INT. J. BIOL. BIOTECH., 11 (1): 135-139, 2014.

NITROGEN EFFECT ON FRUIT SETTING IN COTTON UNDER MOISTURE STRESS

Mahmood-ul Hassan[1], M. Maqsood[2], M. Saleem[1], S. Aftab Wajid[2] and S. Sarwar Alam[1]

[1]*Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan*
[2]*Agronomy Department, University of Agriculture, Faisalabad, Pakistan*
Corresponding author's e.mail:mhj407jb@yahoo.com

ABSTRACT

Two years field experiments were conducted at Nuclear Institute for Agriculture and Biology to study the effect of moisture stress and nitrogen interaction on fruit setting of new genotypes of cotton under climatic conditions of Faisalabad. Experiments were designed according to RCB split-split plot arrangements with three replications. Four moisture stress treatment applied were; local control (LC)-recommended irrigations, moisture stress at inter-node elongation stage (MSI), moisture stress at vegetative growth stage (MSV), and moisture stress at inter-node elongation and vegetative growth stage (MSI+ MSV). Three nitrogen (N) doses used were; 50 kg ha^{-1}, 100 kg ha^{-1}, and 150 kg ha^{-1}. Three cotton genotypes NIAB-846, NIAB-824, and CIM-496 were planted. Highest fruit setting% ($P \leq 0.05$) of 53.89% (during 2008-09) and 58.57 % (during 2009-10) was achieved by interaction of MSV × 50 kg N ha^{-1} × NIAB-846 followed by highest fruit setting in MSV × 100 kg N ha^{-1} × NIAB-846 interaction in both the years. These results showed that in LC (where sufficient irrigation water is available for application at critical growth stages), nitrogen application @ 100 kg ha^{-1} may be more economical as compared to farmers' practice of higher N use i.e. 150 kg ha^{-1}. However, under deficit irrigation, moisture stress at vegetative growth phase (MSV) it produced higher fruit setting in NIAB-846 and CIM-496 genotypes of cotton by lower nitrogen dose of only 50 kg N ha^{-1}as compared to 150 kg N ha^{-1}.

Key words: Moisture stress, nitrogen, Cotton (*Gossypium hirsutum* L.), fruit setting

INTRODUCTION

Cotton is the major cash crop of Pakistan grown over three million hectares and is the backbone of Pakistan's economy. Genetic improvements in cotton during recent decades resulted in release of varieties with high yield potential but the ability of newly emerging genotypes for bolls retention and maturity under abiotic stresses remains a challenge for agronomists. Due to indeterminate to semi determinate growth habit, cotton genotypes have an extended fruiting period which is greatly influenced by abiotic stresses including changing climatic conditions resulting in a loss of greater proportion of the fruits on cotton plants.

Average seed cotton yield ha^{-1}in Pakistan is 769 kg ha^{-1}, which is still much lower as compared to other cotton growing leading countries in the world (Agricultural statistics of Pakistan, 2012-13; Pakistan Economic Survey 2012-13). Research efforts are in progress to develop drought tolerant verities of cotton because water resources of the country are depleting rapidly. The same problem is persisting worldwide and has been reported in several studies during recent decade (Batchelor *et al.*, 1999; Braga, 2000; Gan *et al*., 2000; Clay *et al.*, 2001).Cotton plant is adversely affected either by insufficient irrigation or over irrigation. Insufficient moisture in the root zone due to water stress during the sensitive growth stages, such as the peak flowering and fruit-setting stages, can lead to a reduced number of fruiting positions, boll shedding, and poorly developed bolls; on the other hand, over irrigation of cotton can cause undesired excessive vegetative growth, which may reduce cotton yields (Pettigrew 2004; Aujla *et al.*, 2005; Dagdelen *et al.* 2006; Karam *et al*., 2006; Basal *et al.*, 2009). Additionally; information on moisture stress and N interaction effect on fruit setting of new cotton genotypes is lacking and needs to be investigated for exploration of maximum yield potential. This study was planned with the objectives to determine the interaction effect of moisture stress and N on fruit setting of cotton genotypes.

MATERIALS AND METHODS

Field experiments were carried out at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan under mixed cropping zone of Punjab Province during 2008-09 and 2009-10 growing seasons of cotton. Both the year experimental plots were alkaline in nature (pH: 8.10, 8.40), with low organic matter (0.41%, 0.66%), lower nitrogen (7.70 mg kg^{-1}, 8.70 mg kg^{-1}) and low available phosphorus (4.00 mg kg^{-1}, 5.30 mg kg^{-1}).

The experiments were laid out in Randomized Complete Block Design (RCBD) with split-split plot arrangements in three replicates. Irrigation stress treatments were kept in main plots, nitrogen doses in sub-plots, and genotypes in sub-sub plots. The net plot size was 3.6 × 3.0 m. Experiments comprised of the following treatments:

i. Moisture (I) stress treatments (Main plots)

I_1 Local control (LC) = Eight irrigations as recommended by Govt. Agri. Extension Departments, all irrigations were applied at 50 % Available Soil Moisture Depletion Level (ASMDL)

I_2 Moisture stress at inter-node elongation stage (MSI) = Withholding irrigation in July up to 80 % ASMDL

I_3 Moisture stress at vegetative growth stage (MSV) = Withholding irrigation in September up to 80 % ASMDL

I_4 Moisture stress at inter-node elongation and vegetative growth stage (MSI + MSV) = Withholding irrigation in July and September at 80 % ASMDL

ii. Nitrogen (N) doses (Sub plots)

$N_1$50 kg ha^{-1}

$N_2$100 kg ha^{-1}

$N_3$150 kg ha^{-1}

Urea (46 % N) was used as a source of nitrogen in all the treatments.

iii. Genotypes (Sub-sub plots)

V_1 NIAB-846

V_2 NIAB-824

V_3 CIM-496

Soil water contents were measured by using the gravimetric procedure of direct soil water measurement. For this purpose, soil sampling was done regularly on alternate days, keeping in view of the weather conditions from May to December before the time of crop harvest each year. Composite soil samples at the depth of 0-60 cm were taken randomly in each plot for moisture determination, as the maximum moisture extraction depth of root zone of cotton crop was taken as 150 cm, with the exception of 15 cm surface layer. The soil samples were dried in oven at 100^0C for 24 hours. Crop was sown manually by dibbler method by placing 4-5 seeds per-hill while maintaining row × row and plant × plant distance of 75 cm and 30 cm, respectively. Phosphorus (P_2O_5) was applied to all treatments uniformly @ 70 kg ha^{-1} in the form of single super phosphate, SSP (18 % P_2O_5). Nitrogen (N) treatments as Urea were applied in three equal splits i.e. at sowing, dense flowering and boll development stages. Irrigations were applied according to the treatments while using canal water. At three leaf stage thinning operation was performed to maintain single plant per-hill. The crop was sprayed with Confidor, Talstar, Curacuron, Acetamiprid and Tracer to control spotted bollworms, mealybug, jassids, thrips and white-fly insect-pests.

Ten guarded plants from every plot were selected randomly and then tagged and number of bolls $plant^{-1}$ was counted at crop maturity stage. The number of mature bolls $plant^{-1}$ was averaged. Total number of nodes was also counted from selected plants and then averaged to calculate $plant^{-1}$ nodes number. Fruit setting% was calculated as:

$$\text{Fruit Setting \%} = \frac{\text{Total number of bolls per plant}}{\text{Total number of nodes per plant}} \times 100$$

RESULTS AND DISCUSSION

Fruit setting % in cotton is the fraction of total nodes $plant^{-1}$ and the number of bolls retaining on the plant under multiple interactions. Narrowing the ratio between total nodes and bolls number $plant^{-1}$ by favorable interactions in the field, contributes in exploring the highest yield potential of any genotype. Analysis of variance of main and interaction effects are shown in Table 1. Main and interaction effects of moisture stress, N dose, and genotypes on fruit setting% was found significant ($P \leq 0.05$) both the years. During 2008-09; among different stress treatments I_3 (MSV) resulted in highest fruit setting both the year. Out of three different doses of nitrogen, N_1 (100 kg ha^{-1} N), produced maximum fruit setting. Whereas among genotypes; V_1 (NIAB-846) got highest fruit setting. During 2009-10; main effects of moisture stress and genotypes was similar but N dose effect remains non-significant. Interaction effects I × N × V, were observed significant both the years (Table 1).

Fruit setting by interaction of moisture stress, nitrogen and genotypes during two year field experiments revealed that maximum fruit setting% ($P \leq 0.05$) of 53.89% (during 2008-09) and 58.57% (during 2009-10) was achieved by interaction of $I_3 \times N_1 \times V_1$ (MSV × 50 kg N ha^{-1} × NIAB-846) followed by higher fruit setting% of 50.63 and 52.26 during 2008-09 and 2009-10, respectively interaction of $I_1 \times N_2 \times V_1$ (LC, no stress × 100 kg N ha^{-1} × NIAB-846), Table 2.During 2008-09, minimum fruit setting (26.52%) was observed in interaction treatments of $I_1 \times N_3 \times V_2$ (LC × 150 kg N ha^{-1}× NIAB-824) followed by 28.14% fruit setting by interaction of $I_4 \times N_3 \times V_3$ (MSI+MSV × 150 kg N ha^{-1}× CIM-496). During 2009-10, lowest fruit setting of 25.78% was recorded by interaction of $I_4 \times N_1 \times V_3$ (MSI+MSV × 50 kg N ha^{-1}× CIM-496) followed by 32.68% fruit setting in interaction treatment of $I_4 \times N_2 \times V_3$ (MSI+MSV × 100 kg N ha^{-1}× CIM-496). Minimum fruit setting in CIM-496 by water stress interaction treatments I_1 (LC) and I_4 (MSI+MSV), indicate variable genotypic-specific interaction response, that needs to be further investigated.

Table 1. Effect of moisture stress, nitrogen and genotypes on fruit setting.

Treatments	Fruit setting (%)	
	2008-09	2009-10
Moisture stress (I)		
I_1	36.56 b	42.73 b
I_2	34.93 bc	40.14 c
I_3	43.30 a	47.01 a
I_4	33.32 c	38.50 c
LSD (P <0.05)	2.96*	2.35*
Nitrogen dose (N)		
N_1	36.51 b	41.63
N_2	40.43 a	42.67
N_3	34.13 b	41.99
LSD (P <0.05)	2.56*	NS
Genotypes (V)		
V_1	40.21 a	45.23 a
V_2	35.66 b	40.59 b
V_3	35.21 b	40.46 b
LSD (P <0.05)	2.56*	2.03*
Interaction (LSD, P<0.05)		
I × N	5.12*	4.06*
I × V	NS	4.06*
N × V	4.44*	3.52*
I × N × V	8.87*	7.04*
Grand mean	37.03	42.09
CV	14.72	10.27

*

Significant at P<0.05; NS = non-significant at P<0.05)

Controlling of excessive vegetative growth and managing the cotton plant towards more fruiting is most desirable in cotton for exploring of higher yield potential of any genotype of cotton. Above mentioned results indicate that by favorable interaction abiotic factors in the field; cost of production may be significantly reduced. These findings are also supported my previous studies (Li, 1979; Shi *et al.*, 1987 and Li-Song *et al.*, 2005). Out of three genotypes studied NIAB-846 was found more tolerant with higher fruit setting under stress. Previously in several studies the variation stress tolerance among different genotypes of cotton (*Gossypium hirsutum* L.) has been observed by scientists (Quisenberry *et al*., 1982; Pereira *et al*., 1998; McCarty *et al*., 2004; Pettigrew, 2004; Basal *et al*., 2005; Kar *et al*., 2005). In the present study we have tried to investigate the most suitable genotypic-specific interaction effect of moisture and nitrogen on fruit bearing.

Table 2. Interaction effects of moisture stress, nitrogen and genotypes on fruit setting.

Treatments	Fruit setting (%)	
	2008-09	2009-10
$I_1 \times N_1 \times V_1$	36.48 fghijklm	43.42 defghi
$I_1 \times N_1 \times V_2$	37.47 fghijk	40.55 fghij
$I_1 \times N_1 \times V_3$	30.45 ijklmn	43.12 de
$I_1 \times N_2 \times V_1$	50.63 ab	52.26 ab
$I_1 \times N_2 \times V_2$	42.69 bcdefg	41.42 fghij
$I_1 \times N_2 \times V_3$	44.76 bcdef	45.49 bcdefg
$I_1 \times N_3 \times V_1$	31.80 ijklmn	40.15 fghijk
$I_1 \times N_3 \times V_2$	26.52 n	43.52 defgh
$I_1 \times N_3 \times V_3$	28.89 klmn	37.54 hijkl
$I_2 \times N_1 \times V_1$	37.39 fghijkl	41.30 fghij
$I_2 \times N_1 \times V_2$	46.91 abcde	36.70 hijkl
$I_2 \times N_1 \times V_3$	47.57 abcd	35.43 jkl
$I_2 \times N_2 \times V_1$	39.32 defghi	41.30 fghij
$I_2 \times N_2 \times V_2$	34.40 ghijklmn	35.09 jkl
$I_2 \times N_2 \times V_3$	36.86 fghijklm	49.36 bcd
$I_2 \times N_3 \times V_1$	42.76 bcdefg	51.26 bc
$I_2 \times N_3 \times V_2$	29.18 klmn	33.30 kl
$I_2 \times N_3 \times V_3$	30.50 ijklmn	34.60 jkl
$I_3 \times N_1 \times V_1$	53.89 a	58.57 a
$I_3 \times N_1 \times V_2$	36.46 fghijklm	48.51 bcde
$I_3 \times N_1 \times V_3$	40.68 cdefgh	45.90 bcdefg
$I_3 \times N_2 \times V_1$	29.24 klmn	46.39 bcdef
$I_3 \times N_2 \times V_2$	42.69 bcdefg	41.39 fghij
$I_3 \times N_2 \times V_3$	28.56 lmn	41.64 efghij
$I_3 \times N_3 \times V_1$	43.80 bcdef	51.41 bc
$I_3 \times N_3 \times V_2$	31.43 ijklmn	43.22 defghi
$I_3 \times N_3 \times V_3$	49.94 ab	46.06 bcdef
$I_4 \times N_1 \times V_1$	33.33 hijklmn	39.00 ghijkl
$I_4 \times N_1 \times V_2$	34.00 ghijklmn	41.27 fghij
$I_4 \times N_1 \times V_3$	28.61 klmn	25.78 m
$I_4 \times N_2 \times V_1$	32.98 hijklmn	48.52 bcde
$I_4 \times N_2 \times V_2$	36.46 fghijklm	36.45 ijkl
$I_4 \times N_2 \times V_3$	48.97 abc	32.68 lm
$I_4 \times N_3 \times V_1$	38.51 efghij	40.04 fghijk
$I_4 \times N_3 \times V_2$	31.38 ijklmn	37.65 hijkl
$I_4 \times N_3 \times V_3$	28.14 mn	45.09 cdefg

(Values within a column followed by the same letter are non-significant at $P < 0.05$)

CONCLUSION

It has been concluded that if sufficient irrigation water is available for application at critical growth stages to above mentioned genotypes, nitrogen application @ 100 kg ha^{-1}may be more economical as compared to farmers' practice of higher N use i.e. 150 kg ha^{-1}. On the other hand for the water deficit areas of cotton growing, withholding of irrigation at vegetative growth phase (MSV) it is useful with lower dose of 50 kg N ha^{-1} that may contribute in saving of around 33% Urea fertilizer as compared to recommended rate. Further investigation is required to observe variable genotypic-specific response under multiple abiotic interactions under field conditions.

REFERENCES

Agricultural Statistics of Pakistan (2012-13). *Govt. of Pakistan statistics division* .Pakistan bureau of statistics.

Aujla, M. S., H. S. Thind and G. S. Butter (2005). Cotton yield and water use efficiency at various levels of water and N through drip irrigation under two methods of planting. *Agric. Water. Mgt*., 71(2): 167-179.

Basal H., N. Dagdelen, Unay A, E. Yilmaz (2009). Effects of deficit drip irrigation ratios on cotton (*Gossypium hirsutum* L.) yield and fibre quality. *J. Agron Crop Sci*., 195: 19-29.

Basal, H., C.W. Smith, P.S. Thaxton and J. K. Hemphill (2005). Seedling drought tolerance in upland cotton. *Crop Sci*., 45: 766-771.

Batchelor, W.D., B. Basso and J.O. Paz (1999). Examples of strategies to analyze spatial and temporal yield variability using crop models. *Eur. J. Agron*., 18 (1-2): 141-158.

Braga, R.N. (2000). *Predicting the spatial pattern of grain yield under water limiting conditions*. Ph.D. diss., University of Florida, Gainesville, FL.

Clay, D.E., S.A. Clay, Z. Liu and C. Reese (2001). Spatial variability of C-13 isotopic discrimination in corn (*Zea mays*). Comm. Soil Sci. Plant Anal., 32. Economic Survey 2011-12, Govt. of Pakistan. Finance Division, Economic Advisor's wing Islamabad.

Dagdelen, N., Y. Ersel, F. Sezgin and T. Gurbuz (2006). Water-yield relation and water use efficiency of cotton (Gossypium hirsutum L.) and second crop corn (*Zea mays* L.) in western Turkey. *Agric. Water Manage*., 82 (1–2): 63–85.

Economic Survey of Pakistan (2012-13). Ministry of Finance Govt. of Pakistan.

Gan, Y.T., G.P. Lafond and W.E. May (2000). Grain yield and water use: Relative performance of winter vs. spring cereals in east-central Saskatchewan. *Can. J. Plant Sci*., 80 (1): 533–541.

Kar, M., B.B. Patro, C.R. Sahoo and B. Hota (2005). Traits related to drought resistance in cotton hybrids. *Indian J. Plant Physiol*., 10: 377-380.

Karam, F., L. Rafic, M. Randa, A. Daccache, O. Mounzer and Y. Rouphael (2006). Water use and lint yield response of drip irrigated cotton to length of season. *Agric. Water Manage*, 85 (3): 287-295.

Li, Z. L. (1979). *Cotton Morphology*. Science Publish, Beijing (in Chinese).

Li-Song T., Y. Li and J. Zhang (2005). Physiological and yield responses of cotton under partial root zone irrigation. *Field Crops Res.*, 94: 214-223.

McCarty, J.C., J.N. Jenkins and J. Wu (2004). Primitive accession derived germplasm by cultivar crosses as Sources for cotton improvement. I. Phenotypic Values and Variance Components. *Crop Sci*., 44: 1226-1230.

Quisenberry, J. E., B. Roark and B.L. McMichael (1982). Use of transpiration decline curves to identify drought-tolerant cotton germplasm. *Crop Sci*., 22: 918-922.

Pereira, J.R., P.D. Fernandes and N.E. De-Macedo-Beltrao (1998). Germination of genotypes of upland cotton (*Gossypium hirsutum* L.) under water stress. *Rev.Oleaginosas-e-Fibrosas*, 2: 41-51.

Pettigrew, W.T. (2004). Moisture deficit effect on cotton lint yield, yield components, and boll distribution. *Agron. J*. 96: 377-383.

Shi, H.X., J.R. Hong and Z.H. Jiang (1987). *The Growth and Anatomy of Cotton*. Shanghai Tech Publish, Shanghai (in Chinese).

(*Accepted for publication December 2013*)