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Assessing Nitrogen Use Efficiency for Various Bt-Cotton Cultivars under Semi-arid Conditions of Faisalabad

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Abstract

To assess the effect of nitrogen rate on growth, yield and nitrogen use efficiency of some Bt cotton cultivars, a field trial was conducted during 2014 at Students' Research Farm, Department of Agronomy, University of Agriculture Faisalabad Pakistan. Experiment was laid out in randomized complete block design (RCBD) with factorial arrangement using three cotton cultivars (FH-114, FH-142 and MNH-886) under various nitrogen rates (150, 200 and 250 kg N ha^{-1}). All the data were recorded and analyzed statistically using standard procedures. Different cotton cultivars at varying nitrogen doses significantly affected the growth, development and seed cotton yield. Crop took maximum time for first squaring (45.33 days), flower initiation (62 days and boll splition (188.56 days) with 250 kg N ha^{-1}. Leaf area index (3.63) and number of sympodial branches per plant were also highest at nitrogen level of 250 kg ha^{-1} while total dry matter (12847 kg ha^{-1}), number of monopodial branches per plant (3.77), earliness index (43.74%) and seed cotton yield were recorded higher at 200 kg N ha^{-1}. In case of cultivars, FH-142 produced more seed cotton yield (3369 kg ha^{-1}), total dry matter (TDM) (13461 kg ha^{-1}) and leaf area index (LAI) (3.69) but maximum number of days to first boll splition (118 days) was noted in MNH-886. Time period for flower initiation, earliness index, monopodials and sympodials remained non-significant among cultivars.

Key words: Total dry matter, leaf area index, cotton varieties, earliness index
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Introduction

Cotton is an utmost valuable cash and fiber crop of Pakistan (Ahmed *et al*., 2009). Cotton yield can be improved by good management practices such as maintaining fertilizer (nitrogen) levels (Ali *et al*., 2007). Shabbir, (2007) recorded 20% increase in TDM, 15% in LAI and 5% in CGR with the application of higher nitrogen dose. They also stated that seed cotton yield was considerably affected by cotton cultivars. They observed maximum yield of seed cotton with 200 kg N ha^{-1} and cv CIM-496.

In some crops like cotton, excessive vegetative growth and delayed maturity occurs due to application of higher nitrogen levels than optimum, resulting reduction in seed cotton yield (Rinehardt *et al*., 2004).

Maximum number of sympodial branches per plant was noted with 200 kg N ha^{-1} and lowest in 50 kg N ha^{-1} (Dar and Anwar, 2005). It is also reported that cotton yield varies among different cultivars (Wajid *et al*., 2010). In different cultivars decreased yield is due to reduction in boll weight and number associated with less dry matter production (Bange *et al*., 2003). They also noted that some cultivars reduced their LAI due to poor canopy development. Enhancing N fertilization for different cotton cultivars is one promising way to reach optimum economic returns (McConnell *et al*., 2000).

Felix *et al.* (2003) stated that average TDM of 3 years was 7800 and 12600 kg ha^{-1} with 56 and 168 as N ha^{-1} respectively. Maximum cotton yield was obtained at nitrogen level of 224 kg ha^{-1} that was 1666 kg ha^{-1} against 1638 kg ha^{-1} (168 kg N/ha). Seed cotton yield increased due to increase in nitrogen application in cotton (Bondada and Oosterhuis, 2001). Best nitrogen rate was 180 kg ha^{-1} to accumulate maximum biomass of various cultivars (Liu *et al*., 2010). Plants of different cultivars were incapable to develop proper canopy and boll number due to reduced LAI (Bange *et al*., 2003).

A field study was laid out to estimate the growth and yield performance of five cotton varieties (MNH-786, FH-113, FH-115, FH-207 and FH-901). FH-115 showed best results and gave maximum yield by producing maximum sympodials, more bolls per plant and greater ginning out turn (Fahad *et al*., 2008). Saleem *et al* (2009) manifested that cultivars showed no effect on first floral bud initiation.

Genotype and environment affect the earliness index (Kassianenko *et al*., 2003). The selection of cultivars is a key factor which affects the cropping system (Nichols *et al*., 2004). The primary factor which affected the initiation of first floral bud was cotton varieties and temperature (Iqbal *et al*., 2003).

Nitrogen use efficiency (NUE) can support in forecasting the extent of fertilizer to be added to any agricultural system in any area and thus sustaining the nitrogen equilibrium between inputs and outputs without any losses at either the economic or environmental levels (Mcallister *et al*., 2012). Crops such as cotton fluctuate in the value of the NUE, which may be a return of genetic traits (Hirel *et al*., 2011), agronomic and environmental conditions. Due to the accelerating N fertilizers costs and environmental impacts (Steel *et al*., 1997), it is inevitable to improve NUE and understand the factors

that affect the nitrogen use efficiency in cotton (Larry, 2006; Roberts, 2008).

The present study was therefore, undertaken to assess growth, seed cotton yield and to calculate nitrogen use efficiency of cotton cultivars at varying nitrogen levels under the climatic conditions of Faisalabad.

Materials and methods

A field trial was laid out in randomized complete block design with factorial arrangement using three replications. Net plot size was 3.0 m × 6 m. There were three cotton cultivars (FH-114, FH-142 and MNH-886) and three nitrogen levels (150, 200, 250 kg ha^{-1}). Crop was sown on 27 May 2014 with 20 kg ha^{-1}seed. All crop husbandry practices were done in normal way.

Days taken to first floral bud initiation: Time period from sowing to squaring was noted which were selected in every plant.

Days taken to first flower: First flower initiation days was recorded from the representative plants when yellowish and white flowers appeared on 50% tagged plants.

Days taken to first boll splition: Boll splition period was observed from sowing of crop till the cracked boll lint was appearing.

Earliness index (%): For calculation of earliness index (%) following formula was used (Singh 2004).

$$\text{Earliness index (\%)} = \frac{\text{Weight of seed cotton from first pick}}{\text{Total seed cotton weight from all the picks}} \times 100$$

Number of sympodial branches per plant: Number of sympodial branches per plant was recorded by counting the sympodial branches from the selected plants of each plot and average was taken.

Number of monopodial branches per plant: Noted the monopodials per plant from three tagged plants before first picking.

Leaf area index (LAI): To calculate the leaf area index (LAI) we used the following formula as suggested by Watson (1952).

LAI = Leaf area / Land area

Total dry matter (TDM): Took sample of 5 g and put into the oven at 62ºC until the constant weight achieved.

Yield ha^{-1} (kg): Seed cotton yield per hectare in kg was calculated from the seed cotton yield per plot.

Data collected on growth, biomass and yield were analyzed statistically by employing the Fisher's analysis of variance technique and significance of treatments' means was tested using least significant difference (LSD) test at 5% probability level (Steel *et al*., 1997).

Results

Interaction (nitrogen × cultivars) remained non-significant for all parameters recorded in this study (Table 1). Maximum time period for squaring was 45.33 days with nitrogen rate of 250 kg ha^{-1}. The lowest time period for squaring was 40.77 at 150 kg N ha^{-1}. There were non-significant differences between cultivars (Table 2).

The maximum time period for flowering (62 days) was noted at 250 kg N ha^{-1} and the lowest time period (60.67) at 150 kg N ha^{-1}. Number of days taken to flowering was higher at 250 N (kg ha^{-1}) as compared with 200 N (kg ha^{-1}) and 150 kg N ha^{-1}.

Days to first boll splition were affected significantly by different levels of nitrogen and by various cotton cultivars. Maximum days to first boll splition (118.56) were recorded at 250 N (kg ha^{-1}) and minimum time period for first boll splition was recorded at 150 kg N ha^{-1} (114.67 days). Among cultivars, the maximum days taken to first boll splition (118) were recorded in MNH-886 and minimum (115.56 days) in FH-114 which was at par to FH-142 (116.33 days).

Table 2 shows that highest total dry matter (13592 kg ha^{-1}) was produced at 250 kg N ha^{-1} which was at par to 200 kg N ha^{-1} (12847 kg ha^{-1}). However, the minimum value of total dry matter (11571 kg ha^{-1}) was observed for 150 kg N ha^{-1}. Total dry matter (TDM) was increased to about 14.86% (13592 vs. 11571 kg ha^{-1}). Among cultivars the maximum total dry matter (13641 kg ha^{-1}) was noted in FH-142. The minimum total dry matter (12143 kg ha^{-1}) was noted in MNH-886 and it remained at par with FH-114 (12406 kg ha^{-1}).

Effect of different nitrogen rates on earliness index was statistically significant. The maximum value (43.747) was recorded at 200 kg N ha^{-1}. Likewise, the minimum value was noted at 150 kg N ha^{-1} (40.040). The effect of cultivars was found to be non-significant on this parameter.

Leaf area index (LAI) is the main physiological component of crop yield. LAI was significantly affected by nitrogen rates. Maximum LAI (3.633) was recorded at 250 kg N ha^{-1} which remained at par with 200 kg N ha^{-1} (3.318). The minimum value of LAI (3.158) was noted for 150 kg N ha^{-1}. Also significant effect of cultivars on LAI was observed. The maximum leaf area index (LAI) was observed in FH-142 cultivar (3.692) which was at par to the MNH-886 (3.472) and the minimum leaf area index (LAI) was noted in FH-114 (2.945) as shown in Table 3.

The number of monopodial branches per plant was statistically affected by different levels of nitrogen. Maximum monopodials per plant were observed at 200 kg N ha^{-1} while the lowest monopodials per plant were observed at 150 kg N ha^{-1}. In cultivars there was non-significant difference (Table 3).

The effect of nitrogen levels on fruiting branches per plant was found to be significant. Table 3 shows that various nitrogen levels affected sympodia per plant of cotton cultivars. Result indicated that sympodia per plant was more at 250 kg

N ha^{-1}as compared to other two levels of nitrogen (150 and 200 kg N ha^{-1}). Among cultivars the maximum number of sympodial branches per plant (22.67) was reported in FH-142 and the minimum number of sympodial branches per plant was observed (21.39) in FH-114 and MNH-886.

Seed cotton yield is a combined effect of individual yield components under particular environmental conditions (Table 3). The effect of nitrogen rates on seed cotton yield was statistically significant. The maximum seed cotton yield (3322.0 kg ha^{-1}) was attainted at 200 kg N $ha^{-1}$and the minimum seed cotton (2728.9 kg ha^{-1}) was recorded by 150 kg N ha^{1}. Data on cultivars indicated that maximum seed cotton (3369.0 kg ha^{-1}) was produced by FH-142 and the minimum seed cotton yield (2655.7 kg ha^{-1}) was attained by FH-114.

Discussion

Number of days to squaring is very important phenological character. According to Saleem *et al.* (2009) the cultivars showed no effect on the first floral bud initiation. Rehana *et al.* (2001) reported that cultivars differed significantly for time period for first flower opening. Rehana *et al.* (2001) also noted different time period for first flower opening in cultivars and Panhwar *et al.* (2002) also recorded that the cultivars which matured earlier took more time to first boll open.

LAI from 2-5 have been reported by many workers for cotton in various agro- ecological conditions (Pettigrew, 2002; Ali *et al*., 2004; Shabbir, 2007). Our results corresponded to those of Prasad (2000) who noted that different nitrogen levels significantly affected monopodial branches on various cultivars of cotton. These results are also comparable to Abbasi and Abro, (2002); they observed that various cultivars of cotton behaved differently for sympodial branches under various fertilizer levels.

Our results connate with Bange and Milroy, (2000) and Ali *et al.* (2004) who reported that nitrogen has linear correlation with seed cotton yield. These results are also supported by Badr, (2003) who determined the yield and yield components of (*Gossypium hirsutum* L.) cultivars and observed significant differences. Soomro *et al.* (2005) also studied the seed cotton yield in upland cotton and found significant differences among cultivars.

Conclusion

On the basis of these results, it can be concluded that FH-142 performed best at 200 kg N ha^{-1} under the climatic conditions of Faisalabad.

References

Abbasi, Z.A. and M.B. Abro. (2002). Growth response of cotton cultivars under different NP fertilizer levels. *Pak. J. Appl. Sci.,* 2(4):494-496.

Ahmed, A.U.H., R. Ali, S.I. Zamir and N. Mehmood. (2009). Growth, yield and quality performance of cotton cultivar BH-160 (*Gossypium hirsutum* L.). *J. Anim. Plant Sci.,* 19(4):189-192.

Ali, M.A., Y.H. Tatla and M.J. Aslam. (2007). Response of cotton (*Gossypium hirsutum* L.) to potassium fertilization in arid environment. *J. Agric. Res.,* 45:191-198.

Ali, M.G., M.A. Mohy-ud-Din, S. Ali, Bashir and L. Ali. (2004). Cotton yield as affected by different sowing dares. *Int. J. Agri. Biol.,* 6(4):644-646.

Ali, S.A. and A.E. El-Sayed. (2001). Effect of sowing dates and nitrogen levels on growth, earliness and yield of Egyptian cotton cultivar Giza 88. *Egypt. J. Agric. Res.,* 79:221-232.

Badr, S.S.M. (2003). Evaluation of some Egyptian cotton varieties by the yield and seven methods of earliness of crop maturity measurements. *Egypt. J. Agric. Res.,* 81(2):671-688.

Bange, M.P. and S.P. Milory. (2000). Timing of crop maturity in cotton. Impact of dry matter production and partitioning. Csiro. Plant industry, Australian cotton cooperation Research. *Field Crop Res.,* 68(1):143-155.

Bange, M.P., S.P. Milroy and P. Thongbai. (2003). Growth analysis of short and long season cotton cultivars. Aust. Cotton Cooperative Res. Centre, Australia. *Field Crops Res.,* 88:129-142.

Bondada, B.R. and D.M. Oosterhuis. (2001). Canopy photosynthesis, specific leaf weight, and yield components of cotton under varying nitrogen supply. *J. Plant Nutr.,* 24:469-477.

Dar, J.S. and M.M. Anwar. (2005). Response of varying levels of nitrogen on growth of different inbred lines of cotton. *J. Agri. Soc. Sci.,* 1:48-49.

Fahad. E., A. Ali, M.A. Nadeem, M. Tahir and A. Majeed. (2008). Comparative Yield Performance of New Cultivars of Cotton (*Gossypium hirsutum* L.). Department of Agronomy, University of Agriculture, Faisalabad- Pakistan. *Pak. J. Life Soc. Sci.,* 6(1):1-3

Felix, B., A. Robert, R.L. Travis, D.W.Rains, and R.B. Hutamacher. (2003). Response of irrigated Acala and Pima cotton to Nitrogen fertilization, growth, dry matter partitioning and yield. *Agron. J.,* 95:133-146.

Hirel, B., T. Tetu, P.J. Lea and F. Dubois. (2011). Improving nitrogen use efficiency in crops for sustainable agriculture. Sustainability, 3:1452-1485.

Howard, D.D., C.O. Gwathmey, M.E. Essington, R.K. Roberts and M.D. Mullen. (2001). Nitrogen

fertilization of no till cotton on loess-derived soils. *Agron. J.*, 9 (3):157-163.

Hunt, R. (1978). Plant growth analysis. Studies in biology. Edward Arnold, London. 96:26-38.

Iqbal, M., M.A. Chang, M. Abid, M.Z. Iqbal, M. Hassan and N.I. Khan. (2003). Maturity of cotton cultivars in Multan as determined by nodes above white flower. *Asian J. Pl. Sci.*, 2(3):325-330.

Kassianenko, V.A., V.A. Dragavtsev, G.I. Razorenov and T.S. Razorenov. (2003). Variability of cotton (*Gossypium hirsutum* L.) with regard to earliness. *Genet. Resour. Crop Evol.*, 50:157-163.

Kienzler, K. (2010). Improving the nitrogen use efficiency and crop quality in the Khorezm region,Uzbekistan.Ph.D. diss., ZEF/Rheinische Friedrich-Wilhelms University at Bonn, Germany, Bonn.pp. 228.

Larry, G. (2006). How can we improve nitrogen use efficiency? Proceedings of the 2006 Wisconsin Fertilizer, Aglime and Pest Management Conference, Madison, 17-19 January 2006.

Liu, S., S. Zhang and L. Zhang. (2010). Above-ground dry matter accumulation of cotton genetics at different nitrogen applications. *Cotton Sci.*, 22:77-82.

Mcallister, C.H., P.H. Beatty and A.G. Good. (2012). Engineering nitrogen use efficient crop plants: The Current Status. *Plant Biotechnol. J.*, 10:1011-1025.

McConnell, J. Scott, W.H. Baker and R.C. Kirst. (2000). Varietal responses of cotton to nitrogen fertilization. Special reports-university of arkansas agricultural experiment station. 198:190-192.

Nichols, S.P., C.E. Snipes and M.A. Jones. (2004). Cotton growth, lint yield and fibre quality as affected by row spacing and cultivar. *J. Cotton Sci.*, 8:1-12.

Panhwar, G.N., A.R. Soomro, R. Anjum, S.B. Babar, A.M. Memon and A.W. Soomro. (2002). Predicting earliness in cotton during crop development stage-11. *Asian J. Plant Sci.*, 1:37-38.

Pettigrew, W.T. (2002). Improved yield potential with an early planting cotton production System. *Agron. J.*, 94:997-1003.

Prasad, M. (2000). Nitrogen, phosphorus and sulphur requirement of cotton (*Gossypium hirsutum*) Gobi sarson (*Brassica napus*, subsp oleifera var. annua) rotation. *Indian. J. Agron.*, 43(4):612-615.

Rehana, A., A.R. Soomro and M.A. Chang. (2001). Measurement of earliness in upland cotton. *Pak. J. Biol. Sci.*, 4:462-463.

Rinehardt, J.M., K.L. Edmisten, R. Wells, and J.C. Faircloth. (2004). Response of ultra-narrow and conventional spaced cotton to variable nitrogen rates. *J. Plant Nutr.*, 27:743-755.

Roberts, T.L. (2008). Improving nutrient use efficiency. Turk. J. Agri. For. 32:177-182.

Saleem, M.F., S.A. Anjum, A. Shakeel, M.Y. Ashraf and H.Z. Khan. (2009). Effect of row spacing on earliness and yield in cotton. *Pak. J. Bot.*, 41:2179-2188

Sawan, Z.M., M.H. Mahmoud and O.A. Momtaz. (2006). Agronomy and soils response of yield, yield components, and fibre properties of Egyptian cotton (*Gossypium barbadense* L.) to nitrogen fertilization and foliar-applied potassium and mepiquat chloride. *J. Cotton Sci.*, 10:224-234.

Shabbir. (2007). Growth, Radiation use efficiency of cotton cultivars under Multan conditions. Msc.Thesis Dept. of Agron; Univ. Agric. Faisalabad.

Singh, P. (2004). Cotton breeding. Kalyani Publishers Ludhiana New Dehli Nodia (U.P.) Hyderabad Chennei Kolkata Cuttack India. p. 118-295.

Soomro, A.R., R.G. Kakar, H. Ali and S.A. Abid. (2005). Comparison of yield and its components in some commercial cotton varieties. *Indus J. Plant Sci.*, 4(4):545-552.

Steel, R.G.D, J.H. Torrie and D. Dickey. (1997). Principles and procedure of statistics. A biometrical approach.3rded. McGraw Hill Book Co. Inc. New York. pp. 400-428.

Tilman, D., K.G. Cassman, P.A. Matson, R. Naylor and S. Polasky. (2002). Agricultural sustainability and intensive production practices. *Nat.*, 418:671-677.

Tomar, R.S.S., A.L. Kushwaha, R. Julka and K.C. Mandloi. (2000). Productivity of upland cotton (*Gossypium hirsutum*) genotypes under different levels of fertility and spacing. *Indian J. Agron.*, 45(4):776-781.

Wajid. A., A. Ahmad, T. Khaliq, S. Alam, A. Hussain, W. Naseem, M. Usman and S. Ahmad. (2010). Quantification of growth, yield and radiation use efficiency of promising cotton cultivars at varying nitrogen levels. *Pak. J. Bot.*, 42:1703-1711.

Watson, D.J. (1952). The physiological basis of variation in yield. *Adv. Agron.*, 4:101-104.

Table: 1. Effect of nitrogen rates and cotton cultivars on earliness and growth parameters

Parameters	**Source of Variation**		
	Cultivar (C)	**Nitrogen (N)**	**C × N**
Degrees of Freedom	2	2	4
Days taken to first floral bud initiation	3.5926^{NS}	46.7037*	0.9815^{NS}
Days taken to first flower	2.3333^{NS}	4.3333*	0.1667^{NS}
Days taken to first boll splition	14.0370**	34.0370**	1.3704^{NS}
Total dry matter	4377269*	9397268**	211842^{NS}
Earliness index	4.5074^{NS}	31.7912*	4.6411^{NS}
Leaf area index	1.3286**	0.5277*	0.2083^{NS}
Number of monopodial branches	0.0277^{NS}	7.19444*	0.18056^{NS}
Number of sympodial branches	4.8980^{NS}	300.454*	0.6340^{NS}
Seed cotton yield per hectare	1147453**	791659**	10446^{NS}

Where: *= Significant, **= Highly significant, NS= Non-significant

Table: 2. Effect of nitrogen rates on earliness and growth parameters of cotton cultivars

Nitrogen rate (N)	**Days taken to first floral bud initiation**	**Days taken to first flower**	**Days taken to first boll splition**	**Total dry matter (TDM) kg ha^{-1}**	**Earliness index (%)**
150 kg ha^{-1} (N_1)	40.77 C	60.67 B	114.67 C	11571 B	40.04 B
200 kg ha^{-1} (N_2)	43.11 B	61.67 A	116.67 B	12847 A	43.74 A
250 kg ha^{-1} (N_3)	45.33 A	62.00 A	118.56 A	13592 A	42.43 AB
LSD (5% probability)	**1.934**	**0.881**	**1.250**	**892.33**	**3.033**
Cultivar (C)					
FH-114	42.56	60.89	115.56 B	12406 B	41.40
FH-142	42.89	61.56	116.33 B	13461 A	42.81
MNH-886	43.78	61.89	118.00 A	12143 B	41.99
LSD (5% probability)	**NS**	**NS**	**1.250**	**892.33**	**NS**

Means not sharing common letters are statistically different at 5% level of probability, NS= Non-significant

Table: 3. Effect of nitrogen rates on growth and yield of cotton cultivars

Nitrogen rate (N)	**Leaf Area Index (LAI)**	**Number of monopodial branches/plant**	**Number of sympodial branches/plant**	**Seed cotton yield per/ha**
150 kg ha^{-1} (N_1)	3.15 B	2.05 C	16.05 C	2728.9 C
200 kg ha^{-1} (N_2)	3.31 AB	3.77 A	21.78 B	3322.0 A
250 kg ha^{-1} (N_3)	3.63 A	2.50 B	27.61 A	3016.1 B
LSD (5% probability)	**0.362**	**0.348**	**1.959**	**220.89**
Cultivar (C)				
FH-114	2.94 B	2.83	21.39	2655.7 C
FH-142	3.69 A	2.78	22.67	3369.0 A
MNH-886	3.47 A	2.72	21.39	3042.2 B
LSD (5% probability)	**0.362**	**NS**	**NS**	**220.89**

Means not sharing common letters are statistically different at 5% level of probability, NS= Non-significant