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Evaluation of optimum timing of nitrogen fertilizer application in cotton crop under the climate change scenario

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Abstract

A field experiment was conducted to study the evaluation of optimum timing of nitrogen fertilizer application in cotton crop under the climate change scenario of Rahim Yar Khan Zone. The experiment was conducted at Adaptive Research Farm Rahim Yar Khan during the year 2022-23. The experiment was laid out in RCBD design with three replications. The different timings of Nitrogen fertilizer i.e ½ nitrogen @99.5kg/ha on 30 days after sowing and ½ nitrogen @99.5kg/ha on 60 days after sowing significantly affected the plant population/m^2, plant height (cm), number of mature bolls/plant, seed cotton boll weight (g), and seed cotton yield kg/ha. The different timings of Nitrogen fertilizer was significantly affected almost all the characters related to growth and yield of B.T cotton variety NIAB-878. The average of two years result revealed that significant maximum germination count or plant population/m^2 i.e 9.3, plant height (cm) i.e 105.4, number of bolls/plant i.e 15.2, boll weight (g) i.e 2.7 and maximum seed cotton yield i.e 653.6 kg/ha was obtained where ½ nitrogen @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha was applied on 60 days after sowing.

Keywords: *Cotton. Nitrogen, optimum timings, and fertilizer.*

Introduction

Cotton (*Gossypium hirsutum* L.) is the most important cash crop of Pakistan, cultivated on 2.879 million hectares and is the source of large amount of foreign exchange, contributing about 7.0% of value added in agriculture and about 1.5 percent of GDP and contributes about 66.50% share in national oil production (Anonymous, 2013). Fertilizers occupy vital position in raising seed cotton yield. Experiments proved that an optimal yield could only be produced with the balanced application of all major nutrients in soil (Ahmad, 1998). The scarcity of any nutrient in the soil can be a barrier for the growth of crops even when all other nutrients are in excess in the soil (Soleymani and Shahrajabian 2012). Optimum levels of micro and macro inorganic nutrients are required for normal growth and supplements give improvements. Low yield of cotton in Pakistan is due to many crop husbandry problems such as low or more plant population, water shortage, low seed rate, improper fertilizer management, weed infestation, insect pest and disease problems (Ahmed et al., 2009). Application of chemical fertilizers has played a vital role in increasing crop production all over the world. The alkaline and calcareous soils of Pakistan are low both in nitrogen (N) and in phosphorus (P) requiring the addition of nutrients in appropriate amounts for improving crop yields. The use of N and P fertilizers increased many fold since their introduction in the late fifties (Ahmad, 2000). The addition of N can increase chlorophyll, carotenoid contents, electron transport rate, free amino acids, soluble proteins, specific leaf nitrogen, and stomatal conductance (Snider et al., 2021). Nitrogen (N) is the most abundant nutrient extracted by cotton and exerts a key influence on growth period, maturity time, productivity, and fiber quality (Khan et al., 2017). The N affects the morphological and physiological processes in cotton, which can be dependent on genotype (Iqbal et al., 2020). The N uptake by cotton has a higher demand later in the growth period; around 30 % of total N needed is before 60 days after emergence, and 70 % between 60 and 80 days after emergence, which shows the importance of split N application (Flis, 2019, Yang et al., 2011). Cotton has a total N demand of 250–300 kg ha^{-1} (Ali, 2015), of which more than 50 % is removed from the field by harvesting seed and fiber (Macdonald et al., 2016). Three N applications (sowing, initial

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bloom, and peak bloom) increased N use efficiency and yield in some studies, but in others, a single application showed higher yield than splits (Khan et al., 2017). Cotton growers in Pakistan use a desirable amount of N (125 kg ha^{-1}) but use of K fertilizer is negligible (Mithaiwala et al., 1981). Colakoglu, (1980) recommended optimum dose of 80-120 kg ha^{-1} N, 60-90 kg ha^{-1} P and 100-200 kg ha^{-1} K for optimum seed cotton yield. During the last two decades, cotton production scenario has changed. There is heavy drain of nutrients due to more demand by varieties at certain early maturing and high yielding cotton growth stages. Proper amount and time of fertilizer application is considered a key to the bumper crop. Time of fertilizer application can affect the N utilization efficiency by cereals (Ragheb et al., 1993). In boosting the agricultural productivity, nitrogen is apparently the most contributing fertilizer (Touchton, 1987). Nitrogen has been reported to increase plant height, number of monopodial/sympodial branches $plant^{-1}$ and number of matured bolls $plant^{-1}$ in cotton (Soomro and Waring, 1987; Mukand *et al*. 1989). Seed cotton weight $boll^{-1}$ and seed cotton yield ha^{-1} have been found affected by NPK application at various doses (Nehra *et al*. 1986; Khan *et al*. 1993).

Keeping in view the significant of cotton in Pakistan this study was conducted to see cotton response to varying levels of Nitrogen.

Materials and Methods

The experiment was conducted at of Adaptive Research farm during 2022 and 2023 to determine the evaluation of optimum timing of nitrogen fertilizer application in cotton crop under the climate change scenario. The experiment was laidout in Randomized Complete Block Design (RCBD) with four treatments and repeated thrice. Soil sample were collected before planting crop from plough lair of the experimental site and analysis carried out as per method (Jackson 1962). The soil of the experimental sites was sandy loam with alkaline pH (8.2), 0.72% organic matter, 0.042% N, 4.3ppm available phosphorous & 132ppm available potash. Experimental treatments comprised of four different timings of Nitrogen i.e ½ nitrogen @99.5kg/ha on 30 days after sowing and ½ nitrogen @99.5kg/ha on 60days after sowing, $1/3^{rd}$ nitrogen @66.3kg/ha on 30, 60 and 90 days after sowing, $1/4^{th}$ nitrogen @49.75kg/ha on 30, 60, 90 and 120 days after sowing with a control check. Seed bed was prepared by cultivating the field for two times with tractor mounted cultivated each followed by planking. The cotton B.T variety NAIB-878 was sown on sandy loam soil. Sowing was done on well prepared seed bed 1st week of May in two years. With the help of single row cotton drill by maintaining 2.5 feet row spacing and 12 inch plant to plant distance was maintained by thinning at 6 inch height of the cotton plant. Over all eight irrigation were applied and weeds were controlled through weedicides. Insecticides were applied to control the sucking insects (Whitefly, Thrips, Jassid, & Mites) and boll worms (Pink boll worm). All other agronomic practices were kept normal and uniform for all the treatments. Plant population/m^2 was counted after three weeks of sowing. Plant height (cm) of randomly selected plots from each plot was measured at the time of last picking and average height was calculated. The total number of bolls on the randomly selected plants picked at the time of each picking was counted. Thus total number of bolls on the plants was obtained by summing up the bolls picked during all pickings and average of number of bolls per plant was calculated. For boll weight (g), three samples each of 100 seeds from each plot were weighted and finally averaged. Average boll weight (g) was calculated by dividing the total plants seed cotton yield with respective number of bolls per plant. Seed cotton picked from selected plants during all the pickings was weighted in grams using electric balance. After that the yield of seed cotton per plant was calculated. Seed cotton yield kg ha^{-1} was computed from seed cotton yield per plot. Data collected on different parameters were analyzed statistically by using M STAT-C programme (Anonymous,1986) for analysis of variance and means were separated using Fisher's protected least significant difference (LSD) test at 5% probability level (steel *et al*., 1997).

Results and Discussion

Plant population (m^{-2})

Data concerning average number of germination counts is shown in Table 2 during both years 2022 and 2023 Statistical analysis of the data revealed that the effect of different timings of Nitrogen application have significant results on germination counts for the both growing seasons. Average maximum germination counts were recorded as (9.0) in T_1 where ½ nitrogen @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha was applied on 60days after sowing for the both kharif season 2022-23. On the other hand, lowest value was recorded as (7.4) in control check for both years respectively.

Plant height (cm):

Nitrogen significantly increased plant height. Nitrogen application half @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha resulted in proportionate increase in the plant height of cotton variety NAIB-878 as mentioned in Table-2. The taller plants (105.4cm) were recorded on cotton variety where ½ nitrogen @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha was applied on 60days after sowing during both years 2022-23. The height observed (103.3cm) when $1/3^{rd}$ nitrogen @66.3kg/ha was applied on 30, 60 and 90 days after sowing. The minimum height (98.4cm) was observed in control check. It is well known fact that nitrogen application boosts crop growth and development. These results are in agreement with those of Rochester *et al*. (2001) that plant height in cotton is related to nitrogen, phosphorus and potash applications.

Boll weight (g):

Average boll weight is one of the major components of seed cotton yield in cotton. Data given in Table-2 indicates that Nitrogen significantly influenced boll weight. Maximum boll weight (2.7 g) was recorded where ½ nitrogen @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha was applied on 60days after sowing during both years 2022-23. The minimum boll weight (1.95) was observed in case of control check. The results agree with those of

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Sawan *et al.* (2006); who recorded increase in boll weight by increasing N rate. Seed cotton weight boll^{-1} and seed cotton yield ha^{-1} have been found affected by NPK application at various doses (Nehra *et al*. 1986; Khan *et al*. 1993).

Seed cotton yield kg ha^{-1}:

Data pertaining to seed cotton yield per hectare as influenced by different doses of Nitrogen as mentioned in Table-2 indicates that N had significant effect on the seed cotton yield per hectare. Maximum seed cotton yield per hectare (653.6kg ha^{-1}) was recorded where ½ nitrogen @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha was applied on 60days after sowing on NAIB-878 cotton variety. The lowest seed cotton yield (494.4kg ha^{-1}) was obtained in control check where nitrogen was not applied during both years 2022-23. These findings agree with the findings of Howard *et al.* (2001).These results are supported by Elayan (1992) who reported that nitrogen influenced seed cotton yield ha^{-1} and decrease in seed cotton yield ha^{-1} was recorded when nitrogen was applied beyond the optimum level.

Table 1: The effect of different timings of Nitrogen application on the growth and yield of seed cotton during 2022 and 2023.

Year	Treatments	Average germination counts (m^{-2})	Average plant height (cm)	No. of Bolls/plant	Boll weight (g)	Average seed cotton yield (kg/ ha)
2022	T_1	9.0a	104.6a	14.3a	2.6a	621.9a
	T_2	8.3b	102.6b	12.3b	2.5b	597.9b
	T_3	8.0c	100.0	11.3c	2.3c	550.1c
	T_4	7.6d	97.6d	9.0d	1.9d	478.3d
LSD		**1.02**	**1.65**	**Non-significant**	**1.07**	**25.7**
2023	T_1	9.7a	106.2a	16.2a	2.9a	685.4a
	T_2	8.8b	104.1b	14.3b	2.7b	613.6b
	T_3	8.3c	102.4c	12.4c	2.4c	585.3c
	T_4	7.2d	99.3d	9.6d	2.0d	510.5d
LSD		**1.03**	**1.10**	**Non-significant**	**1.10**	**22.89**

Table 2: Average values of all parameters from 2022-2023

Treatments	Average germination counts (m^{-2})	Average plant height (cm)	No. of Bolls/plant	Boll weight (g)	Average seed cotton yield (kg/ ha)
T_1	9.3	105.4	15.2	2.7	653.6
T_2	8.5	103.3	13.3	2.6	605.7
T_3	8.1	101.2	11.8	2.3	567.7
T_4	7.4	98.4	9.3	1.95	494.4

Table 3: Percentage increase in cotton yield (kg/ha) between different Nitrogen timings for the year 2022 and 2023

Treatments	Combined Avg. yield of 2022 and 2023 (kg/ha)	Percentage increase in cotton yield (%)
T1	653.6	32.2
T2	605.7	22.5

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T3	567.7	14.8
T4	494.4	-

Table 3 shows that the highest yield was produced in T_1 (where ½ nitrogen @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha was applied on 60days after sowing) with 32.2% yield increase for both study years i.e.2022-23.

Conclusions

The results concluded that different doses of Nitrogen have varied effects on cotton yield and other growth parameters when used in different combinations. It has significantly ($p<0.05$) affected germination, plant height, boll weight and yield during both years of the study. ½ nitrogen @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha was applied on 60days after sowing has improved grain yield (653.6 kg/ha) over 2 years in comparison with other doses. Therefore under ecological zone of Rahim Yar Khan, ½ nitrogen @99.5kg/ha was applied on 30 days after sowing and ½ nitrogen @99.5kg/ha was applied on 60days after sowing on cotton crop can be recommended in the region.

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