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MORPHOLOGICAL CHARACTERS IN BT COTTON AS INFLUENCED BY THE SPLIT APPLICATION OF NITROGEN APPLIED AT DIFFERENT GROWTH STAGES UNDER THE AGRO-CLIMATIC CONDITION OF DERA GHAZI KHAN, PAKISTAN

Shuaib Kaleem*[1], M. Shabbir[1] and M. N. Abbas[2]

[1]*Agriculture Adaptive Research Complex, Dera Ghazi Khan, Pakistan*

[2]*Department of Agronomy, College of Agriculture, Dera Ghazi Khan, Pakistan*

ABSTRACT

Nitrogen plays a significant role to improve the growth and yield of cotton. Plant growth, assimilation, morpho-physiological expressions and photosynthate translocation are closely related to nutrients availability. A field trial to evaluate the response of different nitrogen splits on growth and yield components of cotton was conducted under the agro climatic conditions of Dera Ghazi Khan, Pakistan during 2012. Fuzzy seed (@ 20 kg ha^{-1} of cotton genotype (BT-MNH 886) was sown under Randomized Complete Block Design (RCBD) with three replications. Fixed nitrogen (N) dose (375 kg ha^{-1}) which (375 kg ha^{-1}), was applied in four treatments as a source of nitrogen; T_1=5 N splits (@75.00 kg ha^{-1} per split), T_2=6 N splits (@62.50 kg ha^{-1} per split), T_3=7 N splits (@53.57.00 kg ha^{-1} per split), and T_4=8 N splits (@46.87 kg ha^{-1} per split). The data were recorded on the basis of yield and yield attributes of cotton crop that included plant height, leaf area index (LAI), number of bolls per plant, bolls weight and seed cotton yield. On increasing N splits, vegetative characteristic of cotton i.e., plant height was improved while, features like leaf area index, bolls weight and seed cotton yield increased up to certain level of N splits, T3 (7 splits). Further, N split (8 splits in T_4) caused decrease in all these features except for plant height. So the growth and yield performance of cotton genotype (BT-886) was significantly influenced up to 7 splits of nitrogen fertilizer, improving morphological characteristics of cotton crop ultimately enhancing the seed cotton yield.

Keywords: Cotton genotype, nitrogen splits, growth and yield components

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fiber crop used in textile industry (Killi et al., 2005). Cotton crop called the white gold in true sense serves as a backbone of Pakistan economy and occupies a prominent position in local textile and edible oil industry (Nadeem et al., 2010; Sawan et al., 2001). In Pakistan, cotton yield is comparatively lower than other countries which can be due to lack of advanced production practices, crop husbandry, market problems, low land holding, illiteracy, lack of capital and poor socio-economic conditions of the farming community. Poor soil fertility management resulting from imbalanced and non-judicial fertilizer application may be another reason for lower seed cotton yields (Bibi et al., 2011).

It is a big source of raw material for textile industries, spindles and oil expelling units all over the world (Ahmed et al., 2009). Nitrogen significantly enhances crop growth, chlorophyll contents and yield of cotton (Saleem et al., 2010). It has been concluded that rate of plant growth and development is mainly temperature driven, but the amount of growth and photosynthate translocation is related to nutrients availability (Munir et al., 2012).

Among plant nutrients, nitrogen plays an important role in crop productivity and is regarded as growth and yield determinant in irrigated cotton (Ahmad, 2000; Reddy et al., 1998). Cotton yield and fiber quality is associated with advanced agronomic field techniques and judicious use of soil inputs (Reddy et al., 2004). Similarly, with the increase of photosynthetic area, crop assimilation and growth is increased which ultimately increases photosynthates and crop yield (Kaleem et al., 2011).

Nitrogen application to cotton is considered to be essential to meet the basic requirements of nitrogen needed at different growth stages throughout, however excessive amount of nitrogen may reduce lint percentage (Sampathkumar et al., 2006, Amanullah et al., 2013). Nitrogen deficiency also slows down the vegetative and reproductive growth in plants which may leads to potential yield loss (Ali and

**Corresponding author:* e-mail: shuaibkaleem70@gmail.com

Hameed, 2011). Excess and wrong time application of nitrogen causes more vegetative growth that delayed crop and fruit maturity and resulted in low final crop yield (Kandil et al., 2004). Judicious increase in nitrogen to cotton applied at proper growth stage may result in more accumulation of photosynthates, higher fruit weight and nutrients uptake from soil (Anjum et al., 2007). Nitrogen has been reported to increase plant height, monopodial/ sympodial branches, boll weight and bolls per plant and ultimately seed cotton yield (Sawan et al., 2001; Nadeem et al., 2010, Saleem et al., 2010). Cotton plants require nitrogen through-out the growing season but the magnitude varies with the age of plant. Due to extensive cropping system our soils are deficient in organic matter. Nitrogen application interval must not be more than 17 days especially at critical crop growth stage otherwise crop growth will suffer badly affecting plant health, exposure and yield. As regards nitrogen application, cotton experts recommend that 28 percent of the nitrogen requirements for cotton plant are during the first 60 days of growth. The maximum absorption of nitrogen takes place during the first 60-90 days when boll formation is at its peak (Sawan et al., 2001). While, nitrogen application from 90 to 120 days of crop growth is very critical as it is stage of physiological maturity, keeping in view the development of boll size (Hussain et al., 2000; Subhan et al., 2001). Thus its application must be completed within speculated period by completing its dose through splits of normal days and applied at important crop growth stage from germination till boll formation (Sampathkumar et al., 2006).

The climatic conditions in Pakistan are severe, especially in cotton growing area of D.G. Khan where high temperature quickly volatilizes nitrogen, if applied on improper stage by improper way, similarly arid conditions badly affect applied nitrogen, so split application interval for nitrogen was kept with the view to reduce the climatic effect. In D. G. Khan district, farmers mostly apply nitrogen at improper crop stage and no proper interval for nitrogen application is kept in view, ultimately succulent crop with uncontrolled vegetative growth is achieved which attracts sucking insects and bollworms making crop unprofitable and uneconomical. This study was therefore conducted to examine the effect of split application of nitrogen at different growth stages of cotton to find out the best suit to get good crop growth, efficient nutrient use and profitable yield.

MATERIALS AND METHODS

A field experiments was conducted to study the influence of split application of nitrogen fertilizer on the growth and yield of cotton crop under the agro climatic condition of Dera Ghazi Khan, Pakistan. 20 kg ha^{-1} fuzzy seed of cotton (BT-MNH 886) was used for the experiment. Nitrogen fertilizer was applied in four different treatments (T_1, T_2, T_3 and T_4) and each treatment comprised of different N splits (T_1=5, T_2-6, T_3=7 and T_4=8 N splits). Method of application/distribution of Nitrogen (N) was as T_1=5 N splits (@75.00 kg ha^{-1} per split), T_2=6 N splits (@62.50 kg ha^{-1} per split), T_3=7 N splits (@53.57.00 kg ha^{-1} per split), and T_4=8 N splits (@46.87 kg ha^{-1} per split). Urea was used as a source of nitrogen fertilizer and 375 kg N ha^{-1} was splitted in plots as per treatment according to schedule (Table 3a,3b) at different crop growth stages. All the P and K in the form of DAP and Sulphate of Potash (SOP) were added at the time of sowing in all the plots as per recommendations. Net plot size was maintained as 202.43 m^2. Ridges were made 75 cm apart while, 22 cm plant to plant distance was maintained. The soil analysis report was obtained before sowing (Table 1). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Crop was sown manually on 15th May, 2012 by using ridge technology. Pendimethyline was used as pre-emergence weedicide in wattar condition @ 2.5L ha^{-1}. Thinning was done after three weeks of dibbling the seed to maintain the required distance between the plants. All other agronomic practices were kept same for all the treatments throughout the crop growth. Seed cotton was picked in two pickings while, the second picking was done after 180 days of crop plantation. Five healthy plants (free from disease and damage) were selected from each plot of all the treatments and were tagged to calculate the morphological and yield data throughout the season. Plant samples were taken by using per unit area and different growth (plant height and leaf area index) and yield (number of bolls per plant, bolls weight and seed cotton yield) parameters were observed and recorded for data.

Data thus recorded were statistically analyzed by using Fisher's analysis of variance techniques (ANOVA) and least significant difference test (LSD) was applied to check the significance of treatment means at 5% probability level (Steel and Torrie, 1997).

Table – 1: Physio-chemical characteristics of soil at Adaptive Research Zone DG Khan, 2012.

Electrical conductivity	3.14 m cm^{-1}
Soil pH	8.10
Organic matter	0.28 %
Available phosphorous	4.00 ppm
Available potassium	215.00 ppm
Saturation	44%
Texture	Loam

Table – 2: Meterological data of the Adaptive Research Zone DG Khan, 2012.

Month	Temperature Min. (^{0}C)	Temperature Max. (^{0}C)	R.H (%)	Rain (mm)
June-2012	31.00	41.00	49.50	30 .00
July-2012	30.00	40.00	63.00	37.00
Aug-2012	26.00	35.00	68.00	40.00
Sep-2012	29.00	37.00	75.00	130.00
Oct-2012	20.00	33.20	62.00	---
Nov-2012	13.80	27.90	75.00	---
Dec-2012	09.70	22.50	70.00	---

Table – 3a: Schedule of split application of nitrogen fertilizer (Dates) to cotton crop

Total splits*	Interval days	Dates for nitrogen (N) application							
T_1=5 N splits	26	15-06-12	12-07-12	08-08-12	04-09-12	30-09-12	-	-	-
T_1=6 N splits	20.8	15-06-12	07-07-12	29-07-12	19-08-12	09-09-12	30-09-12	-	-
T_1=7 N splits	17.33	15-06-12	03-07-12	21-07-12	08-08-12	26-08-12	13-09-12	30-09-12	-
T_1=8 N splits	14.86	15-06-12	01-07-12	16-07-12	31-07-12	14-08-12	29-08-12	14-09-12	30-09-12

*It may be noted that quantity of nitrogen remained fixed (**375kg ha^{-1}**). The difference among treatments was variation in no. of splits of nitrogen fertilizer

Table – 3b: Schedule of split application of nitrogen fertilizer per split (kg ha^{-1}) to cotton crop

Total splits*	Interval days	Quantity of nitrogen application ha^{-1} per split (kg)							
T_1=5 N splits	26	75.00	75.00	75.00	75.00	75.00	-	-	-
T_1=6 N splits	20.8	62.50	62.50	62.50	62.50	62.50	62.50	-	-
T_1=7 N splits	17.33	53.57	53.57	53.57	53.57	53.57	53.57	53.57	-
T_1=8 N splits	14.86	46.87	46.87	46.87	46.87	46.87	46.87	46.87	46.87

Table 4. Effect of split nitrogen (N) application on the growth and yield of BT-cotton

S. No.	Treatment	Plant height (cm)	Leaf area index (LAI)	No. of bolls plant^{-1}	Bolls weight (g)	Seed cotton yield (Kg ha^{-1})
1	$T_{1=}$ 05 'N' splits	101.13 b	2.66 c	17.45	2.41 c	2654.30 c
2	$T_{2=}$ 06 'N' splits	104.77 b	2.88 b	21.47	2.47 b	3121.10 ab
3	$T_{3=}$07 'N' splits	112.00 a	3.12 a	19.38	2.55 a	3250.00 a
4	$T_{4=}$ 08 'N' splits	116.22 a	2.42 d	21.31	2.44 bc	2927.00 b
Mean		**108.53**	**2.77**	**19.90 NS**	**2.47**	**2988.09**
LSD value		**5.00**	**0.14**	**6.71**	**0.04**	**285.72**

RESULTS AND DISCUSSION

Plant height (cm)

Plant height is an important vegetative growth parameter of cotton plant that is directly influenced by fertilizer especially nitrogen. The results obtained at final maturity (Table 4) indicated increasing trend of plant height with increasing number of nitrogen splits and statistically significant differences were achieved among the treatments. N fertilizer significantly ($p \leq 0.05$) and gradually improved the height of cotton plant. Maximum plant height (116.22 cm) was recorded in T_4 where (375 kg ha^{-1}) nitrogen was applied in 8 equal splits which remained statistically at par with T_3 (112.00 cm) where same nitrogen dose was applied in 7 equal splits. Minimum plant height (101.13 cm) was recorded in T_1 which was also statistically similar with T_2 (104.77 cm) where 5 and 6 splits were given respectively (Table 4). Results revealed that plant height increased with the increase in number of N splits which indicated that nitrogen even applied at latter growth stage, helped to increase plant height and vegetative growth. Our results are in close conformity with the results of Ali et al. (2010), Sawan et al. (2001) and Munir et al. (2012) those found that lesser the nitrogen application during crop life cycle, lesser is plant growth and height.

Leaf area index (LAI)

LAI, the ratio of LA (m^2) per m^2 ground, is a constitutive parameter of many yield predicting models since it is related with radiation interception (Tsialtas and Mslaris, 2008). According to the results given in Table 4, LAI of the cotton plant was also significantly ($p \leq 0.05$) influenced by application of N in splits. Maximum LAI (3.12) was recorded in T_3 and minimum (2.42) in T_4 where nitrogen was applied in equal 7 and 8 splits, respectively (Table 4). This increase in leaf area index in T_3 might be due to increase in leaf area and biomass which increased the solar intercepted area and chlorophyll contents by split application of nitrogen up to physiological maturity (7 splits) thus ultimately increasing the assimilation and photosynthetic area causing increase in plant vegetative growth and LAI which could not be further increased by increasing extra N splits in $T_{4.}$ After the physiological maturity, crop shifts to maturity where already most of the assimilates and photosynthates have been translocated from vegetative to reproductive organs, affecting leaf growth, area and size. At this stage leaves start to shed being older. So last nitrogen split application (8th split of nitrogen at maturity) could not enhance LAI at this growth stage. Amanullah et al. (2013) found in an experiment that nitrogen application at latter crop growth stages badly affected leaf characteristics like number of leaves plant^{-1} (NLPP), leaf length (LL), mean single leaf area (MSLA), leaf area plant-1 (LAPP), leaf elongation rate (LER), leaf area index (LAI), specific leaf area (SLA), and leaf area ratio (LAR)] due the toxic effects of excessive Nitrogen at this particular crop growth stage. Similar findings have also been noticed by Sampathkumar et al. (2006), Sawan et al. (2001) and Kaleem et al. (2011) who found that addition of nitrogen up to certain crop growth stages enhanced net assimilation area, chlorophyll contents and leaf area which failed to increase these parameters if applied at latter crop growth stages.

Number of bolls plant^{-1}

The results obtained at final maturity (Table 4) indicated statistically non-significant differences among the treatment means. Production and fruit retention of a crop is dependent on balanced supply of the available nutrients at proper crop growth stage. Influence of nitrogen splits on number of bolls was although non-significant ($p \leq 0.05$) but results in Table 4 depict that application of N up to certain stage remained fruitful. Similar findings were reported by Sawan et al. (2001), Nadeem et al. (2010), Bednarz et al. (2005) and Nichol et al. (2004). Bolls per plant observed in present study were also in agreement with those obtained by Ali and El-Sayed (2001) who achieved maximum fruit count where N was applied @ 95 to 190 kg ha^{-1} applied up to certain crop growth stags.

Boll's weight (g)

According to the results in Table 4, statistical differences were achieved regarding boll's weight. Split application of nitrogen significantly ($p \leq 0.05$) influenced bolls weight of the cotton. Results showed that maximum boll weight (2.55 g) was achieved in T_3 (7 splits) while, minimum (2.41 g) was obtained in T_1 (5 splits) that was statistically at par with T_4 (8 splits) and T_2 (6 splits). Increase in bolls size by the addition of N up to certain crop growth stage indicated that the influence of particular nutrient with crop through enhancing net assimilation area, chlorophyll content, photosynthetic efficiency and leaf area which ultimately increased assimilate translocatin towards bolls size attainment. These results are in close conformity with the findings of Arain et al. (2001), Soomro et al. (2001), Kaleem et al. (2011) and Munir et al. (2012) who recorded maximum size of cotton bolls when nutrients especially nitrogen was applied in 6-7 equal splits up to certain crop growth stage, facilitating and improving plant growth and photosynthetic activity ultimately improving yield components.

Seed cotton yield (kg ha^{-1})

Results shown in Table 4 depicted that the split application of nitrogenous fertilizer significantly ($p \leq 0.05$) influenced the seed cotton yield. Maximum seed cotton yield (3250.00 kg ha^{-1}) was recorded in T_3 where nitrogen was applied in 7 splits which were statistically at par with T_2 (3121.10 kg ha^{-1}) (6 splits) and T_4 (2927.00 kg ha^{-1}) (8 splits). Similarly, minimum seed cotton yield (2654.30 kg ha^{-1}) was recorded in T_1 (5 splits) as depicted in Table 4. These results are in accordance with the findings of Reddy et al. (2004), Sampathkumar et al. (2006), Sawan et al. (2001), Nadeem et al. (2010) and Munir et al. (2012) those reported that cotton yield and fiber quality were associated with the timely and judicious use of fertilizer inputs. Amanullah et al. (2013) also reported in an experiment that nitrogen application at reproductive stage of the crop helps a lot in photosynthate accumulation and enhancing yield than applied at both crop stages, too earlier and latter crop growth stages. Similar results were reported by Ali et al. (2009) who found that yield was directly proportional to the timely application of the nutrients to the crops.

CONCLUSION

It may be concluded that the optimum dose of nitrogen (53.57 kg ha^{-1}) per split, applied in 7 splits per hectare at suitable crop growth stages (applied from 15.6.2012 to 30.9.2012 with 17.33 days interval of nitrogen application, applied in 7 equal splits) is pre requisite to achieve the maximum growth, vigor and biomass which improved the physiological functions of cotton plant, necessary for vigorous plant growth and higher seed cotton yield. Thus nitrogen fertilizer dose and timing of application is of prime importance. Furthermore, this dose of nitrogen, applied in 7 splits for the cultivar BT-886 may be recommended among farming community to promote for cultivation in DG Khan zone, Pakistan, to improve fertilizer use efficiency and to achieve the better seed cotton yield.

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