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Effect of different levels of nitrogen on phonological parameters of cotton (*Gossypium hirsutum* L.) cultivars under different climatic conditions

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Abstract

An experiment was conducted to investigate the impact of different levels of nitrogen on phonological parameters of cotton (*Gossypium hirsutum* L.) cultivars under different climatic conditions of Punjab (Pakistan) (College of Agriculture, University of Sargodha, Regional Agriculture Research Institute Bahawalpur and Adaptive Research Farm Dera Ghazi Khan) during the year 2016. These different environments have resulted in the adoption of the same crop management practices and cultivars comprising both conventional and non-conventional varieties (MNH-786 non –*Bt* and FH-142 and FH-Lalazar *Bt*) with different doses of nitrogen fertilizer viz. 0, 60, 120, 180, 240 and 300 kg nitrogen per hectare. Results of the experiment showed that among different levels of nitrogen minimum number of days to bud initiation(39.19 days) in Dara Ghazi Khan, flowering (50.66 days) in Dara Ghazi Khan, boll opening (99.44 days) Dara Ghazi Khan and boll maturation (108.94 days) in Bahawalpur location was recorded where we applied no dose of nitrogen (0 kg ha^{-1}). While among different varieties the minimum number of days to bud initiation (35.18 days) in Sargodha location by non-BT MNH-786, day to flowering (53.06 days) in Dara Ghazi Khan by non-BT MNH786, day to boll opening (105.19 days) in Dara Ghazi Khan by BT variety FH Lalazar and boll maturation (116.49 days) in Bahawalpur location by cotton cultivar FH 142. It concluded that no application of nitrogen to cotton cultivars under Dera Ghazi Khan location result in maximum phonological parameters of cotton.

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Introduction

Cotton plays a dynamic role in Pakistan's economy which is the most important cash crop. The fate of success to achieve maximum seed cotton yield depends upon the varieties which can adapt in different climatic conditions (Ali *et al.*, 2005). The main cause in the reduction of the seed cotton yield in different varieties is minimum boll and weight allied with the production of low dry matter. Cultivars that are more resistant to heat are highly productive than heat-sensitive varieties (Pettigrew, 2008). The most important feature in cotton varieties should be high potential, climate-resilient and suitable to adopt in different climatic conditions. The environment strongly influenced the flower and boll maturation (Singh *et al.*, 2007). The cotton crop grows efficiently at an optimum temperature of 33°C but the temperature above 36°C reduces the flowering and boll retention (Singh *et al.*, 2007). Late maturing varieties shed their fruits when grown at higher diurnal temperature (Kakani *et al.*, 2005). Boll formation in *Bt* cotton varieties is more than conventional varieties because of extended growing seasons when sown early (Hezhong *et al.*, 2006). The cotton crop needs specific thermal time at each vegetative and reproductive stage for higher production of seed cotton yield (Bange and Milroy, 2004). Cotton being indeterminate growth and the perennial plant is very sensitive to photoperiod (Bange *et al.*, 2008). Extremely high and low temperature adversely affects the seed cotton yield.

A recent study, Luo *et al.* (2014) measured the influence of a rise in temperature in the phenology of cotton crop and the incidence of cold shocks and heat stress for the period centered on 2030 in Australia. Cotton growth will be affected due to a probability of the periodic occurrence of cold and heat shocks increasing events on the phenology of cotton as a consequence of future climate change. A maximum number of bolls produced by *Bt* cotton varieties due to the extended growing season (Hezhong *et al.,* 2006). On the other hand, conventional varieties performed well at timely sowing as well as at late sowing regimes (Akhter *et al.,* 2002; Arshad *et al.,* 2007). At high temperature and electrical conductivity plant become injured by the fluid release from the plant, enzyme present inside become denatured, due to this reason plants showed abnormality ultimately reduced the seed cotton yield. So, for the highest production of the crop selection of cotton varieties is very important (Asha and Ahamed, 2013). Iqbal *et al.* (2003) stated that the first floral bud initiation was affected by different cotton cultivars including temperature. They also reported that cultivars MNH-552, MNH-554 and AC-134 with five nitrogen levels found no significant effect on anthesis days and seed cotton yield at the lower and higher level of nitrogen. (Kassianenko *et al.,* 2003) stated that an earliness index was affected by the interaction of genotype with an environment. Imran *et al.* (2016) reported a maximum time 45.33 days for squaring at the rate of 250 kg N ha^{-1}, while the minimum time for squaring was 40.77 days at 150 kg nitrogen per hectare. The maximum time for flowering 62 days reported at 250 kg N ha^{-1}, while the less time (60.67 days) at 150 kg nitrogen per hectare, the no. of days for flowering was higher at 250 kg N ha^{-1} when compared with 200 and 150 kg N ha^{-1} respectively (Imran *et al.*, 2016). The different cultivars revealed no effect on the first floral bud initiation (Saleem *et al.*, 2009), while Rehana *et al.* (2001) stated that different cultivars showed a significant difference for the time to the first flower opening. Similarly, different periods were recorded for the first flower opening by (Rehana *et al.*, 2001). Panhwar *et al.* (2002) reported that early matured cultivars took more time to first boll opening.

Imran *et al.* (2016) recorded the maximum number of days for first boll split (118.56) at 250 kg nitrogen per hectare while the minimum no. of days (114.67) at 150 kg nitrogen per hectare. The cultivar MNH-886 reflected more no. of days for first boll Split (118) and FH-114 showed less no. of days for first boll split (115.56) which was at par with FH-142 showing 116.33 days for first boll Split. Panhwar *et al.* (2018) studied that number of bolls per plant can be more by increasing the N levels at 150 kg per hectare. Ali *et al.* (2007) stated that through proper management of fertilizer, cotton yield can be increased. Khan and Dar (2006) observed that by increasing the nitrogen fertilizer rate seed cotton yield can be increased. Panhwar *et al.* (2018) found in his study that a no. of bolls plant^{-1} can be maximized by increasing the nitrogen at 150 kg ha^{-1}, these results are confirmed by Khan and Dar (2006) who described that more no. of bolls plant^{-1} can be obtained by increasing the N application at 50 and 200 kg ha^{-1}. The most important nutrient required for cotton production is nitrogen which greatly influences the growth, development and seed cotton yield. The quality of the cotton is also determined by the application of the fertilizer. So, the application of nitrogen is crucial for better vegetative growth and development due to its indeterminate growth (Hou *et al.*, 2007). The cotton plant gains an advantage from the elevated carbon dioxide being the C4 plant. 5.5 % more seed cotton yield was observed in prevailing temperature while 56% reduced when temperature raised to extreme temperature and 28% reduction was recorded when temperature raised to the least temperature (Jalota *et al.*, 2009). Proper sowing time plays a vital role to get maximum production with great efficiency. So, to achieve this goal selection of varieties accordingly time of plantation is most important. Although, in the wheat-cotton cropping system of Pakistan having the different climatic conditions, cotton varieties within the same species, showed a different response to temperature, comprising the different phenological period, fluctuation in the formation of squire and bolls (Singh *et al.*, 2007). Therefore, this study was planned to investigate the effect of nitrogen on phonological parameters of cotton (*Gossypium hirsutum* L.) cultivars under different climatic conditions.

Materials and methods

The trials were conducted at Sargodha Agronomy Research Area, College of Agriculture, University of Sargodha, Adaptive Research Farm of Dera Ghazi Khan and Regional Agricultural Research Institute of Bahawalpur under arid and semi-arid conditions of Punjab province of Pakistan during the Kharif season of 2016.

Design and treatments

The experiments were arranged in split-plot design having three replications with a net plot size 8 × 3.75 m each. Cotton cultivars were randomized in main plots while nitrogen doses were managed in subplots. The treatments were as under.

Cultivars (Main plots)

V_1 = FH-142

V_2 = MNH-786

V_3 = FH-Lalazar

Nitrogen levels (Sub plot)

N_1 = (Control)

N_2 = 60 kg ha^{-1}

N_3 = 120 kg ha^{-1}

N_4 = 180 kg ha^{-1} (Standard)

N_5 = 240 kg ha^{-1}

N_6 = 300 kg ha^{-1}

The crop was sown during the Kharif season, on 75 cm spaced ridges keeping the plant to plant distance of 30 cm, at all locations. Phosphorous and potassium were applied at 60-60 kg ha^{-1}, respectively. Nitrogen, phosphorous and potassium were applied in the form of urea, diammonium phosphate (DAP) and sulfate of potash (SOP). The 1/3 nitrogen and all of the phosphorous and potassium fertilizer were applied at sowing time while the remaining 2/3rd of N was applied in two splits, the first dose was applied at first irrigation and the second dose was top-dressed at the flowering stage. All other cultural practices were kept normal for the crop at three experimental sites.

Crop husbandry

During both cropping seasons, all crop management practices at all three locations were kept alike. The crop was sown at ridges with a delinted seed rate at 8 kg ha^{-1}.

Observations

Five plants were randomly selected in both years and tagged in each plot for recording the data regarding the developmental stages (Days to bud initiation, Days to flowering, Days to boll opening and Days to boll maturation).

Growing degree days (Thermal time) were calculated according to Gallagher and Biscoe (1978), which determines the thermal time taken for each stage initiation. Where Tt is a function of mean temperature over a base temperature (Tb).

$$Tt = \frac{\sum(Tmax + Tmin) \ \ - Tb}{2}$$

Where; T_{max} and T_{min} represent the maximum and minimum temperatures, respectively. Whereas T_b represents the base temperature (15°C) for the cotton crop (FAO, 2003).

Number of days to bud initiation

Days taken to bud initiation were noted by selecting a sample of five plants selected randomly. These selected plants were tagged to wait till 50% of bud formation. Daily visits were done to the experimental field for recording the observation. An average number of days needed to complete the 50 % bud formation was observed from the date of sowing.

Number of days to flowering

After the random selection of five plants, the number of days to flowering was recorded. These selected plants were tagged to observe the date of fifty percent flowering. A daily regular survey in field trial was done for recording observation. The number of average days taken to attain the flowering stage from the date of crop sowing was counted.

Days to boll opening

Days taken to boll opening were recorded by a random selection of five plants. These selected plants were tagged to observe the 50% boll opening. A regular survey of the experimental field was done for an observation. The number of average days taken to attain 50% completion of boll formation was documented from the date of crop sowing.

Days to boll maturation

Boll maturity period was observed by selecting five plants randomly and tagging was performed afterward. For recording, this parameter daily visits were made of the experimental site. Then 50% of mature bolls dates were observed before boll opening. Afterward, an average number of days of 50% bolls to mature were noted from crop sowing date.

Statistical analysis

The statistical analysis of data was executed by employing Fisher's analysis of variance techniques (Steel *et al.*, 1997). To test the significance of the treatments tuky HSD test was implemented at 5% probability level.

Result and discussion

Bud formation has a significant role in seed cotton yield and its initiation is greatly governed by environmental and genetic factors especially temperature plays a vital role in first square initiation and its further development. The effect of different levels of nitrogen on days to bud initiation (days) of cotton (*Gossypium hirsutum* L.) cultivars under different climatic conditions were found significant. Results regarding the effect of cotton cultivars under different locations on days to bud initiation revealed that a smaller number of days for bud initiation were observed in non-*Bt* variety MNH-786 (35.18 days) in Sargodha while maximum *Bt* varieties (FH-Lalazar a) at DGK location. These findings also matched with Sarwar *et al.* (2012) who confirmed that non-*Bt* cotton cultivar MNH-786 attained minimum days for squaring than *Bt* cotton cultivars. Different levels of nitrogen produced a significant effect on the number of days for bud initiation. The maximum number of days for bud initiation (39.19 days) was observed at 300 kg N ha^{-1}. While the minimum number of days for bud initiation (32.22 days) was observed at 0 kg N ha^{-1}. These results are corroborated with findings of Sarwar *et al.* (2012) who described a positive relationship between the days for floral bud initiation and nitrogen doses (Fig. 1). The basic component for the reproductive growth of the cotton crop is a flower, which plays an important role to increase the seed cotton yield. The effect of different levels of nitrogen on days to flowering/ anthesis of cotton (*Gossypium hirsutum* L) cultivars under different climatic conditions was found significant. Results related to cultivars' effect on several days to flowering showed that non-*Bt* cotton variety MNH-786 takes a smaller number of days for flowering (53.06 days) at Sargodha, while the maximum days to flowering were recorded (54.76 days) at Bahawalpur location by *Bt* cotton variety FH-Lalazar followed. These results coincided with the findings of Habib *et al.* (2013); Sarwar *et al.* (2012); Panhwar *et al.* (2010); Rehana *et al.* (2001) who reported that cultivar significant effect on days to flowering of cotton cultivars.

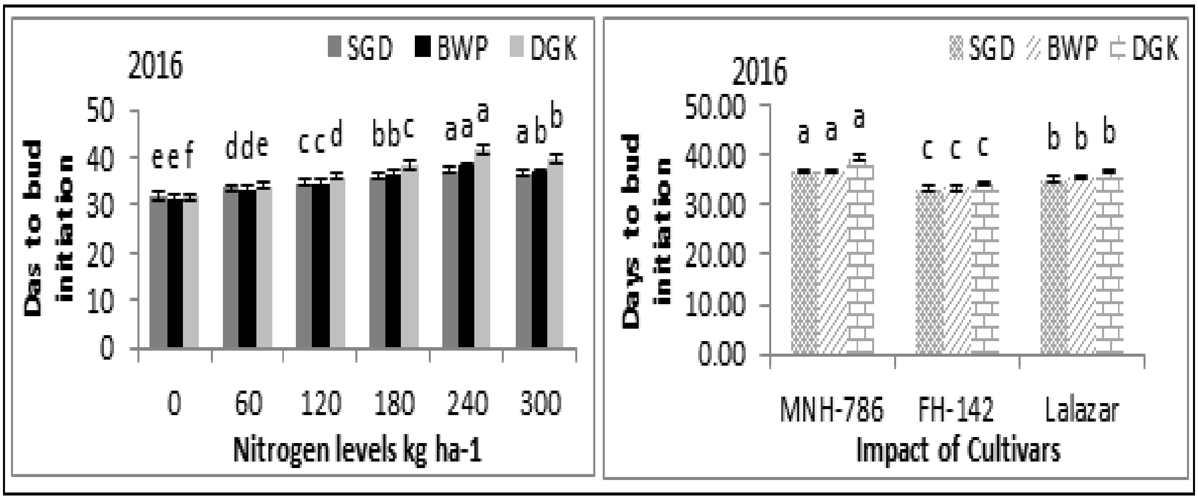

Fig. 1. Days to bud initiation at selected localities.

A positive effect of the nitrogen rate on the initiation of flowering days was observed on days to flowering of cotton cultivars. More number of days taken to flowering (56.35 days) was observed at 300 kg N ha^{-1} at Dara Ghazi Khan Location. While minimum days to flowering (50.64 days) were noted in control plots at Dara Ghazi Khan Location. These results are in line with the results of Sarwar *et al.* (2012) who explained that different nitrogen levels significantly affected the flowering days (Fig. 2).

Boll opening is a very important benchmark for the improvement of seed cotton yield. Early boll opening means early harvesting of the crop. Earliness of the boll opening at different stages of crop development indicates the earliness of cotton genotypes.

The effect of different levels of nitrogen on days to boll opening (days) of cotton (*Gossypium hirsutum* L) cultivars under different climatic conditions was found significant.

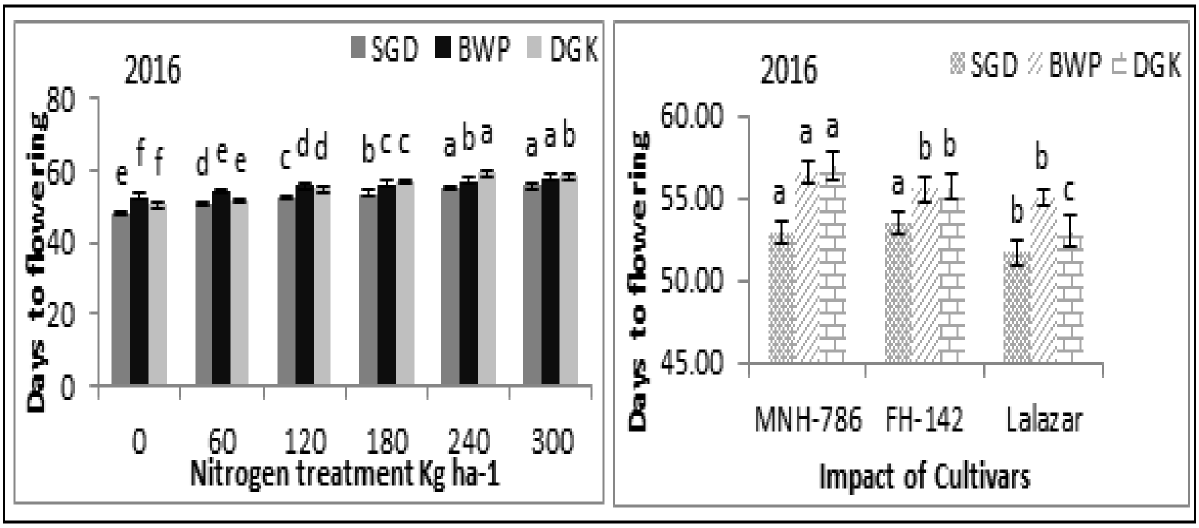

Fig. 2. Days to flowering/ anthesis at selected localities.

Results revealed that among different cultivars of cotton it was noted that *Bt* cotton cultivar FH-Lalazar attained a smaller number of days (105.19 days) for boll opening at Dara Ghazi Khan location. While the maximum number of days for boll opening (106.04 days) was attained at Sargodha location by *Bt*-FH-142. The difference in the number of days for boll opening might be due to the difference in the genetic makeup of cultivars. These findings are endorsed by Anjum *et al.* (2002); Saira *et al.* (2002); Soomro *et al.* (2002); Soomro *et al.* (2004) who reported that genotypes significantly differed in days to boll opening. Saleem *et al.* (2009) also confirmed the effect of genotypes on the boll opening days.

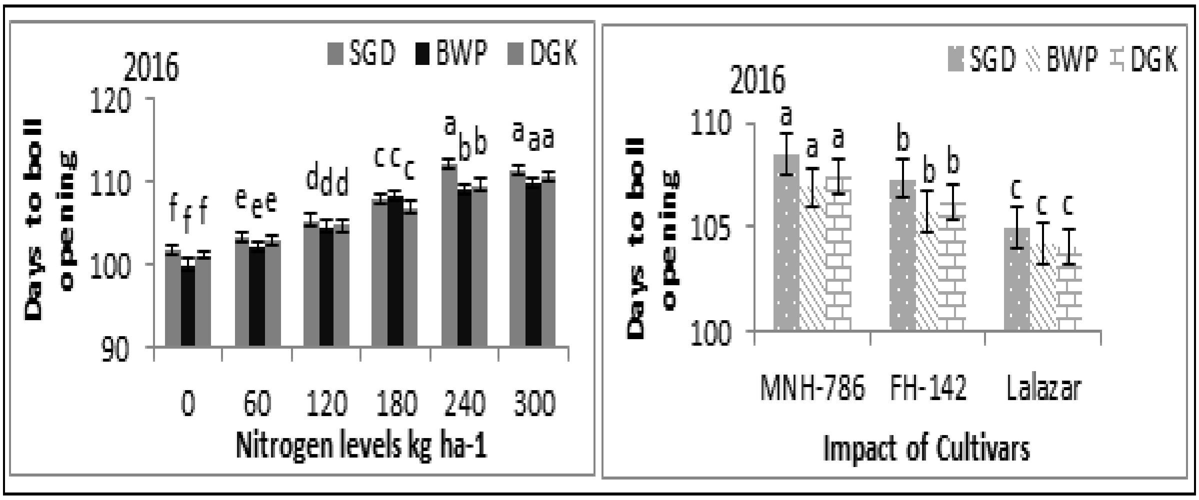

Fig. 3. Days to boll opening at selected localities.

Data regarding various levels of nitrogen revealed that a maximum number of days for boll opening 110.27 days were taken at Sargodha location where we applied nitrogen at a level of 300 kg N ha^{-1}. Oppositely, the minimum number of days for boll opening 99.44 days were observed where we applied no nitrogen in the Sargodha location. Genetic characters of a plant play a vital role in a no. of days taken for boll opening. These findings are confirmed by Ayissaa and Kebedeb, (2011) who stated that varieties and nitrogen doses had a significant impact on days to boll opening initiation. Ayissaa and Kebedeb, (2011) also confirmed that nitrogen excess or shortage negatively affected the boll opening period of the cotton crop because in nitrogen-deficient conditions the process of growth becomes poor and stagnant, while nitrogen excess prolonged its vegetative growth (Fig. 3).

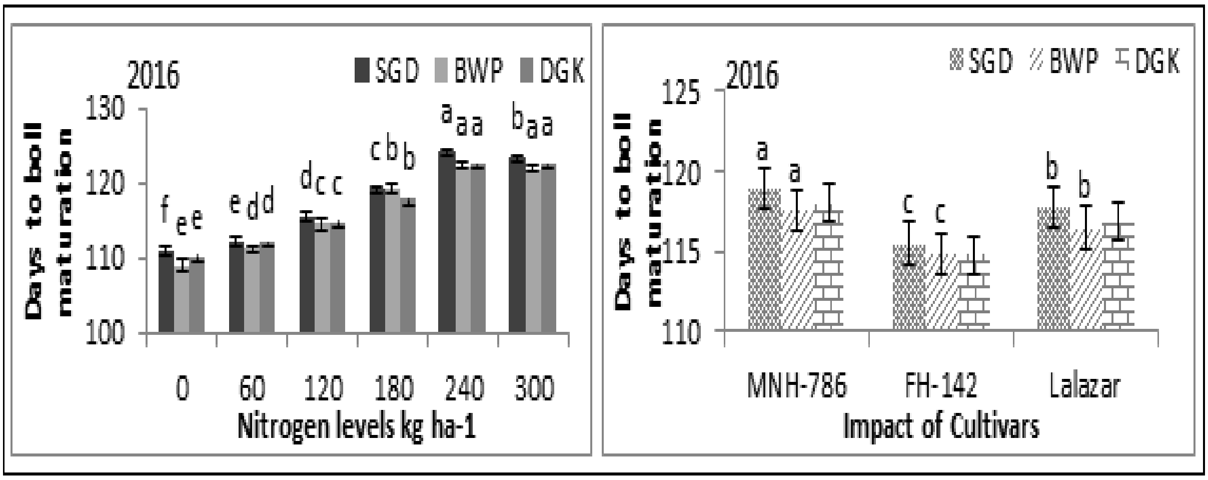

Fig. 4. Days to boll maturation at selected localities.

The time interval between flowering and boll opening is defined as the boll maturation period. The yield of seed cotton completely depends upon boll maturation. More will be the boll maturation more will be the yield and vice versa. The effect of different levels of nitrogen on days to boll maturation (days) of cotton (*Gossypium hirsutum* L) cultivars under different climatic conditions were found significant. Our results clarified that cultivar response to several days for boll maturation was significant. Among the cotton varieties, *Bt* cotton variety FH-142 attained a smaller number of days (116.45 days) in Bahawalpur location. While FH-Lalazar showed a maximum number of days (117.57 days) in Sargodha location. The difference in the number of days taken for boll maturation may be attributed to the difference in the number of growing degree days by the cultivars. These results are also confirmed by Ayissaa and Kebedeb, (2011).

Significant results were observed in the number of days taken for boll maturation with different levels of nitrogen application on an average a maximum number of days for boll maturation (123.32 days) were attained in Sargodha location at 300 kg N ha^{-1}. While a minimum number of days (108.94 days) were taken for boll maturation was observed in control plots in the Bahawalpur location.

These findings comply with that of Ayissaa and Kebedeb, (2011) who reported that a nitrogen level above optimum delayed maturity due to excessive vegetative growth of cotton (Fig. 4).

Conclusion

Therefore, it was concluded from our study that no application of nitrogen to cotton cultivars under Dera Ghazi Khan Location result in maximum phonological parameters of cotton (*Gossypium hirsutum* L.).

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