand, plant spacing allowed plant to grow its canopy according to its potential due to this, plant can promote its monopodial branches. These results are in line with the findings of Ullah *et al.* (2012).

The results provided in Table 7 show that number of bolls were significantly enhanced by the effect of sowing date and plant spacing. Interaction of plant spacing and sowing date had significantly affected the number of bolls per plant. Significantly a maximum value of 58.66 was recorded when sowing date and plant spacing was used as 15-April at 24 inch. Whereas least significant value was recorded as 17.33 where 01-June at 6 inch sowing date and plant spacing were used. Out of the many factors it might be one of them that bolls per plant increases as an increase in the sympodial branches. Khalid *et al.* (2016) reported that there is an increase in 25% bolls per plant in early sown cotton cultivars and have less boll shedding per plant which ultimately supported yield enhancement. Ali *et al*. (2009) reported that due to moderate temperature of environment for early sown variety; photosynthates were translocated easily which fulfilled plant nutrient needs that support more number of bolls. These results are also confirmed by the findings of Ullah *et al.* (2012), Hakoomat *et al.* (2011), Iqbal *et al*. (2012b) and Deho *et al*. (2012).

The data provided in Table 8 show the signifi-

Table 7. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (number of bolls)

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	58.667^{a}	42.000^{b}	39.667^{bc}	32.000^{cde}	43.083^{A}
2	D_2	33.000^{bcde}	38.667^{bcd}	38.000^{bcd}	26.667^{efg}	34.083^{B}
3	D_3	24.333^{efg}	27.000^{ef}	29.333^{de}	19.333^{fg}	25.000^{C}
4	D_4	27.667^{ef}	25.333^{efg}	18.667^{fg}	17.333^{g}	22.250^{C}
5	Mean	35.917^{A}	33.250^{A}	31.417^{A}	23.833^{B}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016 D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

Table 8. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (boll weight (g))

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	3.9567^{k}	4.2200^{h}	4.6300^{f}	5.0290^{a}	4.4589^{C}
2	D_2	4.1333^{i}	4.6700^{ef}	4.7000^{de}	4.8067^{c}	4.5775^{B}
3	D_3	5.0060^{a}	4.7333^{d}	4.7967^{c}	4.9367^{b}	4.8682^{A}
4	D_4	4.3340^{g}	4.3470^{g}	4.0167^{j}	4.2563^{h}	4.2385^{D}
5	Mean	4.3575^{D}	4.4926^{C}	4.5358^{B}	4.7572^{A}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016
D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

cant effect on boll weight of cotton when different sowing dates and plant spacing were used. The interaction of sowing date and plant spacing had a huge positive effect on boll weight of cotton. Significantly maximum boll weight was obtained 5.02 in 15-April at 6 inch sowing date and plant spacing was used which were statistically at par with 5.00 when sowing date and plant spacing was used as 15-May at 24 inch. Significant boll weight (3.95g) was obtained when sowing date and plant spacing were used as 15-April at 24 inch. Due to moderate temperature of the environment for early sown variety, photosynthates were translocated easily which fulfilled plant nutrient needs due to which accumulation in boll is enough to support better lint production. These results were also conformed by the findings of Ali *et al*. (2009), Deho *et al*. (2012) and Hakoomat *et al.* (2011).

The data presented in Table 9 show that the time of sowing had significant effect on the plant height of cotton. Significantly maximum 126.08 cm plant height was recorded in 15-April and it was statistically in par with the plant height 116.33cm at the sowing date 01-May. Significantly less plant height 99.42cm was recorded at 01-June which was statistically in par with 15-May where 109.0cm height of plant was obtained. Data presented in above given table showed that plant population had significant effect on the plant height of cotton. Significantly maximum plant height 123.83cm was recorded when plant population was 87120 plant/ha and it was statistically in par with 113.67cm plant height where plant population (43560 plant/ha) was recorded. Significantly less plant height (93.33cm) was recorded which had 29040 plant/ha and was statistically in par with 21780 plants/ha which had plant height (97.33cm). Interaction of sowing date on different plant spacing had no significant effect on the plant height. The plant height depends upon the genetics of cultivar (Batool *et al*., 2010). Height of plant mainly depends upon existing environmental conditions. Early sown varieties have more plant height as compared to the late sown because early varieties have more duration of growth than late ones. The above given results were confirmed by the findings of Hakoomat *et al.* (2011), Ullah *et al.* (2011),

Table 9. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (plant height (cm))

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	113.0^{bcde}	124.33^{abc}	123.67^{abc}	143.33^{a}	126.08^{A}
2	D_2	113.67^{bcde}	109.67^{bcdef}	116.67^{bcd}	125.33^{ab}	116.33^{AB}
3	D_3	99.67^{def}	103.0^{cddef}	124.00^{abc}	109.33^{bcdef}	109.0^{BC}
4	D_4	97.33^{def}	93.33^{ef}	89.67^{f}	117.33^{bcd}	99.42^{C}
5	Mean	105.92^{B}	107.58^{B}	113.50^{AB}	123.83^{A}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016
D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016.

Table 10. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (CLCV%)

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	0.0000^{d}	0.0000^{d}	0.0000^{d}	0.0000^{d}	0.0000^{B}
2	D_2	0.0000^{d}	0.0000^{d}	0.0000^{d}	0.0000^{d}	0.0000^{B}
3	D_3	0.3333^{d}	0.6667^{cd}	0.0000^{d}	$O.3333^{d}$	0.3333^{B}
4	D_4	1.6667^{c}	3.6667^{b}	4.0000^{b}	6.0000^{a}	3.8333^{A}
5	Mean	0.5000^{B}	1.0833^{AB}	1.0000^{AB}	1.5833^{A}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016
D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

Iqbal *et al*. (2012a) and Deho *et al*. (2012).

The results presented in Table 10 show that sowing date and plant spacing had significant results on eradication of Cotton Leaf Curl Virus (CLCV) of cotton. Interaction of different sowing dates with various plant spacing successfully eradicates CLCV. Significantly maximum CLCV was recorded as 6.00 when sowing date and plant spacing were as 01-June and 6 inch. Significantly least CLCV was detected as 0.00 which was statistically on par with 0.66 when sowing date and plant spacing were 15-April and 24 inch; 15-May and 18 inch respectively. It is in the genetics of the plant to protect itself from virus and other diseases (Batool *et al*., 2010). Early sown varieties have minimum virus infestation that might be due to available temperature and other environmental conditions as compared with late sown varieties because early sown varieties are subjected to that temperature in which virus is inactive and plants get enough time to get mature and protect themselves. These results are confirmed by the findings of Muddassir *et al.* (2016).

The results from Table 11 show that date of sowing had no effect on plant population while plant spacing significantly affect the population of cotton plants. Interaction of plant spacing with different sowing dates had significantly provided better plant population. Significantly maximum plant population was achieved as 70180 when sowing date and plant spacing were 15-April and 6 inch. Least significant density was achieved as 17747 which were statistically in par with 26055 when sowing date and plant spacing were 15-April and 24 inch; 01-June and 18 inch respectively. Plant spacing is crucial to get proper plant population. More or less than a optimum limit, it causes reduction in yield, quality and quantity (Hakoomat *et al*., 2011). Proper plant population can save input cost and help plant to perform better in the existing environment as it gets better light, water and air. These findings were supported by the work of Siebert *et al*. (2006), Elayan *et al*. (2015), Karavina *et al*. (2012) and Nadeem *et al.*

Table 11. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (plant population/ha)

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	17747^{g}	26620^{f}	35493^{de}	70180^{a}	37510^{A}
2	D_2	20973^{fg}	27911^{ef}	41947^{cd}	60177^{b}	37752^{A}
3	D_3	17747^{g}	29040^{ef}	39527^{cd}	45173^{c}	32872^{B}
4	D_4	20973^{fg}	26055^{fg}	37913^{cd}	58080^{b}	35755^{AB}
5	Mean	19360^{D}	27407^{C}	38720^{B}	58403^{A}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016
D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

Table 12. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (seed cotton yield (kg/ha))

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	3359.3^{cd}	3603.3^{bc}	4190.0^{ab}	4745.0^{a}	3974.4^{A}
2	D_2	3064.7^{cde}	3581.3^{bc}	3718.7^{bc}	4758.7^{a}	3780.8^{A}
3	D_3	2379.0^{ef}	3234.3^{cd}	3468.3^{c}	3121.3^{cd}	3050.7^{B}
4	D_4	1742.0^{fg}	1621.0^{g}	1952.0^{fg}	2766.7^{de}	2020.4^{C}
5	Mean	2636.2^{C}	3010.0^{B}	3332.3^{B}	3847.9^{A}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016; D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

Table 13. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (fibre length (mm))

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	28.443^{fg}	28.790^{de}	29.303^{c}	28.277^{fg}	28.703^{C}
2	D_2	28.220^{g}	29.953^{b}	30.537^{a}	29.287^{c}	29.499^{AB}
3	D_3	29.933^{b}	30.697^{a}	27.767^{h}	30.007^{b}	29.601^{A}
4	D_4	29.810^{b}	30.567^{a}	28.550^{ef}	28.867^{d}	29.448^{B}
5	Mean	29.102^{B}	30.002^{A}	29.039^{B}	29.109^{B}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016; D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

(2010).

The results provided in Table 12 showed that date of sowing had significant effect on cotton seed yield. Significantly maximum cotton seed yield was recorded as 3974.4kg/ha which was statistically on par with 3780.8kg/ha where sowing date were 15-April and 01-May respectively. Significantly less cotton seed yield was recorded as 2020.4kg/ha where crop was sown at 01-June. Plant spacing also significantly increased seed cotton yield, maximum value was obtained as 3847.9kg/ha where plant spacing was used as 6 inch. Significantly least cotton seed yield was recorded as 2636.2kg/ha where plant spacing was used as 24 inch. Interaction of sowing date and plant spacing had no significant effect on cotton seed yield. Cotton seed yield might be affected the by time of sowing as well as population. If a crop is sown on proper time it will get suitable environment which trigger photosynthetic activity in plant that supports more food production which ultimately help the plant to express its potential. On the other hand plant population is directly proportional to yield, because more the plants there will be more branches, leaves, bolls which produce lint and seed. So proper time and population not only increase the cotton

Table 14. Comparison of treatment means for plant population and the effect of cotton planting dates on seed cotton yield and fibre quality (fibre fineness (µg/inch))

S. No	Days of sowing	Plant spacing				
		S_1	S_2	S_3	S_4	Mean
1	D_1	6.0833^{c}	5.8300^{efg}	5.8333^{ef}	5.8333^{ef}	5.8950^{c}
2	D_2	6.4100^{a}	6.1733^{b}	6.0500^{c}	6.0600^{c}	6.1733^{a}
3	D_3	5.8600^{ef}	5.9567_{d}	5.9567^{d}	6.0433^{c}	5.9542^{b}
4	D_4	5.8667^{e}	5.8000^{fg}	5.7667^{g}	6.1800^{b}	5.9033^{c}
5	Mean	6.0550^{a}	5.9400^{b}	5.9017^{c}	6.0292^{a}	

Means sharing the different letters are significantly different from each other's at 0.05%.
S_1=24 inch plant spacing; S_2= 18 inch plant spacing; S_3= 12 inch plant spacing; S_4=6 inch plant spacing; D_1=15-04-2016; D_2=01-05-2016; D_3=15-05-2016; D_4=01-06-2016

seed yield but also provide better quality products. These findings are supported by the work of Ullah *et al.* (2011), Hakoomat *et al*. (2011) and Nadeem *et al.* (2010).

The results from Table 13 showed that date of sowing and different plant spacing had significant effect on the fibre length of cotton. According to the given data, the interaction of maximum fibre length 30.69, 30.56 and 30.53 were recorded at 15-May and 18 inch; 01-June and 18 inch; 01-May and 12 inch date of sowing and plant spacing respectively. Significantly less fibre length 28.22 was recorded at 01-May and 24 inch which was statistically on par with 28.44 where 15-April and 24 inch date of sowing and plant spacing were used. Fibre length was affected due to physiological changes imposed by the environment. When suitable temperature and space were given to the plant, photosynthetic assimilation provide optimum energy to fulfil all the needs which results better fibre length (Ullah *et al.,* 2011). These results are confirmed by the findings of Deho *et al*. (2012) and Wrather *et al.* (2008).

The results presented in Table 14 showed that different sowing dates and plant population significantly effect fibre fineness of cotton. According to the provided data it is concluded that interaction of sowing dates and plant population had significant effect on fibre fineness. Significantly maximum fibre fineness 6.41 data was recorded at 01-April and 24 inch sowing date and plant spacing. Significantly less fibre fineness was recorded as 5.76 which was statistically on par with 5.80 when sowing date and plant spacing were 01-June and 12 inch; 01-June and 18 inch respectively. Though there are many requirements but when a crop is sown on the proper time and place then it performs well in many aspects and demand of energy is fulfilled when required agronomic practices were uniform. It supports ideal growth which results better quality and quantity of the fibre. These results are conformed by the findings of Siebert *et al*. (2006), Deho *et al*. (2012) and Ullah *et al.,* (2011).

CONCLUSION

Our study concluded that the sowing date and plant spacing affects cotton yield and quality of fibre, so there is a need to grow cotton plants under optimum agronomic practices.

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