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Effect of Nitrogen Levels and Plant Spacing on Growth and Yield of Cotton

Muhammad Ather Nadeem, Asghar Ali, Muhammad Tahir, Muhammad Naeem[1], Asim Raza Chadhar and Sagheer Ahmad
Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
[1]University College of Agriculture and Environmental Sciences, Islamia University, Bahawalpur, Pakistan

Abstract
Growth and yield response of cotton to different nitrogen levels and plant spacing was studied at farmer's field at Tandlianwala, Faisalabad. The experiment comprised three plant spacings viz. 10, 20 and 30 cm with three nitrogen levels i.e. 50, 100 and 150 kg ha^{-1}. Plant spacing and nitrogen levels had significant differences for yield components and seed cotton yield. Plant spacing of 20 cm with nitrogen level of 100 kg ha^{-1} produced more seed cotton yield due to more number of monopodial, sympodial branches, number of bolls per plant, Average boll weight and 100 cotton seed weight. So, to grow cotton under agro-ecological conditions of Tandlianwala, Faisalabad, plant spacing of 20 cm and 100 kg nitrogen per hectare is recommended.

Key words: Plant spacing, Nitrogen, Cotton, Yield.

Introduction
Cotton (*Gossypium hirsutum* L.) is considered as mainstay of Pakistan's economy. It is an important cash crop, major source of foreign exchange and plays an important role in agriculture, industry and economic development of the country. In Pakistan cotton is grown on an area is 3.22 million hectares with total production of 12417 thousand bales and average seed cotton yield of 732 kg ha^{-1} (Anonymous, 2007). Despite of concerted efforts of breeders and agronomists, yield per unit area is still far below from many other cotton producing countries of the world. Low yield of cotton in Pakistan is attributed to some production as well as economic constraints. Poor quality seed, low seed rate, low plant population, poor management or agronomic practices, conventional sowing methods, imbalanced fertilizer application, weed infestation and insect attack are main causes of its low yield. In cotton plant, spacing has effects on the growth and yield characteristics of the plant. Plant population (density) is very important for attaining optimum crop growth and yield under irrigated conditions. Mostly, farmers maintain plant spacing and density according to their traditional methods of planting rather than variety requirement and hence do not obtain the high crop yield. Hussain *et al.* (2000) reported that 30 cm spacing between cotton plants increased plant height, number of bolls per plant and boll weight as compared to 10 cm and 20 cm. However, plant spacing did not affect ginning out turn or fiber quality. On the other hand Muhammad *et al*. (2002) found that boll weight decreased by increasing plant population. The field conditions that produce short stature plants can generally tolerate higher plant density without incurring significant yield reduction (Hake *et al*., 1991). Adequate plant population facilitates the efficient use of applied fertilizers and irrigation (Abbas, 2000). When density is low, fruiting branches are longer and a greater percentage of bolls are produced on outer position of fruiting branches but first position bolls produced by high density are the biggest and best resulting in high yield. Fruit initiation was influenced by plant density in upland cotton (Buxton *et al*., 1977).

As far as fertilizers are concerned judicious use of nitrogenous fertilizer is more important. Nitrogen is an essential nutrient for cotton that affects plant growth, fruiting and yield (Boquet *et al*., 1994). Nitrogen plays a dominant role in growth processes as it is an integral part of chlorophyll molecule, a constituent of enzyme molecules, protein and nucleic acids (Marschner, 1986). Nitrogen fertilizer requirements depend on many factors including yield goal, inorganic soil type and numerous environmental factors. (Powers and Schepers, 1989). Future elevated CO_2 will not have any deleterious effects on fiber quality if nitrogen is optimum (Reddy *et al*., 2004).

Realizing the immense importance of cotton crop, there is a dire need to improve the yield potential of the crop under the local environmental conditions. Keeping all these points in view, a research framework was made with the purpose to evaluate the effect of plant spacing and different nitrogen levels on seed cotton yield, under the agro-ecological conditions at Tandlianwala, Faisalabad.

Corresponding Author: M. Ather Nadeem
Department of Agronomy
University of Agriculture, Faisalabad Pakistan
Email: drman@uaf.edu.pk

Materials and Methods

The study pertaining to the effect of different nitrogen levels and plant spacing was conducted at farmer's field at Tandinawala, Faisalabad during 2007. The experiment was laid out in split plot design using three replications. Plant spacing was randomized in main plots while nitrogen in subplots. The experiment comprised three levels of plant spacing viz. 10, 20 and 30 cm with three nitrogen levels i.e. 50, 100 and 150 kg ha^{-1} with net plot size of 6.0 x 3.0 m. Cotton variety N-884 was sown on 25^{th} of May, 2007 with single row hand drill in 75 cm apart rows using seed rate of 20 kg ha^{-1}. Phosphorus @ 60 kg ha^{-1} and prescribed doses of nitrogen was applied as single super phosphate and urea, respectively. Whole of the phosphorus and half of the nitrogen was side dressed at sowing while remaining half nitrogen was top dressed with first irrigation. All other agronomic practices were kept uniform for all the treatments. Ten plants were selected to record number of monopodial and sympodial branches per plant, number of bolls per plant and seed cotton weight per boll. Three samples of 100 seeds were taken at random from each plot to record 100 cotton seed weight. The seed cotton yield was recorded on per plot basis and was converted to kg ha^{-1}. Nitrogen uptake efficiency and nitrogen use efficiency was calculated according to the procedure described by Reynolds *et al*. (2001). Data collected was analyzed statistically by applying Fisher's analysis of variance technique. Least significant difference (LSD) test was employed at 5% probability level to test the significance of the treatments' means (Steel *et al*., 1997).

Results and Discussion

Number of monopodial branches per plant is an important yield component that plays an important role in final yield. The data regarding number of monopodial branches per plant are given in Table 1. It is clear from the Table that the number of monopodial branches per plant of cotton was affected significantly by plant spacing. Significantly maximum plant height was recorded in plots where plant to plant distance of 20 cm (P_2) was maintained. The minimum number of monopodial branches was obtained with plant spacing of 10 cm (P_1) which, however, was statistically similar to 30 cm (P_3) plant spacing. Similarly, Nitrogen levels affected the monopodial branches significantly. Significantly the maximum number of monopodial branches was obtained with application of 100 kg N ha^{-1} (N_2) while, minimum was recorded with 50 kg N ha^{-1} (N_1) which, however, was statistically similar to 150 (N_3). The interaction between plant spacing and nitrogen levels was found to be non-significant. The minimum number of monopodial branches with N_1 might be due to deficiency of the nutrients resulting in poor growth. Graig *et al.* (2000) also reported the similar results. The minimum number of monopodial branches by the plants at spacing of 10 cm can be attributed to less space due to closer plants. The results are in line with those of Alfaqeih (2002) and Ali *et al.* (2009) who reported lower number of monopodial branches with closer spacing.

The number of sympodial branches per plant is a key factor which contributes to the final yield. The yield is directly related to the number of sympodial branches $plant^{-1}$. More the number of sympodial branches per plant, more will be the yield. The data regarding number of sympodial branches $plant^{-1}$ is given in Table 1 which shows that number of sympodial branches per plant varied significantly among different plant spacing under study. The 30 cm plant spacing (P_3) gave the maximum number of sympodial branches per plant (24.00) and was statistically at par with 20 cm plant spacing. The minimum number of sympodial branches was recorded with plant spacing of 10 cm. Maximum number of sympodial branches at greater plant spacing can be attributed to less competition for nutrients and more light penetration among plants. The effect of nitrogen levels on number of sympodial branches was also significant. The maximum number of sympodial branches per plant was observed in nitrogen level of 150 kg ha^{-1} (N_3) which was statistically similar to 100 kg ha^{-1} (N_2). The minimum number of sympodial branches was recorded with plant spacing of 10 cm. The interaction between nitrogen levels and plant spacing was non-significant. Higher number of sympodial branches with wider plant spacing might be due to less competition and more light penetration and availability of space. The results are in line with those of Ali *et al.* (2009) who reported more number of sympodial branches in plants sown with wider spacing.

The yield of cotton crop depends upon the number of bolls per plant. It is directly related to the final yield. The data representing number of bolls per plants are given in Table-1 which indicates that all the treatments related to plant spacing produced significantly different number of bolls per plant. The minimum number of bolls per plant was recorded with 10 cm plant spacing. The maximum number of bolls was observed in 20 cm. The 30 cm plant spacing produced significantly more number of bolls than 10 cm spacing but less than 20 cm plants spacing. The interaction between plant spacing and nitrogen levels was non-significant. Effect of different nitrogen levels on number of bolls per plant was significant. Increase in nitrogen from 50 kg to

Table 1 Effect of different nitrogen levels and plant spacing on growth and yield components of cotton

	No. of monopodial branches	No. of sympodial branches	Number of bolls per plant	Av. Boll weight (g)	100 cotton seed weight (g)	Nitrogen uptake (kg ha^{-1})	Nitrogen Uptake Efficiency (kg kg^{-1})	Nitrogen Use Efficiency (kg kg^{-1})
Nitrogen levels (kg ha^{-1})								
N_1= 50	1.04b	24.39b	18.78c	2.79c	6.22c	48.97c	0.98a	41.85a
N_2= 100	1.35a	23.31ab	23.22a	3.43a	6.56b	76.56b	0.77b	22.84b
N_3= 150	1.25a	23.26a	19.11b	3.27b	7.61a	85.38a	0.57c	15.01c
LSD	0.197	0.021	1.14	0.148	0.229	5.324	0.124	2.048
Plant spacing (cm)								
P_1= 10	1.11b	23.17b	19.66c	2.58c	6.62b	74.35	0.74	21.75
P_2= 20	1.20a	23.78ab	20.88a	3.78a	6.76ab	75.15	0.75	22.44
P_3= 30	1.14b	24.00a	20.56b	3.11b	7.02a	74.33	0.74	22.09
LSD	0.050	0.01	0.39	0.09	0.298	NS	NS	NS
Inter- action	NS	NS	NS	NS	NS	NS	NS	NS

Any two means not sharing a letter in common differ significantly at 5% probability level

100 kg ha^{-1} resulted in significant increased in significant number of bolls per plant. 150 kg ha^{-1} nitrogen showed the decline number of bolls per plant. This is due to the excessive vegetative growth of plant due to high rate of nitrogen. These results are in line with those reported by Hooger and Gidnavar (1997) and Siddiqui, 2007. They revealed that number of bolls per plant decreased with increasing plant density.

Boll weight is a vital contributor towards final yield of cotton crop. From present study it was concluded that the average boll weight was significantly affected by the plant spacing and the highest boll weight was attained when crop was sown at 20 cm plants spacing and given nitrogen what was statistically at par with P_3 N_3. Average boll weight showed a decreasing trend with increased nitrogen at each level of plant spacing. The plant spacing 10 cm resulted minimum boll weight. The boll weight increased with increase plant spacing up to 20 cm and further increase in plant spacing resulted in significant decrease in boll weight the maximum boll weight was recorded 3.78 and minimum 2.58 with plant spacing 20 and 10 cm respectively, matching with the results of Ali *et al.* (2009). The nitrogen levels also significantly affected the boll weight and the highest boll weight was achieved in N_2 (3.43). The minimum was recorded in N_1 (2.79). The interaction between plant spacing and nitrogen levels was also significant (Table 1).

100-cotton seed weight is the key factor contributing to the seed cotton yield. Data regarding 100-cotton seed weight are presented in Table 1. The perusal of the table indicates that plant spacing differed significantly with respect to 100-cotton seed weight. The plant spacing of 30 cm resulted in maximum 100 cotton seed weight but was statistically at par with 20 cm. The minimum 100 cotton seed weight (6.62 g) was obtained from the 10 cm plant spacing which was also statistically similar 20 cm plant spacing. The data regarding nitrogen levels indicated statistically significant test weight. The minimum seed cotton weight was recorded when nitrogen was applied 50 kg ha^{-1}. The cotton seed weight increased significantly with each increase nitrogen level and maximum seed cotton weight was obtained with 150 kg ha^{-1}. The interaction between plant spacing and nitrogen levels was non-significant. These results are almost similar to the findings of El-Gahel *et al* (1991).

Nitrogen uptake, nitrogen uptake efficiency and nitrogen use efficiency were significantly affected by variation in amount of nitrogen applied. More nitrogen was taken up by the plants in case of N_3 where it was applied in maximum amount. Nitrogen uptake decreased significantly with the decrease in rate of nitrogen application. On the other hand nitrogen uptake efficiency and nitrogen use efficiency were higher in lower dose of nitrogen (50 kg ha^{-1}), which may be due to effective utilization of available nitrogen by the plants. Nitrogen uptake efficiency and nitrogen use efficiency decreased with the increasing amount of nitrogen (100 and 150 kg ha^{-1}, respectively) as there may be losses of nitrogen due to volatilization and leaching. Plant spacing had non-significant effect on nitrogen uptake, nitrogen uptake efficiency and nitrogen use efficiency.

The final yield is the function of combined effect of all the yield components under a particular set of environmental conditions. Data regarding seed cotton yield are given in the Table 2. The perusal of the Table indicated that the plant spacing and different levels of nitrogen had significant effect on the seed cotton yield while their interaction was also significant. The perusal of the Table further indicated that plant spacing of 20 cm gave maximum seed cotton yield (Kg ha^{-1}) and it was statistically higher than any other plant spacing under study. The minimum seed cotton yield (Kg ha^{-1}) was found in case of plants sown at 10 cm plant spacing. The plant spacing of 30 cm remained midway between the treatments P_1 and P_3. As far as the different nitrogen levels are concerned N_2 gave more seed cotton yield (Kg ha^{-1}) than that of N_3 and N_1. These results are in line with Ali *et al.* (2009). The reason for production of more seed cotton yield in N_2 was that the nitrogen was used more efficiently than all other levels and helps in boosting reproductive phases of the crop.

Therefore, it is suggested that among different plant spacing (10 cm, 20 cm and 30 cm) and different nitrogen levels (50, 100 and 150 kg ha^{-1}), 20 cm plant spacing with 100 kg of nitrogen per hectare are optimum for cotton crop under agro-ecological conditions of Tandlianwala, Faisalabad. This result shows that nutrients are available to the cotton crop at all growth stages by above combination, that is why, crop gives maximum seed cotton yield as compared to other combination of plant spacing and nitrogen levels.

Table 2 Effect of nitrogen levels and plant spacing on seed cotton yield (t ha^{-1})

	Plant spacing (cm)			Means
Nitrogen Levels (kg ha^{-1})	**P_1=10**	**P_2=20**	**P_3=30**	
N_1=50	2068.33c	2118.32d	2091.33d	2092.67C
N_2=100	2234.00e	2331.66a	2286.67b	2284.11A
N_3=150	2223.00f	2281.33b	2250.00c	2251.56B
Mean	2175.22C	2243.78A	2209.33B	

Any two means not sharing a letter in common differ significantly at 5% probability level.

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