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EFFECTS OF PLANT SPACING AND NITROGEN FERTILIZER LEVELS ON COTTON YIELD AND GROWTH

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Abstract: Cotton (Gossypium hirsutum L.) is main profitable fiber crops. Plant spacing (Sp) and nitrogen fertilizer (N) applications plays major role to obtain high cotton yield, therefore the present study focused on it. The aims of this study were examine effects and suggest appropriate Sp, N and their interactions for higher cotton yield. The treatments included plant spacing Sp1= 15cm, Sp2=23cm, Sp3=30cm and nitrogen levels (F0=0 kgNPKha–1, F1=50kgNha–1, F2= 100kgNha–1, F3=150kgNha–1). Seed cotton yield was significantly affected by Sp, N and their interaction. The other parameters such as plant height, total bolls per plant, seed cotton weight per plant, staple length and GOT % recorded maximum at 30cm plant spacing and significantly affected by Sp, N but their interaction was not significant. It may be concluded from the study, CRIS-342 significantly enhanced seed cotton yield when grown at plant spacing 23cm with the application of 150Nkgha-1.
Keywords: Cotton, Plant spacing, Nitrogen fertilizer, Yield.

1. Introduction

In present years, cotton has become the main cash crop for local farmers due to its high earnings, net income and main profitable fiber. Therefore it is usually called ‘White Gold’. (Taisheng Du et al.2008). Application of Nitrogen fertilizer is a crucial management practice because it affects the maturity, yield, and fiber quality of cotton (Hutmacher et al. 2004). During the previous numerous decades, the significant increase in using fertilizer nitrogen (N) was carried out (Johnston 2000). The effects of planting date, plant spacing, genotypes on seed cotton yield, its components, ginning out turn (GOT%), and fiber quality traits are significant. High seed cotton yield can be obtained at high plant spacing in early sowing (Muhammad Iqbal and Mueen Alam Khan 2011). Whereas excess application of N results in excessive vegetative growth which can prevent boll formation, holding and increases defoliant applications (Cisneros and Godfrey 2001), declines profitable return and pollutes the environment respectively (Boquet and Breitenbeck 2000; Howard et al. 2001).

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Recently, new cotton cultivars have more response to N application than that of obsolete cultivars. Nitrogen fertilization analysis and management practices around the cotton belt influence by N requirement (Boquet and Breiten beck 2000; Bondada and Oosterhuis 2001; Bronson et al. 2001; Boquet et al. 2005; Pettigrew and Adamczyk 2006; Pettigrew and Zeng 2014).

The purpose of cultural methods is receiving international concentration to enhance crop effectiveness against weeds and therefore develops a significant constituent of an integrated weed management (IWM) system (Gibson et al. 2002; Chauhan & Johnson 2010b; Chauhan et al. 2010). One of such cultural methods is the decrease of row spacing to enhance crop competitive capacity against weeds (Knezevic et al. 2003, 2007, 2013, 2015, Kristensen et al. 2008; Mashingaidze et al. 2009; Chauhan & Johnson 2010a).Leaf senescence was put off because of increasing plant spacing and N rate decreased boll load combination of lessened boll weight and nutritional influence. Medium plant density with moderate N rate or high plant density with low N rate improve cotton yield and decrease cost in the Yellow River Delta of China and other areas with similar ecologies (Hezhong Dong et al; 2012).

The specificity of cotton N application is higher at primary bloom than that of at any further growth (Bell et al. 2003; Fritschi et al. 2004).

While high plant density and additional N can enhance total plant biomass per unit ground area and final reproductive allocation as denoted by harvest index was mostly decreased by high plant density or additional N because of excessive growth and lower lint yield (Ali et al. 2009). Plant spacing or N fertilization significantly affects cotton plant growth and yield, and their single effects have been well recognized (Bondada et al.1996; Boquet et al.1993; Bednarz et al.2000, 2005). Low soil fertility and poor field management created a big challenge to increase cotton yield in the area (Dong et al.2009, 2010a). Plant spacing and fertilizer application especially nitrogen plays major role in the cotton production. Therefore the present study focused on plant spacing and nitrogen application. To suggest most appropriate nitrogen level and plant spacing for higher yield and quality characters of cotton.

2. Materials and Methods

The study conducted at experimental field of cotton research institute of sakrand during summer season. The variety was CRIS-342 and designed by split plot design with three replications. The plot size was 5x8m (40m2). The agronomic practices followed according to recommendations of cotton research institute sakrand, for growing of cotton crop. The sowing was done on flat bed in the month of May, with hand drill, treat the seeds with sulfuric acid (H_2SO_4), and 5-6kg seeds acre. The treatments of plant spacing, which is the main plot, are P1/P2/P3, for the level of 15.0cm, 23.0cm and 30.0cm, respectively; the treatment of nitrogen fertilizer, which is the sub plot, are F0/F1/F2/F3, the level of N, P and K is 0-0-0, 50-50-0, 100-50-0, 150-50-0 per ha, respectively. We irrigated six times during the growth period, the nitrogenous fertilizer urea applied at various stages just before irrigation, weeding and inter culturing carried out after two irrigations. The picking started in the first week of October, when more than 50% bolls observed to open.

2.1. Observations Recorded

On the basis of randomly selected ten plants in each plot, the following observation recorded: The plant height (cm) recorded at crop maturity from soil surface up to tips of plant before picking. The total bolls per plant recorded before picking, when bolls fully mature. Seed cotton weight (g) per plant calculated from each plant by dividing the seed cotton yield per plant by number of bolls per plant. The average bolls weight calculated by formula:-

$$\text{Boll weight}\left(\text{g}\right) = \frac{\text{Weight of seed cotton yield per plant}}{\text{Number of bolls per plant}}$$

The seed cotton yield per plot calculated at maturity from each plot. The seed cotton collected in gunny bags from each plot separately and weighted on electronic balance in kilograms. Staple length is the observation taken from fiber length and measured in millimeters. GOT% is the percentage of seed lint and calculated by weight of 100 seed lint. GOT% formula:

$$\text{GOT \%} = \frac{\text{Weight of lint}}{\text{Weight of seed cotton}}$$

3. Results

The results on mean performance of the experiment are given in table. The results on individual parameter are discussed:

3.1 Plant height

The data for mean plant height (cm) of cotton crop variety CRIS-342 as influenced by different levels of nitrogen and plant spacing is shown in table. It may be seen from the table that differences in plant height due to plant spacing and nitrogen fertilizer levels were significant (P□0.01), while the interaction of plant spacing X nitrogen fertilizer levels was non-significant.

It observed that plant spacing 30cm resulted in maximum plant height (117.0cm), followed by 23cm plant spacing plant height (116.42cm), while 15cm plant spacing displayed lowest plant height (114.84cm). The results revealed that cotton fertilized with nitrogen 150kgha–1 resulted in maximum plant height (130.22cm), followed by 50kgNha–1 (123.22cm) and 100kgNha–1 (127.67cm) respectively, while 0kgNha–1 displayed lowest plant height (83.22cm).The results further explains that the interaction of plant spacing 30 cm and nitrogen level 150kgha–1 recorded greater plant height (131.67cm) followed by 150kgNha–1 with 23cm plant spacing (130.33cm) and 100kgNha–1 with 23cm plant spacing (128.67cm), while 0kgNha–1 with 15cm plant spacing recorded lowest plant height (82.0cm).

3.2. Total bolls per plant

The data for mean total bolls per plant as influenced by different levels of nitrogen and plant spacing is shown in table. It can be seen from the table that differences in total bolls per plant due to plant spacing and nitrogen levels were significant (P□0.01), while the interaction of plant spacing X nitrogen levels was non-significant. It observed that plant spacing 30cm resulted in maximum total bolls per plant (26.50), followed by 23cm plant spacing (25.25) respectively, while 15cm plant spacing displayed lowest total bolls per plant (24.08). The results revealed that cotton fertilized with nitrogen 150kgha–1 resulted in maximum total bolls per plant (31.00), followed by 100kgNha–1 (27.67) and 50kgNha–1 (25.33), while 0kgNha–1 displayed lowest total bolls per plant (17.11). The results further explains that the interaction of plant spacing 30cm and nitrogen level 150kgha–1 recorded greater total bolls per plant (32.67), followed by 150kgNha–1 with 23cm plant spacing (31.00) and 100kgNha–1 with 30cm plant spacing (28.67), while 0kgNha–1 with 15cm plant spacing recorded lowest total bolls per plant (16.00).

3.3. Seed Cotton weight

The data for mean seed cotton weight plant–1 (g) of cotton crop variety CRIS-342 as influenced by different levels of nitrogen and plant spacing is shown in table. It may be seen from the table that differences in seed cotton weight plant –1 due to plant spacing and nitrogen levels were significant (P□ 0.01), while the interaction of plant spacing x nitrogen levels was non-significant. It observed that plant spacing 30cm resulted in maximum seed cotton weight plant–1 (86.90g plant–1), followed by 23cm plant spacing (81.68g plant–1), while 15cm plant spacing displayed lowest seed cotton weight plant–1 (79.48g plant–1).

The results revealed that cotton fertilized with nitrogen 150kg ha–1 resulted in maximum seed cotton weight plant–1 (101.57gplant–1) followed by 100kgNha–1 (89.83g plant–1) and 50kgNha–1 (82.87gplant–1), while 0kgNha–1 displayed lowest plant height (56.47gplant–1). The results further explains that the interaction of plant spacing 30cm and Nitrogen level 150kgha–1 recorded greater seed cotton weight plant–1 (107.80g plant–1), followed by

150kgNha–1 with 23cm plant spacing (100.11gplant–1) and 100kgNha–1 with 30cm plant spacing (92.40Kgha–1), while 0kgNha–1 with 15cm plant spacing recorded lowest seed cotton weight plant–1 (52.80g plant–1).

3.4. Seed cotton Yield

The data for mean yield Kgha–1 of cotton crop variety CRIS-342 as influenced by different nitrogen levels and plant spacing is shown in table. It may be seen from the table that differences in yield Kgha–1 due to plant spacing and nitrogen levels was significant (P□0.01), while the interaction of plant spacing X nitrogen levels was highly significant. It observed that plant spacing 23cm resulted in maximum yield (2179.75Kgha–1), followed by 30cm plant spacing (2095.42Kgha–1), while 15cm plant spacing displayed lowest yield Kgha–1 (2009.25Kgha–1). The results revealed that cotton fertilized with nitrogen 150kgha–1 resulted in maximum yield Kgha–1 (2675.67Kgha–1), followed by 50 kgNha–1 (2387.67Kgha–1) and 100 kgNha–1 (2184.89Kg ha–1), while 0kgNha –1 displayed lowest yield Kgha–1 (1131.00Kgha–1).

The results further explains that the interaction of plant spacing 23cm and nitrogen level 150kgha–1 recorded greater Yield Kgha–1 (2803.33 Kgha–1), followed by 150kgNha–1 with 30cm plant spacing (2693.33Kgha–1) and 100kgNha–1 with 23cm plant spacing (2451.67Kgha–1) respectively, while 0kgNha–1 with 15cm plant spacing recorded lowest yield Kgha–1 (1060.67Kgha–1).

3.5. Staple length

The data for mean staple length (mm) of cotton crop variety CRIS-342 as influenced by different levels of nitrogen and plant spacing is shown in table and its analysis of variance. It may be seen from the table that differences in staple length (mm) due to plant spacing and nitrogen levels were significant (P□0.01), while the interaction of plant spacing X nitrogen fertilizer levels was non - significant. It was observed that plant spacing 30cm resulted in maximum staple length (27.17mm), followed by 23cm plant spacing (26.93 mm), while 15cm plant spacing displayed lowest staple length (26.81mm). The results revealed that cotton fertilized with nitrogen 150kgha–1 resulted in maximum staple length (28.24mm), followed by 50 kgNha–1 (27.21mm) and 100 kg Nha–1 (27.52mm) respectively, while 0 kg Nha–1 displayed lowest staple length (24.89mm). The results further explains that the interaction of plant spacing 30cm and nitrogen level 150kgha–1 recorded greater staple length (28.37mm), followed by 150kgNha–1 with 23cm plant spacing (28.23mm) and

100kgNha–1 with 30cm plant spacing (27.67mm), while 0kgNha–1 with 15cm plant spacing recorded lowest staple length (24.60mm).

3.6. Ginning out turn

The data for mean GOT% (Ginning out turn) of cotton crop variety CRIS-342 as influenced by different levels of nitrogen and plant spacing is shown in table. It may be seen from the table that differences in GOT% due to plant spacing and nitrogen levels were significant (P□0.01), while the interaction of plant spacing X nitrogen fertilizer levels was highly significant.

It observed that plant spacing 30cm resulted in maximum GOT% (37.37%), followed by 23cm plant spacing (37.21%), while 15cm plant spacing displayed lowest GOT% (37.09%). The results revealed that cotton fertilized with nitrogen 150 kgha–1 resulted in maximum GOT% (38.21%), followed by 50kgNha–1 (37.47%) and 100kgNha–1 (37.82%) while 0kgNha–1 displayed lowest GOT% (35.39%). The results further explains that the interaction of plant spacing 30cm and nitrogen level 150kgha–1 recorded greater GOT% (38.33%), followed by 150kg Nha–1 with 23 cm plant spacing (38.20%) and 100kgNha–1 with 30cm plant spacing (38.00%), while 0kgNha–1 with 15cm plant spacing recorded lowest GOT% (35.27%).

4. Discussion

The results confirmed by Zakaria et al (2006), which conducted experiment on N rates of 95 or 143kgha–1 and increased traits with the higher N rate such as number of opened bolls per plant, boll weight, seed index, and lint index, seed cotton yield per plant, seed cotton yield, and lint yield per hectare increased. Donald J. Bouquet (2005) stated that lint percentage decreased by wide rows, and maximum yields of UNR (Ultra Narrow Rows) cotton attained from plant densities in the range of 128000 to 256000ha–1 and N rate of 90kgha–1. Cotton yield can be increased through proper management procedures of fertilizer levels and plant spacing are highly significant (Ali et al.2007). The influence of different planting spacing on cotton canopy structure and yield formation studied under no water and fertilizer stress condition. The field-scale experiment with four planting densities ranks from 30000 to 82500 plants per hectare. It observed that spacing 30cm, resulted in maximum plant height (117.0cm) and cotton fertilized with nitrogen 150kgha–1(130.22cm). These results are supported by the findings of Ernest et al (2006) who stated that reductions in row spacing decreased plant height and greater N increased plant height. Mohamed et al (1991) found that increase in plant spacing decreased plant height. McConnell et al. (2001) reported that plant height continued to increase with application of N up to 112 kgNha–1. N fertility may have prominent impact on post-harvest plant residue quality of cotton. Neither factor is likely to significantly affect decomposition (Fitzgerald L. Booker et al. 2000). Nitrogen (N) management approaches for cotton may need to be improved because of the use of high yielding cultivars and advanced cropping systems. Muhammad Bismillah and Dar (2006) described that application of N at 50 and 200kgha–1 produced the highest number of bolls plant–1, maximum average boll weight, maximum number of seeds boll–1, staple length, and seed cotton yield compared with the other nitrogen rates (Bradow, J.M and G.H. Davidonis .2000).

5. Conclusion

The cotton variety CRIS-342 significantly enhanced seed cotton yield when grown at plant spacing 23cm with the application of 150Nkgha-1 that is the form of urea under environmental condition of Sakrand and other areas with similar ecologies.

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Table. The performance of agronomic traits and quality traits in cotton under four fertilizer and three parameter treatment

Treatments		Determination indexes					
		Mean plant height (cm)	Mean total bolls per plant	Mean seed cotton weight per plant	Mean Seed cotton yield (kg ha^{-1})	Mean staple length (mm)	Mean GOT%
F0	P1	82.00	16.00	52.80	1060.67	24.60	35.27
	P2	83.33	17.00	56.10	1185.00	24.77	35.37
	P3	84.33	18.33	60.50	1147.33	25.30	35.57
F1	P1	122.00	24.33	80.30	2106.67	27.10	37.30
	P2	124.33	25.33	81.40	2279.00	27.20	37.50
	P3	123.33	26.33	86.90	2169.00	27.33	37.60
F2	P1	126.67	26.67	88.00	2339.33	27.40	37.70
	P2	127.67	27.67	89.10	2451.67	27.50	37.77
	P3	128.67	28.67	92.40	2372.00	27.67	38.00
F3	P1	128.67	29.33	96.80	2530.33	28.13	38.10
	P2	130.33	31.00	100.11	2803.33	28.23	38.20
	P3	131.67	32.67	107.80	2693.33	28.37	38.33

Note: F (F0, F1, F2, F3), different Fertilizer levels, P(P1, P2, P3), different parameters.