Pak. j. life soc. Sci. (2015), 13(1): 20-26 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

RESEARCH ARTICLE

Performance of Cotton (*Gossypium hirsutum* L) through Foliar Application of Growth Promoters

Syed Muhammad Naeem Gillani[1], Rana Muhammad Iqbal[2], Muhammad Akram[3*], Fahad Ajmal[1], Muhammad Aamir Wasim[1] and Muhammad Ijaz[4]

[1]Cholistan Institute of Desert studies, The Islamia University of Bahawalpur, Pakistan.
[2]University College of Agriculture and Environmental Sciences, The Islamia University of Bahawalpur, Pakistan
[3]Department of Environmental Sciences, COMSATS Institute of Information Technology, Vehari Pakistan
[4]Sub Campus Bahadur Layyah, Bahauddin Zakariya University Multan, Pakistan

ARTICLE INFO
Received: Nov 11, 2014
Accepted: Jan 30, 2015
Online: Feb 07, 2015

Keywords
Cotton
Growth and yield
NAA
NPK fertilizer

***Corresponding Author:**
akramcp@gmail.com

ABSTRACT

Cotton is an important cash crop of Pakistan and it is important to improve the yield of crop through application of growth regulators and nutrients. An experiment was conducted at studied at research area of agriculture farm near Cholistan Institute of Desert Studies, Islamia University of Bahawalpur to check the effect of foliar application of different nutrients and growth promoter on cotton. The experiment was comprised of treatments as control, phostrogen (N.P.K 10:10:27), miracle Gro (N.P.K 15:30:15) + chelated (B.Cu.Fe.Mn.Zn 0.02:0.07:0.15:0.05:0.06), N.P.K Shultz (15:30:20, bloom plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05), NAA @ 1%, N.P.K + NAA @ (1%), Phostrogen + NAA (1%), miracle Gro + NAA (1%), bloom plus (N.P.K) + NAA (1%). Data of different morphological and yield components showed that plant height, chlorophyll contents, leaf area, number of bolls per plant, number of seed, seed cotton yield and boll weight were increased with in different combination of nutrients. The maximum effect on growth, physiology and yield was observed in treatment (bloom plus N.P.K 15:30:15) + NAA (1%). Earliness index, mean maturity days and production rate index was also influenced with foliar application of NAA (1%) and N.P.K. The combine application of N.P.K and NAA showed a positive improvement in the growth and yield of cotton.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the important cash crops of Pakistan. *Gossypium* is a genus of 40 species of shrubs in the mallow family, Malvaceae, native to the tropical and subtropical regions. Commercial species of cotton plant are *Gossypium hirsutum* (90% of world production) *Gossypium barbadense* (8%), *Gossypium arboreum* and *Gossypium herbaceum* (2%) (Germplasm Resources Information Network, 2007). Cotton is considered as mainstay of Pakistan's economy. It is an important cash crop, major source of foreign exchange earnings and plays an important role in agriculture, industry and economic development of the country. In Pakistan cotton is grown on an area of 3.22 million hectares with total production of 12417 thousand bales and average seed cotton yield of 732 kg ha^{-1} (Anonymous, 2010).

Pakistan occupies fourth position in area and production but ranks 9th in average yield of cotton amongst the top cotton producing countries of the world (ICAC, 1998). It accounts for 8.6% of the value added in agriculture and about 1.8 percent in GDP. Cotton the queen of fiber and the leading fiber crop of the world is grown over an area of 3106 thousand hectares with a production of 12913 thousand bales and average yield of 707 kg ha^{-1}. During kharif 2010, the cultivation of Bt cotton increased in Pakistan and different varieties cultivated with a diverse percentage as (Australian Bt) with high incidence (60-100%) of cotton leaf curl virus infection. In Punjab Bt cotton is grown on almost 80% areas with different names Bt-121and Bt-131 with a

range of segregation (10-20%) in the fields of Bt cotton (Anonymous, 2010).

Foliar application of growth regulators and nutrients is effective when sprayed alone (Hallikeri et al., 2002). Plant growth regulators are substances when added in small amounts modify the growth of plant usually by stimulating or inhibiting part of the natural growth regulation. These are considered as new generation of agrochemicals after fertilizers, pesticides and herbicides. Plant growth regulators are capable of increasing yield by 10-20% under laboratory conditions and 10-15% in the field conditions (Kumar, 2001). Plant growth regulators have positive effects on chlorophyll contents and fruiting nodes in cotton (Norton et al., 2005). Nitrogen (N) in one form or another account for about 80% of total mineral nutrients absorbed by plants (Marschner, 1995).

Naphthalene acetic acid (NAA) is a class of plant hormone that effect on growth and yield of crops and increased seed cotton yield significantly (Pothiraj et al., 1995). Nitrogen, phosphorus (P) and potassium (K) also act as growth regulators of plants and N is an essential nutrient for cotton that affects plant growth, fruiting and yield of crops (Boquet et al., 1994). Phosphorus enhanced crop growth, N and K uptake, total chlorophyll concentration and yield of cotton plant. Boll weight is an important yield determining factor that varies with P levels (Sawan et al., 2008). Potassium deficiency is a plant disorder that is most common on light, sandy soils, because K^+ ions are highly soluble and will easily leach from soils without colloids (Datnoff et al., 2007). Keeping in view the above importance the study was planned to observe the effect of growth promoters especially commercially available on cotton and to find out the adequate amount of growth promoter like NAA and to check their combine effect with nutrients (N.P.K) on growth and physiology of cotton crop.

MATERIALS AND METHODS

A field experiment was conducted to investigate the effect of different growth promoters on growth and physiology of cotton crop at Cholistan Institute of Desert Studies, Baghdad-ul-Jadeed Campus, The Islamia University of Bahawalpur, Pakistan during the year 2010 under irrigated conditions in the cotton-growing season. The growth promoters were naphthalene acetic acid (NAA) and N.P.K, and their combinations. In the experiment treatments were applied as:

T_0 = Control, T_1 = Phostrogen (N.P.K 10:10:27), T_2 = Miracle Gro (N.P.K 15:30:15) + chelated (B.Cu.Fe. Mn.Zn 0.02:0.07:0.15:0.05:0.06), T_3 = N.P.K Shultz (15:30:20, T_4 = Bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05), T_5 = NAA @ 1% = N.P.K + NAA @ 1%, T_7 = Phostrogen + NAA @ 1%, T_8 = Miracle Gro + NAA @ 1%, T_9 = Bloom plus (N.P.K) + NAA @ 1%

The experiment was laid out in Randomized Complete Block Design (RCBD). There were three replicate for each treatment. Net plot size was 3 m × 6 m. All the treatments were applied at fifteen days intervals. Seed rate used was 10kg per acre. Weeding was performed at regular interval of fifteen days initially for three month after sowing. Crop was irrigated with canal water at regular intervals depending upon the climatic conditions. All the other agronomic practices were kept uniform and standard in all the treatments. For data collection four plants were selected from each treatment and labeled as A, B, C and D. The total plants in ten treatments and in three replicates were 120. Plant height was measured from base to top of the plant by using scale and recorded data regularly. Leaf area per plant was measured by leaf area meter. Chlorophyll contents leaves were estimated as SPAD-502 value. The chlorophyll contents of four tagged plants were recorded and then average was calculated. When cotton crop reached the stage of boll formation, bolls of tagged plants were also counted regularly and then average was taken.

Earliness Index was calculated with the formula described by Singh (2003).

Earliness index (%) = Weight of seed cotton from first pick / Total seed cotton weight from all picks

Mean maturity date was calculated by the formula as proposed by Christids and Harrison (1955). Mean maturity date (MMD) = $(W_1 \times H_1) + (W_2 \times H_2) +$ ……. + (Wn × Hn) / $W_1 + W_2 +$……..+ Wn

Production rate index was calculated from total seed cotton weight divided by the MMD (Saleem et al., 2010a).

Production rate index (g/day) = Total seed cotton weight (g) / Mean maturity date (days)

Statistical analysis

Data collected on different parameter during the course of this study were analyzed statistically by using MSTAT-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

Plant height (cm): Plant height in all the treatments continued to increase from 45 days after sowing (DAS) towards the final harvest. There was 27.07% increased in bloom plus (N.P.K) + NAA @ 1% treatment than control at 54 DAS. There was 26.86% increase in T_9 (bloom plus (N.P.K) + NAA @ 1%) treatment than control at 99 days of sowing. Treatment T_9 (bloom plus (N.P.K) + NAA @ 1%) had maximum plant height

(80.67) while control had lowest height (59). Treatments T_8 (miracle Gro + NAA @ 1%), T_7 (phostrogen + NAA @ 1%) and T_6 (N.P.K + NAA @ 1%) were at par with each other, but significantly differ with control (Table 4).

Leaf area per plant (cm^2): Leaf area in all the treatments continued to increase from 45 DAS to 99 days after sowing and then gradually declined towards the final harvest. After 63 DAS, treatment T_9 (bloom plus (N.P.K) + NAA @ 1%) had highest leaf area (38.86) and treatment T_8 (miracle Gro + NAA @ 1%) had (29.59) and control had lowest (25.97) value. After 108 DAS, there was 22.97% increase in T_9 treatment (bloom plus (N.P.K) + NAA @ 1%) than control (Fig. 1). Regression analysis suggests the dependence of seed cotton yield on leaf area (Table 2). Linear and positive correlation was observed between seed cotton yield and leaf area as shown in (Table 3).

Chlorophyll content (SPAD-502 value): Chlorophyll content in all the treatments continued to increase from 45 DAS to 90 DAS and then decreased towards the final harvest. At 108 DAS chlorophyll content per plant decreased in T_9 (bloom plus (N.P.K) + NAA @ 1%) treatment (6.68%), T_8 (miracle Gro + NAA @ 1%) treatment (6.01%) and T_7 (phostrogen + NAA @ 1%) treatment had 8.64% (Fig: 2). The maximum chlorophyll content in T_8 treatment might be due to the combine effect of nutrients (N.P.K) and growth regulators (NAA @ 1%). Regression analysis suggests the dependence of seed cotton yield on chlorophyll content (Table 2). Linear and positive correlation was observed between chlorophyll content and seed cotton yield (Table 3).

Number of bolls per plant: After 81 days of sowing, Maximum number of bolls 3.33 was recorded in T_9 (bloom plus (N.P.K) + NAA @ 1%) treatment, while minimum (1.50) was recorded in control. There was 62.35% increase in T_9 (bloom plus (N.P.K) + NAA @ 1%) treatment than control. There was 57.02% increase in T_9 (bloom plus (N.P.K) + NAA @ 1%) treatment than control at 90 DAS (Table 5). Regression analysis suggests the dependence of seed cotton yield on number of bolls per plant (Table 2). Linear and positive correlation was obtained between number of boll per plant and seed cotton yield (Table 3).

Weight of seed cotton per open boll (g): Weight of seed cotton per open boll showed that that weight of cotton per open boll was maximum (3.433) in T_9 (bloom plus (N.P.K) + NAA (1%) and minimum value (2.833) was calculated in control. While all other treatments were statistically at par each other. Treatment T_6 (N.P.K + NAA @ 1%) and T_5 (NAA @ 1%) were also statistically at par with each other. Different growth regulator treatments increased weight of cotton significantly than control. There was 17.47% more weight of seed cotton per open boll in T_9 () treatment than control (Table 1).

Weight of locules per open boll (g): Results of experiment indicate that that weight of locule per open boll was maximum (1.367) in T_8 (miracle Gro + NAA @ 1%) and minimum value (1.10) in control. Treatment T_5 (NAA @ 1%) and T_7 (phostrogen + NAA @ 1%) are statistically at par with T_8 (miracle Gro + NAA @ 1%). All other treatments were statistically at par each other but significantly different with control. Treatment T_8 (miracle Gro + NAA @ 1%) has 19.53% more weight of locule per boll then control (Table 1).

Number of cotton seed per boll

The number of cotton seeds per boll indicates that that numbers of seeds per boll are maximum (20.67) in treatment T_9 (N.P.K (bloom plus) + NAA @ 1%) and minimum (15.0) in control where growth regulators was not applied. Different growth regulators treatments increased number of seeds per boll significantly than control. There is 27.43 numbers of seeds per boll in T_9 (bloom plus (N.P.K) + NAA @ 1%) than control (Table 1).

Table 1: Effect of different growth promoters on weight of seed cotton per boll, weight of locules per boll, number of cotton seeds boll, seed cotton yield, earliness index, mean maturity date and production rate index in cotton.

Treatments	Weight of seed cotton per boll (g)	Weight of locules per boll (g)	Number of cotton seeds per open boll	Seed cotton yield ($kgha^{-1}$)	Earliness index (%)	Mean maturity date (days)	Production rate index (g/days)
T_o	2.83 b	1.10 b	15.33 de	1869.29 f	68.23	159.67	21.76 f
T_I	3.13 ab	1.33 ab	18.33 abc	2416.45 e	66.16	160.11	28.05 e
T_2	2.96 ab	1.23 ab	15.67 de	2561.75 de	66.81	159.97	29.77 de
T_3	3.20 ab	1.26 ab	15.00 e	2407.48 e	61.76	161.03	27.78 e
T_4	3.06 ab	1.30 ab	17.33 bcde	2504.35 de	63.60	160.64	28.97 de
T_5	2.97 ab	1.33 ab	17.67 bcd	2902.60 bc	67.25	159.88	33.74 bc
T_6	3.00 ab	1.20 ab	17.67 bcd	2811.11 cd	65.56	160.23	32.60 cd
T_7	3.03 ab	1.33 ab	16.67 cde	2915.16 bc	64.39	160.48	33.76 bc
T_8	3.33 ab	1.36 a	19.33 ab	3180.67 ab	66.30	160.08	36.93 ab
T_9	3.43 a	1.30 ab	20.67 a	3433.61 a	66.29	160.08	39.86 a
LSD at 5%	0.57	0.24	2.60	308.70	NS	NS	3.71

T_0 = Control, T_1 = Phostrogen (N.P.K 10:10:27), T_2 = Miracle Gro (N.P.K 15:30:15) + chelated (B.Cu.Fe.Mn.Zn 0.02:0.07:0.15: 0.05:0.06); T_3 = N.P.K Schultz (20:30:15), T_4 = Bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05), T_5 = NAA @ 1 % ; T_6 = N.P.K + NAA @ 1%, T_7 = Phostrogen + NAA @ 1%, T_8 = Miracle Gro + NAA @ 1%, T_9 = N.P.K (Bloom plus) + NAA @ 1% ; N.S = Non Significant.

Table 2: Linear regression coefficients (r^2) between seed cotton yield and different parameters of cotton

Characters	Linear regression coefficient (r^2)
SCY vs plant height	0.3726 ^{NS}
SCY vs leaf area per plant	0.9215 **
SCY vs Chlorophyll contents	0.7161*
SCY vs number of bolls per plant	0.8362*
SCY vs number of cotton seed per boll	0.6197^{NS}
SCY vs weight of seed cotton per open boll	0.4923^{NS}

SCY= seed cotton yield, NS: Non significant, *= Significant, **= highly significant

Table 3: Correlations coefficients (*r*) of physiological and morphological indices characterizing cotton grown under various growth promoters' treatments

Parameters	WSCB	NSPB	SCY
LA	0.60*	0.68*	0.96**
PH	0.61^{NS}	0.67*	0.61^{NS}
NBPP	0.61*	0.82*	0.91**
Ch.C	0.57^{NS}	0.75*	0.85*

Note: * and ** significant at 0.05 and 0.01 levels, respectively; NS = non-significant; PH = Plant height; LA = Leaf area; NSPB = Number of seed per boll; SCY = Seed cotton yield; Ch.C = Chlorophyll content; NBPP = Number of bolls per plant; WSCB = weight of seed cotton per open boll

Seed cotton yield (Kg/ha): Seed cotton yield was maximum (3433.61) in treatment T_9 (bloom plus (N.P.K) + NAA @ 1% and minimum (1869.29) in control. Different growth regulator treatments increased crop yield significantly than control. There was 45.56% more yield in treatment T_9 (bloom plus (N.P.K) + NAA @ 1%) than control. While T_1 (phostrogen (N.P.K 10:10:27)), T_4 (bloom plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05)) and T_3 (N.P.K Shultz (15:30:20) were statistically at par each other (Table 1).

Earliness index (%): Earliness index showed that it decreased by the application of nutrients and growth promoters and their combined interaction (N.P.K + NAA @ 1%). In treatment T_3 (N.P.K Shultz (15:30:20) earliness index is low as compared to other treatments and control. In T_3 (N.P.K Shultz (15:30:20) earliness index (61.76) which was 9.48% less as compared to control treatment (68.23). There was significant difference between control and other treatments. In T_7 earliness index was 64.39 which were less as compared to control (68.23). In treatment T_4 (bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05)) earliness index is decreases (6.78%) as compared to control while all others treatments are also show significant difference with control (Table 1).

Mean maturity date (days): Mean maturity date was not effected and it showed non significant results. Mean maturity date was maximum (161.03) in treatment T_3 (N.P.K Schultz 20:30:15) treatment and minimum (159.67) in control. Treatment T_8 (miracle Gro + NAA @ 1%) and T_9 (N.P.K (Bloom plus) + NAA @ 1%) has same (160.08) mean maturity date and both showed similar results. Treatment T_7 (phostrogen + NAA @ 1%) had 160.48 and T_5 (NAA @ 1%) that was very close to control and in T_4 (bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05: 0.05)) mean maturity date (160.64) was recorded. There was 0.60% more mean maturity date in treatment T_4 (bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05)) than control. Application of N.P.K and growth promoter showed non significant results on mean maturity (Table 1).

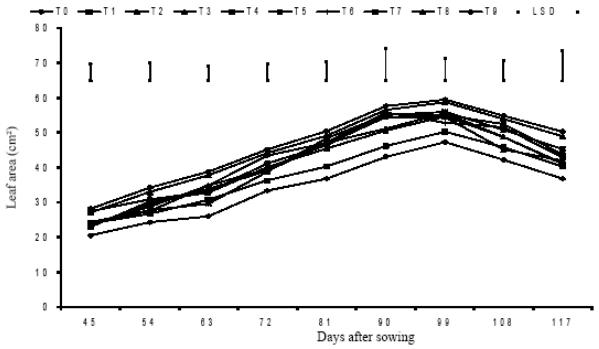

Fig. 1: Effect of different growth promoters on leaf area per plant (cm^2) in cotton

T_0 = Control, T_1 = Phostrogen (N.P.K 10:10:27), T_2 = Miracle Gro (N.P.K 15:30:15) + chelated (B.Cu.Fe.Mn.Zn 0.02:0.07: 0.15:0.05:0.06); T_3 = N.P.K Schultz (20:30:15), T_4 = Bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05), T_5 = NAA @ 1 % ; T_6 = N.P.K + NAA @ 1%,,T_7 = Phostrogen + NAA @ 1%, T_8 = Miracle Gro + NAA @ 1%, T_9 = N.P.K (Bloom plus) + NAA @ 1%

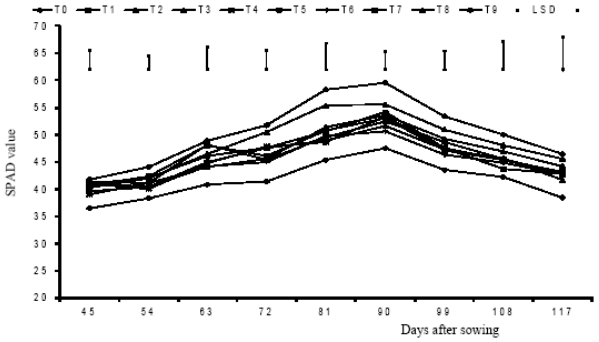

Fig. 2: Effect of different growth promoters on SPAD value in cotton

T_0 = Control, T_1 = Phostrogen (N.P.K 10:10:27), T_2 = Miracle Gro (N.P.K 15:30:15) + chelated (B.Cu.Fe.Mn.Zn 0.02:0.07: 0.15:0.05:0.06); T_3 = N.P.K Schultz (20:30:15), T_4 = Bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05), T_5 = NAA @ 1 %; T_6 = N.P.K + NAA @ 1%,,T_7 = Phostrogen + NAA @ 1%, T_8 = Miracle Gro + NAA @ 1%, T_9 = N.P.K (Bloom plus) + NAA @ 1%

Table 4: Effect of different growth promoters on plant height (cm) in cotton

Treatments	45 DAS	54 DAS	63 DAS	72 DAS	81 DAS	90 DAS	99 DAS	108 DAS	117 DAS
T_o	23.33	28.50 c	33.42 c	37.83 d	43.75 c	50.50 d	59.00 d	63.89 d	67.02
T_I	27.58	33.58 b	38.67 b	41.67 bcd	50.83 bc	61.17 abc	66.42 bcd	71.27 bcd	74.50
T_2	27.33	33.67 b	39.25 ab	43.08 bcd	52.83 ab	62.17 ab	71.33 abc	74.25 abc	76.75
T_3	26.50	34.08 b	38.25 bc	44.17 bcd	53.92 ab	64.00 ab	71.33 abc	74.13 abc	77.00
T_4	28.19	33.42 b	38.58 b	44.42 bc	53.67 ab	60.00 bc	71.25 abc	72.75 bcd	75.33
T_5	25.42	32.92 b	36.33 bc	40.42 cd	49.58 bc	56.50 c	64.25 cd	68.82 cd	71.33
T_6	25.75	32.92 b	39.08 ab	45.58 bc	56.25 ab	65.58 a	76.42 ab	78.40 abc	80.07
T_7	27.75	32.08 bc	36.83 bc	42.67 bcd	49.83 bc	58.92 bc	66.42 bcd	69.51 cd	78.42
T_8	27.92	35.25 ab	39.33 ab	47.33 ab	58.92 a	65.58 a	77.83 a	81.24 ab	83.08
T_9	29.50	39.08 a	43.92 a	52.17 a	56.08 a	66.50 a	80.67 a	83.90 a	85.00
LSD at 5%	N.S	4.13	5.05	6.47	7.68	5.42	10.16	10.09	N.S

Means sharing the common letter in a column do not differ significantly from each other at p 0.05; T_0 = Control, T_1 = Phostrogen (N.P.K 10:10:27), T_2 = Miracle Gro (N.P.K 15:30:15) + chelated (B.Cu.Fe.Mn.Zn 0.02:0.07:0.15:0.05:0.06); T_3 = N.P.K Schultz (20:30:15), T_4 = Bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05), T_5 = NAA @ 1 % ; T_6 = N.P.K + NAA @ 1%, T_7 = Phostrogen + NAA @ 1%, T_8 = Miracle Gro + NAA @ 1%, T_9 = N.P.K (Bloom plus) + NAA @ 1%; N.S = Non Significant, DAS = Days after sowing

Table 5: Effect of different growth promoters on number of bolls per plant in cotton

Treatments	63 DAS	72 DAS	81 DAS	90 DAS	99 DAS	108 DAS	117 DAS
T_0	0.00 b	1.25 c	1.50 d	2.41 c	7.41 c	8.65 c	9.93
T_1	0.33 ab	2.33 ab	2.16 cd	3.08 c	9.41 bc	9.83 bc	12.03
T_2	0.00 b	1.75 abc	2.50 bc	2.91 c	9.75 b	10.67 b	11.43
T_3	0.00 b	2.50 ab	1.91 cd	2.91 c	9.83 b	11.17 b	11.60
T_4	0.33 ab	2.58 a	2.16 cd	3.41 bc	10.50 ab	10.26 bc	11.93
T_5	0.25 ab	2.33 ab	3.00 ab	4.00 bc	10.25 ab	11.92 b	12.50
T_6	0.33 ab	1.83 abc	2.33 bc	3.33 c	11.50 ab	10.47 bc	12.17
T_7	0.25 ab	2.16 ab	2.41 bc	2.66 c	9.91 b	10.17 bc	11.17
T_8	0.58 a	1.66 bc	2.33 bc	5.08 ab	11.42 ab	11.75 b	12.60
T_9	0.33 ab	2.58 a	3.33 a	6.08 a	12.17 a	14.50 a	14.27
LSD at 5%	0.33	0.84	0.74	1.69	2.09	1.95	N.S

Means sharing the common letter in a column do not differ significantly from each other at p 0.05; T_0 = Control, T_1 = Phostrogen (N.P.K 10:10:27), T_2 = Miracle Gro (N.P.K 15:30:15) + chelated (B.Cu.Fe.Mn.Zn 0.02:0.07:0.15:0.05:0.06); T_3 = N.P.K Schultz (20:30:15), T_4 = Bloom Plus (N.P.K 15:30:15) + chelated (Fe.Mn.Zn 0.10:0.05:0.05), T_5 = NAA @ 1 % ; T_6 = N.P.K + NAA @ 1%,,T_7 = Phostrogen + NAA @ 1%, T_8 = Miracle Gro + NAA @ 1%, T_9 = N.P.K (Bloom plus) + NAA @ 1%; N.S = Non significant, DAS = Days after sowing

Production rate index (g/day): Different nutrients and growth promoters' treatments increased the production rate index significantly than control (T_0). Treatment T_8 (Miracle Gro +NAA @ 1%) has 36.93 production rate while treatment T_9 (N.P.K (Bloom plus + NAA @ 1%) has 39.86 that was statistically at par each other. Treatment T_6 (N.P.K + NAA @ 1%) and T_7 (phostrogen + NAA @ 1%) are also at par each other but significantly different from control. N.P.K + NAA combine interaction show more significant results as compared to only (N.P.K) treatment (Table 1).

Regression and correlation analysis: Regression analysis indicate that regression between leaf area, chlorophyll contents, number of bolls per plant were significant, however regression between plant height and seed cotton yield were non significant (Table 2). The correlation coefficients (*r*) between different growth and yield clearly showed a significant positive relationship between leaf area, number of boll per plant and seed cotton yield. The correlations between the plant height and seed cotton yield were non significant (Table 3).

DISCUSSION

Crop responses to interaction between plant growth regulators and nutrients show that this interaction effected the crop growth, development and physiology (Mir et al., 2010). In the present study application of growth regulators and nutrients significantly increased the plant height and number of bolls per plant (Table 4, 5). Previously, Delwar (2010) studied the effect of N.P.K on growth and concluded that number of leaves per plant increased with increasing nutrient concentration. Similar, results were reported by Mir et al. (2010) that number nodes per plant and leaf area were affected significantly by the application of growth regulators and nutrients. Chlorophyll contents were also enhanced by the effect of nutrient like potassium and phosphorus on cotton crop (Zakaria et al., 2011), Similar results were recorded in our experiment (Fig. 2). Number of seeds per boll was yield component increased with an increase in nitrogen (Ali and Sayed, 2001). Results of present experiment indicated that yield and yield components improved by application of

NAA and N.P.K (Table 1). Mohsen and Baniaini (2008) from an experiment concluded that foliar spray of nitrogen increased the boll number, boll weight and seed cotton. Similar findings were observed in our study (Table 1). Some derived parameters like earliness index were also increased K application, however, significant results were obtained in the first season only (Sawan et al., 2008). Mean maturity period decreased with increasing phosphorus levels and they also found that production rate index was influenced by phosphorus fertilizers application. In another study, increase in phosphorus level decreased the production rate index (Saleem et al., 2010b). Although, in our experiment, earliness index and mean maturity date were not affected by application of growth regulator and nutrients and maximum production rate index was recorded where both NPK and NAA were applied (Table 1). The correlation coefficients (*r*) between different physiological characteristics clearly showed a significant positive relationship between numbers of bolls per plant. Frankenberger and Arshad (1995) in an experiment also concluded that plant growth parameters significantly were increased by the application of growth regulators.

Conclusions

All the growth and yield parameters are affected significantly with these treatments. The combine treatments of NAA + N.P.K show more significant results as compared to only single treatment. Plant height, leaf area, number of nodes per plant and yield parameters is affected with growth regulators and nutrients and their combine effect. It is also concluded that earliness index, mean maturity days and production rate index also affected by the foliar application of growth promoter NAA and nutrients (N.P.K). Application of bloom plus (N.P.K) + NAA @ 1% show more significant results as compared to control and others treatments.

REFERENCES

Anonymous, 1986. MSTATC. Microcomputer Statistical Programme. Michigan State University, Michigan, Lansing, USA.

Anonymous, 2010. Economic Survey of Pakistan. (2009-10). Finance Division, Economic Advisory Wings Islamabad, Pakistan, pp: 16-17.

Ali SA and AE Sayed, 2001. Effect of sowing dates and nitrogen levels on growth, earliness and yield of Egyptian cotton cultivar Giza 88. Egypt Journal of Research, 79: 221-232.

Boquet DJ, Moser EB and GA Breitenbeck, 1994. Boll weight and within-plant yield distribution in field-grown cotton given different levels of nitrogen. Agronomy Journal, 86: 20-26.

Christids RG and GJ Harrison, 1955. Cotton Growing Problems. McGraw-Hill Book, New York, USA, pp: 16.

Datnoff LE, WH Elmer and D Huber, 2007. Mineral Nutrition and Plant Disease, American Phytopathological Society, St. Paul, MN, USA, pp: 278.

Delwar HMD, 2010. Institute of Tropical Agriculture, University Putra Malaysia 43400 Serdang, Selangor, Malaysia effects of nitrogen, phosphorus and potassium levels on Kena (*Hibiscus cannabinus* L.) growth and photosynthesis under nutrient solution. Journal of Agriculture Science, 2: 49-50.

Frankenberger WT and M Arshad, 1995. Phytohormones in soils microbial production and function. Marcel Dekker, New York, USA, pp: 503.

Germplasm Resources Information Network 2007. "Gossypieae L." United States Department of Agriculture. (http://www.ars-grin.gov/cgi-bin/npgs/html/genus.pl?5113 assessed on 27-03-2012).

Hallikeri SS, HL Halemani and BM Khadi, 2002. Integrated foliar nutrition for yield maximization of rainfed cotton. Karnataka Journal of Agriculture Science, 15: 562-565.

International Cotton Advisory Committee (ICAC), 1998. Organic cotton production IV, pp: 3-7.

Kumar KKA, 2001. Effect of plant growth regulators on morpho-physiological traits and yield attributes in hybrid cotton (*Gossypium hirsutum* L.). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, India.

Mohsen S and E Baniaini, 2008. Members of Scientific Staff Investigation of Nitrogen and Boron Effects on Cotton Properties in Iran Tehran Agricultural and Natural Resources Research Center, Islamic Republic of Iran, pp: 01.

Mir MR, M Mobin NA Khan, MA Bhat, NA Lone, KA Bhat, SM Razvi, SA Wani, N Wani, S Akhter, S Rashid, NH Masoodi and WA Payne, 2010. Crop Responses to Interaction between plants growth regulators and nutrients. Journal of Phytology, 10: 09-19.

Marschner H, 1995. Mineral nutrition of higher plants. Second Edition. Academic Press, London, UK, pp: 889.

Norton LJ, H Clark, Borrego and B Ellsworth, 2005. Evaluation of two plant growth regulators from LT Biosyn Arizona Cotton Report. pp: 142.

Pothiraj P, NT Jaganathan, R Venkataswamy, M Premshekhar and S Purushothaman, 1995. Effect of growth regulators in cotton cv. MCU-9. Madras Agriculture Journal, 82: 283-284.

Singh SS, 2003. Soil fertility and nutrient management. Kalyani Publishers New Delhi India, pp: 38.

Saleem MF, A Shakeel, MF Bilal, MQ Shahid and SA Anjum, 2010a. Effect of different phosphorus levels on earliness and yield of cotton cultivars. Journal of Soil and Environment, 29: 128-135.

Saleem MF, MA Cheema, F Rasul, MF Bilal, SA Anjum and MA Wahid, 2010b. Effect of phosphorus on agronomic traits of cotton cultivars. Crop and Environment, 1: 39-43.

Sawan ZM, MH Mahmoud and AH El-Guibali, 2008. Influence of potassium fertilization and foliar application of zinc and P on growth yield and fiber properties of Egyptian cotton (*Gossypium barbadense* L.). Journal of Plant Ecology, 1: 259-270.

Steel RGD, JH Torrie and DA Dickey, 1997. Principles and Procedures of Statistics: A Biometrical Approach. 3rd Edition, McGraw Hill Book Co. Inc. New York. pp: 400-428.

Zakaria MS, AH Fahmy and SE Yousef, 2011. Effect of potassium, zinc and phosphorus on seed yield, seed viability and seedling vigor of cotton (*Gossypium barbadense* L.). Archives of Agronomy and Soil Science, 57: 75-90.