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EFFECT OF FRUITING BRANCH REMOVAL AND NITROGEN RATE ON COTTON SENESCENCE

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ABSTRACT

Removal of early fruiting branches with optimum nitrogen dose caused more source and less sink at early stages leading to delay in onset and progression of senescence in cotton. Field trials were conducted to investigate the effects of squares and fruiting branches removal under different nitrogen levels on the growth of Bt cotton at Students' Farm, University of Agriculture Faisalabad, during 2011 and 2012. Experiment was laid out in randomized complete block design (RCBD) with factorial arrangement using three replications. Treatments comprised of manual alteration of plant architecture (F_1: no fruiting branch removal, F_2: removal of first fruiting branch, F_3: removal of first and second fruiting branch, F_4: removal of all squares from first fruiting branch, F_5: removal of all squares from first and second fruiting branch) and nitrogen rates (N_1: 175, N_2: 225 and N_3: 275 kg ha^{-1}). Results exhibited more number of nodes above white flower (NAWF) recorded in F_5, followed by F_3, F_4 and F_2 while minimum NAWF recorded in F_1. Among nitrogen levels maximum nodes above white flower were recorded in N_3 followed by N_2 and N_1 during both years of study. Before manual alteration of the plants architecture, no variation in plant height was observed at squaring stage, but at physiologically cut-out stage plants gained more height with removal of squares/fruiting branches with maximum level of nitrogen. Shorter boll maturation period was recorded in F_4 and F_5 than in F_1, F_2 and F_3. Lower earliness index was observed in F_5 and F_3 and higher earliness index in F_1. Longer boll maturation period, earliness index and seed index were recorded with 275 kg N ha^{-1}. Removal of first and second fruiting branch and removal of all squares from first and second fruiting branch along with higher nitrogen dose helped in delayed onset of senescence in cotton leading to improved translocation of assimilates towards economic part and thus more seed cotton yield (data not given).

Key words: NAWF, NACB, Plant height, senescence Bt cotton.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a main leading fiber crop of the world, grown commercially in more than fifty countries (Smith, 1999). Cotton is perennial in nature and has been adapted to annual cultivation due to enormous efforts of plant breeders (Ali *et al.*, 2003). Pakistan ranked 4th in cotton production after China, USA and Uzbekistan in the world (Khadi *et al*., 2010). In 2014-2015, cotton was planted on an area of 2.9 million hectares, having production of 13.98 million bales, Cotton has 7.1% of value added in agriculture and 1.5% to GDP (Govt. of Pakistan, 2015).

In 1996 transgenic Bt cotton was planted commercially in the United States (Hardee and Herzog, 1997). Biological characteristics e.g. days to squaring, flowering, boll spilition and boll maturation period of Bt cotton varieties vary from conventional cotton varieties (Sarwar *et al*., 2012). In cotton maximum values of genetic advances were observed for seed cotton yield, plant height and earliness index (Farooq *et al*., 2014). Bt transgenic cotton varieties have a drawback of slow emergence but first true leaf appearance is early than conventional cotton varieties (Zhao *et al.,* 2002). Premature senescence occurred mostly in transgenic Bt (*B. thuringiensis*) cotton cultivars during its commercial production (Dong *et al*., 2006). It was suggested that removal of early square and/or fruiting branches might be a helpful practice for commercial cultivation of Bt cotton (Dongmei *et al*., 2009). Removing early fruit and/or fruit bearing branches (REFB) enhanced the levels of total N, soluble protein, (Dongmei *et al*., 2009), lint yield (Stewarta *et al*., 2001), boll size (5.1 to 5.7 %), number of fruiting nodes (Dong *et al*., 2008) and root growth (Dumka *et al*., 2004) than in the control. Early season squares and fruiting branches removal increased root growth (Dumka *et al*., 2004), photosynthetic rate (Wells, 2001; Dumka *et al*., 2003) and Cry 1Ac expression in Bt cotton (Dongmei *et al*., 2009).

Nitrogen plays a vital function in building the protein structure in plants (Frink *et al*., 1999). Nitrogen deficiency stress enhanced the production of ethylene (Lege *et al*., 1997), increase the content of inhibitors like abscisic acid in the leaves and decreased the auxins

content (Anisimov and Bulatova, 1982) leading to fruit abscission at the reproductive stage (Zhao and Oosterhuis, 2000) so that senescence started at early growth stages. In Bt cotton, the uptake of N may be increased due to introduction of Bt gene (Chen *et al*., 2005).

It was also indicated that the removal of early flower bud and/or fruiting branch could change the nitrogen metabolism (Deng *et al*., 1991). Prebloom square removal was applied on Bt cotton cultivars and yield increase was observed; prebloom square loss, increased ability of the Bt cotton to insect pest management (Stewarta *et al*., 2001). Compensation following square removal was greater at higher nitrogen application than at lower nitrogen application (Malik *et al*., 1981). Therefore, it was hypothesized that removal of early fruiting branches might enhance vegetative growth and development, and delay senescence at early stage (Dongmei *et al*., 2009), and measurement of phenology, plant height, node above white flower and node above cracked bolls at different stages under variable N rates. Thus, the present study was conducted to find best indicator of changes in growth behavior of cotton.

MATERIALS AND METHODS

The experiments were conducted at students' Farm, University of Agriculture, Faisalabad, for the two consecutive years (on 15th May 2011 and repeated in 16th May 2012). The experimental area is located at 73.09^{o} East longitude, 31.25^{o} North latitude and at an altitude of 183 meters above sea level. Soil samples were taken before sowing of crop to a depth of 15 cm and 30 cm for physio-chemical analysis (Table-1) prior to sowing. Land remained fallow during rabi season of both study years. Experiments were conducted in randomized complete block design (RCBD) in factorial arrangement with three replications. There were five rows per plot with 0.75 m row to row distance and 0.30 m plant to plant spacing, resulting a net plot size of 6 m x 3.75 m. Seedbed was prepared by cultivating the field for two times with tractor-mounted cultivator each followed by planking. Delinted seed of Bt cotton (cv. IR-3701) was obtained from office of Punjab Seed Corporation in Ayub Agricultural Research Institute and planted on ridges with the help of dibbler. The experiment comprised of five treatments regarding manual alteration in growth viz. no fruiting branch removal (F_1), removal of first fruiting branch (F_2), removal of first and second fruiting branch (F_3), removal of all squares (floral bud) from first fruiting branch (F_4), removal of all squares from first and second fruiting branch (F_5) and three levels of nitrogen viz. 175 (N1), 225 (N2) and 275 kg ha^{-1} (N3). Whole of phosphorus @ 87 kg ha^{-1} and potassium @ 100 kg ha^{-1} was applied at sowing and variable rates of nitrogen calculated for each treatment based on gross plot area and were applied in three equal splits viz. at planting, at squaring stage and at peak flowering stage. Phosphorus, potassium and nitrogen as per treatment were applied in the form of single super phosphate, K_2SO_4 and urea. In total nine irrigations were applied; irrigation requirement of crop was measured through water scouting. Maximum temperature, minimum temperature and rainfall during cotton crop growth period are presented in fig. 1. Weeds were controlled by one pre-emergence herbicide Dual gold @ 1.50 L ha^{-1} (S-metola cholor) at sowing and one post emergence herbicide Roundup @ 2.7 L ha^{-1} (Glyphosate) with help of protective shield at 50 days after planting. Insecticides i.e. Polo 500 SC (Diafenthioran) @ 620 ml ha^{-1} & Confidor 200 SL (imidacloprid) @ 620 ml ha^{-1} were applied to control the sucking insects (Aphid, Jassid, Whitefly, Thrips and Mites) and Proclaim 019 EC (Emamectin benzoate) @ 500 ml ha^{-1} & Karate 2.5 EC (Lambda-cyhalothrin) @ 1 L ha^{-1} for control of pink bollworm, american bollworm, spotted bollworm and army worm. Data on following observation was recorded using standard procedures during the course of studies.

Observations: Five guarded plants were selected at random from each plant when first square (floral bud) of a size visible with naked eye appeared on 50 % of selected plants. Number of days from planting to appearance of first flower was noted from the five guarded selected plants and average number of days taken to appearance of first flower was calculated. Number of days from planting to first boll splition was noted from the five selected plants and average number of days taken to boll splition was calculated. Boll maturation period (days) was calculated by deducting number of days taken to flowering from number of days taken from planting to boll splition. Number of the main stem node (i.e. at which first fruiting branch develop) was determined by designating node immediately above the cotyledonary scars as number two, and counting the successive ascending nodes until the one that gave rise to the first fruiting branch. Height of first fruiting branch (cm) was measured from pseudonode (cotyledonary node) to first fruiting branch of five selected plants and was averaged. Weekly node above white flower (NAWF) measurements were initiated from five selected plants with the appearance of first flower and continued until physiological cutout stage (NAWF=4) came (Sarwar *et al*., 2012), then average node above white flower was calculated. Node above crack boll measurements were initiated from five selected plants with twenty days interval after the appearance of first boll splition (50% opening on guarded plants) and continued until NACB=4 (Gwathmey and Hayes, 1997), and was averaged. Earliness index (%) was measured with the help of

following formula. This index is referred as maturity coefficient.

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

Weight of 100 seeds in grams is expressed as seed index (Saleem *et al*., 2010b). Thus to note seed index three samples of 100 seeds from each plot were weighted (g) and finally averaged. Plant height (cm) of five randomly selected plants from each plot was measured at three different stages; at appearance of first floral bud (squaring stage), at physiologically cutout stage and at last pick and average height was calculated for different stages.

Statistical analysis: Data on all the above mentioned measurements were statistically analyzed using Statistix-10 program and means were compared using least significant difference (LSD) test at P≥5 (Steel *et al*., 1997).

RESULTS

Phenological and earliness traits: Data in table-2 indicated that days to first flowering, first boll splition, node number for first fruiting branch height and first fruiting branch height (cm) were significantly affected by fruiting branch and/or square removal (F) and nitrogen rates (N) while their interaction (F x N) was non-significant. Comparison of treatments' showed that delayed first flowering (60.08) and first boll splition (93.54) were recorded in F_3 (removal of first and second fruiting branch) and enhanced first flowering (48.84) and first boll splition (81.06) were recorded in F_1 (no fruiting branch removal), while years showed non-significant effects. More nodes for first fruiting branch (9.72) and taller first fruiting branch (31.89 cm) were recorded in F_5 (removal of all squares from first and second fruiting branch) while F_3 (removal of first and second fruiting branch) and F_4 (removal of all squares from fruiting branch) were statistically at-par with each other and less nodes for first fruiting branch (8.16) and minimum first fruiting branch height (26.55cm) was observed in F_1 (no fruiting branch removal), however more first fruiting branch height (29.71 cm) was recorded during 2011 and less first fruiting branch height (28 .18 cm) was observed during 2012. Among the nitrogen levels more number of days to first flowering (57.74), days to first boll opening (91.22), node numbers for first fruiting branch (10.58) and first fruiting branch height (34.65) were recorded in N_3 (275 kg ha^{-1}) followed by (54.86 days, 86.72 days, 8.39 and 27.40 cm) in N_2 (225 kg ha^{-1}) and then (51.24 days, 81.16 days, 7.57 and 24.78 cm) in N_1 (175 kg ha^{-1}) during both study years (Table-2).

Table-3 depicted that fruiting branch/square removal (F) and nitrogen levels (N) have significant effects on boll maturation period and earliness index; whereas seed index was significantly affected by nitrogen levels (N) and not by branch/square removal. Interactive response was non-significant, however years showed non-significant for all these three parameters. Comparison of treatments' showed that minimum boll maturation periods (29.80 days) and earliness index (47.36 %) were recorded in F_5 (removal of all squares from first and second fruiting branch) as against maximum boll maturation period (34.64 days) and earliness index (52.79 %) in F_1 (no fruiting branch removal), which itself was not statistically different than F_2 (removal of first fruiting branch) and F_3 (removal of first and second fruiting branch) in case of boll maturation period (Table-3). Among nitrogen rates more boll maturation period (33.61 days), earliness index (50.77 %), seed index (7.87 g) were recorded in N_3 (275 kg ha^{-1}) compared to other N rates.

Senescence related traits: A gradual decrease towards the death of the cotton crop was measured in the form of node above white flower (NAWF). Total observations from early flowering to physiologically cutout stages were eight and NAWF included as fixed factor for easy and clear measurement of senescence in cotton crop. Data in Table-4 indicated that node above white flower (NAWF) was significantly affected by fruiting branch/square removal (F), nitrogen rates (N), observation (O), and (F x O) while other interactions (F x N, N x O and F x N x O) were found to be non-significant. Comparison of treatments' showed that more NAWF (8.69) were recorded in F_5 (removal of all squares from first and second fruiting branch) followed by 8.41 in F_3 (removal of first and second fruiting branch), 7.94 in F_4 (removal of all squares from first fruiting branch), 7.73 in F_2 (removal of first fruiting branch) and 7.26 in F_1 (no fruiting branch removal) respectively. Application of 275 kg N ha^{-1} recorded maximum NAWF (8.78) followed by (8.00) with medium rate of nitrogen (225 kg ha^{-1}) and minimum NAWF (7.24) was recorded with175 kg N ha^{-1}. In weekly interval observations more and at par node above white flower (9.67) were recorded in O_1 (3rd week of July), (9.82) in O_2 (4th week of July) and (9.82) in O_3 (1st week of August) and minimum node above white flower (3.28) were recorded in O_8 (2nd week of September). Years were also significant, more NAWF (8.07) was observed during 2011 and less NAWF (7.94) during 2012. Interactive effect of (F x O) showed that highest node above white flower were recorded in F_3 (removal of first and second fruiting branch) and F_5 (removal of all squares from first and second fruiting branch) at all the times of observations while F_2 (removal of first fruiting branch) and F_4 (removal of all squares from first fruiting branch) showed similar but less NAWF, however lower NAWF was observed in F_1 (no

fruiting branch removal) from flowering till physiologically cutout stage (Fig.2).

Node above crack boll (NACB) and plant height (cm) were recorded three times during crop growth. Data in table-4 indicated that fruiting branch/square removal (F), nitrogen rates (N) and number of observations (O) significantly affected node above crack boll (NACB). The interactive responses i.e. F x N was significant for NACB while other interactions (F x O, N x O, F x N x O) remained non-significant, years showed non-significant effect. Maximum nodes above cracked bolls (12.13 & 11.99) were recorded in F_5 (removal of all squares from first and second fruiting branch) and F_3 (removal of first and second fruiting branch) while F_2 (removal of first fruiting branch) and F_4 (removal of all squares from first fruiting branch) are at-par with each other and minimum (8.97) NACB (nodes above cracked bolls) was observed in F_1 (no fruiting branch removal). Among nitrogen rates highest nodes above cracked bolls (11.84) was recorded with the application of 275 kg N ha^{-1} followed by (11.00) NACB in 225 kg N ha^{-1} and minimum NACB (9.67) was observed in 175 kg N ha^{-1}. Time of recording observation indicated that maximum NACB was observed during 3rd week of September (18.41) followed by 8.96 NACB recorded during 2nd week of October and minimum NACB (5.14) during 1st week of November. Figure-3 showed interactive effect of (F x N). Lower nodes above cracked bolls were recorded in F_1 (no fruiting branch removal) at all the levels of N application, while higher NACB were recorded in F_3 (removal of first and second fruiting branch) and F_5 (removal of all squares from first and second fruiting branch) with medium and higher application of nitrogen.

Plant height at squaring stage was non-significant, however plant height at physiological cutout stage and plant height at last pick were significantly affected by fruiting branch and/or square removal, nitrogen rates their interaction was also significant (table-5). Maximum plant height (164.71 & 181.76 cm) were recorded in F_5 (removal of all squares from first and second fruiting branch) while F_2 (removal of first fruiting branch) and F_4 (removal of all squares from first fruiting branch) are at-par with each other and minimum plant height (148.37 & 165.12 cm) were recorded in F_1 (no fruiting branch removal) at both physiologically cutout stage and at last pick. Among interaction more plant height (180.30 & 197.53 cm) and (176.50 & 192.93 cm) were recorded in F_5 (removal of all squares from first and second fruiting branch) and F_3 (removal of first and second fruiting branch) at highest level of N application, while minimum plant height (136.57 & 154.23 cm) and (141.13 & 157.80 cm) were observed in F_1 (no fruiting branch removal) and F_3 (removal of first and second fruiting branch) with lowest level of nitrogen application both at physiologically cutout stage and at last pick (maturity stage).

Table 1. Physico-chemical analysis of soil.

Characteristics	Unit	Value			
Study period		**2011**		**2012**	
Depth of sample	Cm	1-15	15-30	1-15	15-30
Mechanical analysis					
Sand	%	50	48	50	49
Silt	%	22	23	21	22
Clay	%	28	29	29	29
Textural class		Loam			
Chemical analysis					
Saturation	%	32	34	38	35
EC	dS/m	2.02	1.79	1.90	1.76
pH	--	7.8	7.7	7.7	7.7
Organic matter	%	1.14	1.03	1.03	0.93
Total nitrogen	%	0.057	0.040	0.046	0.038
Available phosphorus	Ppm	18.1	17.5	16.1	17.5
Available potassium	Ppm	150	150	180	150

Table 2. Effect of nitrogen rate and fruiting branch and/or square removal on phenological traits of Bt cotton.

Year	Days to flowering	Days to boll splition	Node number for first fruiting branch	First fruiting branch height (cm)
2011	54.55	86.85	8.86	29.71 a
2012	54.67	85.88	8.83	28.18 b
LSD (p=0.05)	**NS**	**NS**	**NS**	**1.18**
Fruit/branch removal (F)				

F_1	48.84 d	81.06 d	8.16 d	26.55 d
F_2	55.93 b	88.95 b	8.42 cd	27.59 cd
F_3	60.08 a	93.54 a	8.78 bc	28.77 bc
F_4	52.58 c	82.95 cd	9.15 ab	29.92 b
F_5	55.62 b	85.32 c	9.72 a	31.89 a
LSD (p=0.05)	2.06	**3.09**	**0.57**	**1.87**
Nitrogen levels (N)				
N_1	51.24 c	81.16 c	7.57 c	24.78 c
N_2	54.86 b	86.72 b	8.39 b	27.40 b
N_3	57.74 a	91.22 a	10.58 a	34.65 a
LSD (p=0.05)	**1.59**	**2.39**	**0.44**	**1.45**
F x N interaction		**NS**		

Means not sharing a letter in common within a column in each category differ significantly at 5% probability level. **F_1**: No fruiting branch removal, **F_2**: Removal of first fruiting branch, **F_3**: Removal of first and second fruiting branch, **F_4**: Removal of all squares from first fruiting branch, **F_5**: Removal of all squares from first and second fruiting branch, **N_1**: 175 kg ha^{-1}, **N_2**: 225 kg ha^{-1}, **N_3**: 275 kg ha^{-1}.

Table 3. Effect of nitrogen rate and fruiting branch and/or square removal on phenological and earliness traits of Bt cotton.

Year	Boll maturation period (days)	Earliness index (%)	Seed index (g)
2011	32.29	49.64	7.62
2012	32.18	49.80	7.67
LSD (p=0.05)	**NS**	**NS**	**NS**
Fruit/branch removal (F)			
F_1	34.46 a	52.79 a	7.52
F_2	32.78 a	50.23 b	7.65
F_3	33.63 a	48.21 c	7.78
F_4	30.51 b	50.00 b	7.56
F_5	29.80 b	47.36 c	7.72
LSD (p=0.05)	**1.74**	**1.02**	**NS**
Nitrogen levels (N)			
N_1	30.86 c	49.17 b	7.51 b
N_2	32.24 b	49.21 b	7.55 b
N_3	33.61 a	50.77 a	7.87 a
LSD (p=0.05)	**1.35**	**0.79**	**0.15**
F x N interaction	**NS**		

Means not sharing a letter in common within a column in each category differ significantly at 5% probability level. NS= Non-significant, **F_1**: No fruiting branch removal, **F_2**: Removal of first fruiting branch, **F_3**: Removal of first and second fruiting branch, **F_4**: Removal of all squares from first fruiting branch, **F_5**: Removal of all squares from first and second fruiting branch, **N_1**: 175 kg ha^{-1}, **N_2**: 225 kg ha^{-1}, **N_3**: 275 kg ha^{-1}.

Table 4. Effect of nitrogen rate and fruiting branch and/or square removal on nodes above white flower and nodes above cracked bolls of Bt cotton.

Years	Nodes above white flower	Years	Nodes above cracked bolls
2011	8.07 a	2011	10.92
2012	7.94 b	2012	10.75
LSD (p=0.05)	**0.09**	**LSD (p=0.05)**	**NS**
Fruit/branch removal (F)		**Fruit/branch removal (F)**	
F_1	7.26 e	F_1	8.97 c
F_2	7.73 d	F_2	10.46 b
F_3	8.41 b	F_3	11.99 a
F_4	7.94 c	F_4	10.64 b
F_5	8.69 a	F_5	12.13 a
LSD (p=0.05)	**0.51**	**LSD (p=0.05)**	**0.40**
Nitrogen levels (N)		**Nitrogen levels (N)**	

N_1	7.24 c	N_1	9.67 c
N_2	8.00 b	N_2	11.00 b
N_3	8.78 a	N_3	11.84 a
LSD (p=0.05)	**0.11**	**LSD (p=0.05)**	**0.31**
Observations (O)		**Observations (O)**	
O_1 (3^{rd} week of July)	9.67 a	O_1 : (3^{rd} week of September)	18.41 a
O_2 (4^{th} week of July)	9.82 a	O_2: (2^{nd} week of October)	8.96 b
O_3 (1^{st} week of August)	9.82 a	O_3 : (1^{st} week of November)	5.14 c
O_4 (2^{nd} week of August)	9.38 b	**LSD (p=0.05)**	0.31
O_5 (3^{rd} week of August)	8.29 c	**Interactions**	
O_6 (4^{th} week of August)	7.42 d	**F x N**	*
O_7 (1^{st} week of September)	6.37 e	**F x O**	**NS**
O_8 (2^{nd} week of September)	3.28 f	**N x O**	**NS**
LSD (p=0.05)	**0.19**	**F x N x O**	**NS**
Interactions			
F x N	**NS**		
F x O	*		
N x O	**NS**		
F x N x O	**NS**		

Means not sharing a letter in common within a column in each category differ significantly at 5% probability level. *= Significant, NS= Non-significant, **F_1**: No fruiting branch removal, **F_2**: Removal of first fruiting branch, **F_3**: Removal of first and second fruiting branch, **F_4**: Removal of all squares from first fruiting branch, **F_5**: Removal of all squares from first and second fruiting branch, **N_1**: 175 kg ha^{-1}, **N_2**: 225 kg ha^{-1}, **N_3**: 275 kg ha^{-1}.

Table 5. Effect of nitrogen rate and fruiting branch and/or square removal on plant height of Bt cotton

	Plant height at squaring (cm)	Plant height at physiological cutout stage (cm)	Plant height at last pick (cm)
2011	34.85	155.35	172.30
2012	33.56	155.64	172.44
LSD (p=0.05)	**NS**	**NS**	**NS**
Fruit/branch removal (F)			
F_1	33.45	148.37 d	165.12 b
F_2	34.42	150.50 cd	167.72 b
F_3	34.27	160.69 b	177.32 a
F_4	34.28	153.20 c	169.94 b
F_5	34.61	164.71 a	181.76 a
LSD (p=0.05)	**NS**	**3.93**	**5.21**
Nitrogen levels (N)			
N_1	33.54	141.71 c	158.95 c
N_2	33.97	157.60 b	174.33 b
N_3	35.12	167.17 a	183.85 a
LSD (p=0.05)	**NS**	**3.04**	**4.03**
Interaction (F x N)			
F_1 x N_1	33.03	136.57 f	154.23 e
F_1 x N_2	33.50	162.17 c	178.40 c
F_1 x N_3	33.83	146.37 de	162.73 de
F_2 x N_1	35.03	140.70 ef	158.73 de
F_2 x N_2	33.23	147.30 de	164.13 d
F_2 x N_3	35.00	163.50 bc	180.30 c
F_3 x N_1	34.16	141.13 ef	157.80 de
F_3 x N_2	33.36	164.43 bc	181.23 c
F_3 x N_3	35.30	176.50 a	192.93 ab
F_4 x N_1	32.60	141.27 ef	158.17 de

F_4 x N_2	35.16	149.17 d	165.93 d
F_4 x N_3	35.10	169.17 b	185.73 bc
F_5 x N_1	32.86	148.90 d	165.80 d
F_5 x N_2	34.60	164.93 bc	181.93 c
F_5 x N_3	36.36	180.30 a	197.53 a
LSD (p=0.05)	**NS**	**6.81**	**9.03**

Means not sharing a letter in common within a column in each category differ significantly at 5% probability level. NS= Non-significant, **F_1**: No fruiting branch removal, **F_2**: Removal of first fruiting branch, **F_3**: Removal of first and second fruiting branch, **F_4**: Removal of all squares from first fruiting branch, **F_5**: Removal of all squares from first and second fruiting branch, **N_1**: 175 kg ha^{-1}, **N_2**: 225 kg ha^{-1}, **N_3**: 275 kg ha^{-1}.

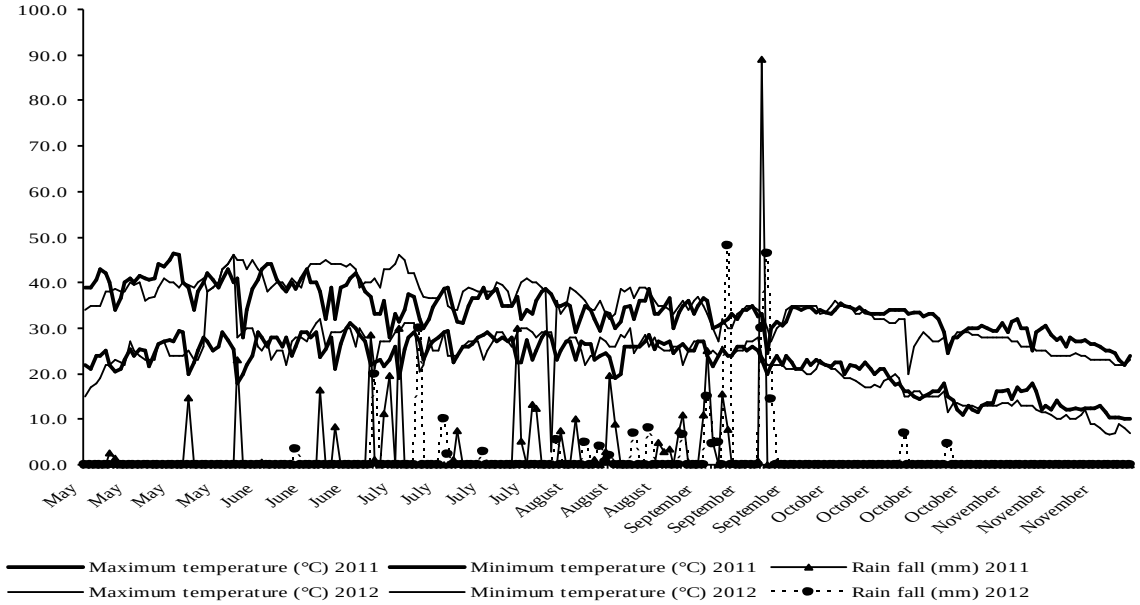

Fig-1. Weather conditions during cotton crop growth period.

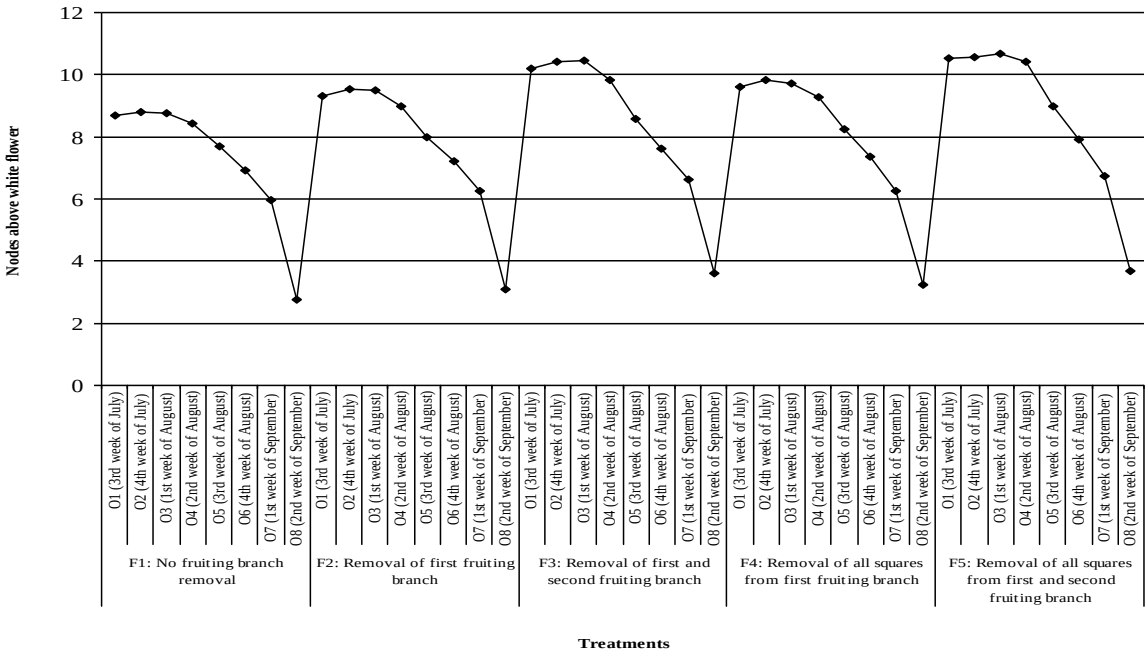

Fig-2. Interactive effect of fruiting branch and/or square removal (F) × observations (O)on nodes above white flower of Bt cotton

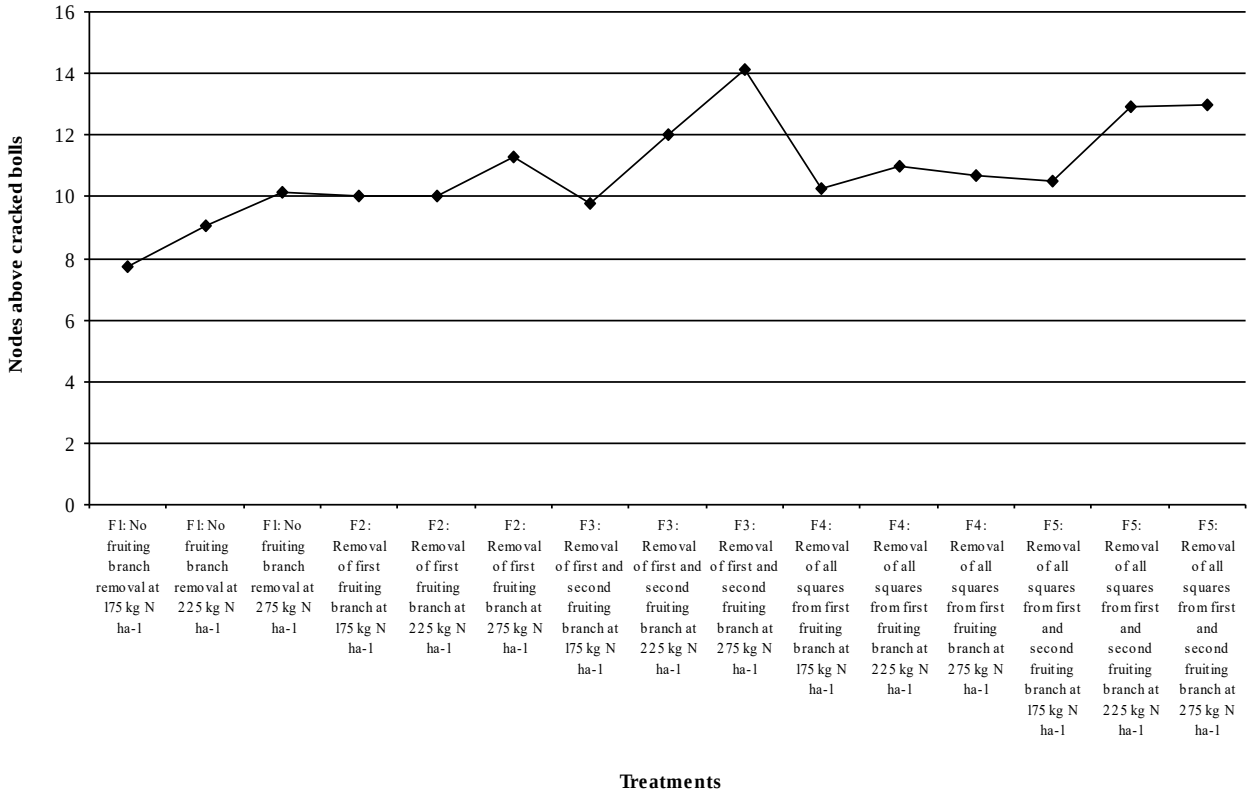

Fig-3: Interactive effect of fruiting branch and/or square removal (F) × nitrogen levels (N) on nodes above cracked bolls of Bt cotton

DISCUSSION

Phenological and/or earliness traits: Appearance of first flower can be altered by various factors like prevailing environmental condition (Shaheen *et al*., 2001), mineral nutrition (Saleem *et al*., 2010a) and cultivars (Anjum *et al*., 2001). When flower appears on cotton plant several hormonal changes occur leading to increased concentration of abscisic acid up to 100 folds, as abscisic acid has role in desiccation tolerance in seed, this higher concentration of abscisic acid in flower indirectly increase concentration of ethylene and form abscission zone on peduncle and flowers start to drop. Manual removal of early squares increased the concentration of cytokinins and decreased concentration of abscisic acid in cotton and its effect remained effective till 45 days after the removal (Dong *et al*., 2009).

In our study more days to first flower was reported with removal of first and second fruiting branch than control; and same was done with in higher nitrogen dose followed by medium and lower nitrogen rates. Similar trend was observed in days to first boll splition. Removal of squares and/or floral buds as well as higher N not only delayed senescence but also increased node number for first fruiting branch (Bilal *et. al*., 2014) and first fruiting branch height that may be due to increase in main stem node and increased internodal length. Node number for first fruiting branch and first fruiting branch height are the morphological measures of earliness in cotton (Saleem *et al*., 2010a). Cotton cultivar matured earlier approximately 4 to 7 days by decrease in one node number of first fruiting branch (Ahmed and Malik, 1996). Less days to boll maturation period with removal of all squares from two early fruiting branch was due to more source availability at early stages which helped in rapid boll filling, but less earliness index in removal of first and second fruiting branch and with two early fruiting branch removal were due to more sink availability. Less boll maturation period with lower application of N caused reduced boll size, early boll filling with lower yield as compared to higher N rates (Saleem *et al*., 2010c).

Senescence related traits: Premature senescence mostly occurring in commercially cultivated Bt cotton might be due to more sink and less source ratio as a result of biological control of boll worm (Dong *et al*., 2006). In addition, senescence is usually associated with increased concentration of ABA, ethylene and decrease in cytokinins (Buchanan, 1997). Among numerous factors such as nutrient deficiency (Wright, 1999), and alteration in phytohormones (Yong *et al*., 2000) especially cytokinins, ABA (Abscisic acid) and ethylene (Yang *et al*., 2004) caused initiation of senescence and progress in

cotton crop. Yield and quality of cotton was affected by both premature senescence and late maturity (Dong *et al*., 2006). For appropriate management in cotton it is very important to understand causes of senescence and it would be helpful to overcome the losses due to premature and/or late senescence (Dong *et al*., 2009). Manual changes in plant architecture may enhance concentration of cytokinins and decrease concentration of ABA at early stage to enhance more vegetative growth at its initial stages of crop growth.

Nodes above white flower were counted from peak flowering till physiological cutout stage to measure its senescence in field condition. More nodes above white flower were recorded with removal of all squares from first and second fruiting branch. The removal of early squares might have enhanced the concentration of growth promoter hormones whereas the subtended and main leaves of these branches also served as source of photosynthetic apparatus at initial stages, while minimum node above white flower in control treatment may be due to increased concentration of ABA at early stages when square converted into young boll after fertilization. According to Dong *et al*. (2009) concentration of ABA enhances 100 fold in developing seed, because ABA has its role in desiccation tolerance hence it would prevent seed to desiccation injury that may be the cause of early senescence as it was observed in control treatment. At peak flowering stage nodes above white flower were more from mid July to first week of August and then gradually decreased so physiological cutout stage came in 2nd week of September during both years of study. Senescence too early (premature senescence) or too late (late maturity) can be measured by nodes above white flower counts (Jones and Snipes, 1999). Guinn and his coworkers reported a series of detailed studies on the causes of cutout, hormonal effects and nutritional stress being the most important (Guinn, 1986).

More node above crack boll and plant height were observed from plots, where first and second fruiting branch were removed and supplied with higher dose of nitrogen, which is an indication of delay in senescence as compared with control. At squaring, differences in plant height were non-significant. Thereafter delay in senescence (increased plant height) was recorded in plots where either two early fruiting branches were removed or where all squares were removed from those two fruiting branches. The previous studies showed that fruit loss changes the partitioning of plant resources in support of vegetative growth (Jones *et al*., 1996). Preferred partitioning of photosynthates towards vegetative parts like root, stem, and leaf due to fruit losses might be responsible for the increased plant height (Sadras, 1996). Early fruit (sink) removal enhanced the vegetative growth and increased fruiting from at later-developed positions also compensates earlier losses of fruit (Bednarz and Roberts 2001).

Conclusion: Removal of first and second fruiting branch and/or removal of all squares from first and second fruiting branch delayed cotton senescence processes. Moreover, addition of higher dose of nitrogen further helped in delaying senescence by early healing up of the injury caused by manual branch/squares removal. It is further concluded that nitrogen application could be managed during cotton crop growing period by measuring nodes above white flower at different stages in field condition. Future studies should focus on removal of fruiting branches instead of square removal. Although these removal strategies resulted in similar results, fruiting branch removal is easier, quicker and can be readily mechanized by agricultural engineers.

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