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INFLUENCE OF FLOWER BUD REMOVAL ON GROWTH, DRY MATTER PRODUCTION AND PARTITIONING IN COTTON (*Gossypium hirsutum* L.)

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Abstract: Field experiments were conducted to investigate the effects of flower bud removal on crop growth and dry matter production at the experimental farm of Central Cotton Research Institute, Multan, during the crop season 1999 to 2001. Cotton cultivar CIM-482 was planted during last week of May having three treatments consisting of simulated flower bud loss, inflicted at squaring and bloom phases of cotton growth and development. Nitrogen was applied at the rate of 150 kg ha^{-1} at squaring and/or bloom stages of cotton. The removal of squares was performed weekly in respective phases of growth. The treatments were arranged in split plot design having three replications. Results showed that complete or partial removal of flower buds during squaring and bloom stages caused significant increase in plant height and number of nodes on main stem. There were significant differences in vegetative, reproductive and total dry matter production among different flower bud removal inflicted either at squaring and bloom stages coupled with partial and complete flower bud removals. Bloom stage removal treatments significantly reduced reproductive-vegetative ratio (RVR) values compared to squaring stage. The removal of flower buds caused heavy fruit shedding compared to non-simulated crop.

Keywords: Cotton, dry matter yield, flower bud removal, fruit shedding.

INTRODUCTION

Cotton is an important cash crop of the country. Pakistan harvested 11.0 million bales of lint cotton during the year 2000-2001 and still hectic efforts are needed to increase yield per unit land area, so as to surpass the production level of 12.3 million bales achieved during year 1991-92. The increase in its yield can be achieved through improvement in agro-techniques, judicious use of fertilizers, insect pests and diseases control, efficient use of irrigation and water etc.

Among major nutrients, nitrogen is the most commonly used fertilizer in cotton crop. Cotton crop in general shows tremendous response to nitrogenous fertilizers and is considered a limiting factor in cotton production [Malik and Makhdum 1990]. Nitrogen supply is a double edge sword in cotton vegetative-reproductive balance. The high nitrogen supply in case of early shedding results in excessive vegetative growth. In contrast, early fruit setting and low nitrogen supply results in cut-out long before end of the season. In both cases, there is loss in yield [Gerik *et al.* 1994, Jones *et al.* 1996a]. These situations demand to coincide the timing of nitrogen fertilization to maintain vegetative-reproductive balance, when fruiting forms are abscised due to various stresses (nutrients, temperature, water) or insect damage during reproductive development [Jones *et al.* 1996a].

Development of cotton crop is a full season process involving a complex balance between vegetative and reproductive allocation [Jones *et al.* 1996b]. It has been reported that during cotton crop season fruit abscission, due to any reason, can cause plants to redirect assimilates to alternate sinks and shift dry matter allocation from reproductive to vegetative organs [Pettigrew *et al.* 1992]. It has been found that stem carbohydrate concentrations were lowest when increases in fruit dry weights were greatest. Under rank growth conditions, stem carbohydrate concentration was highest when vegetative growth was maximal [Saleem and Buxton 1976]. Therefore, characterizing how cotton allocates its photosynthate between fruit and vegetative growth under limited boll loads is critical to understand cotton yielding potential.

The relationship between the production of photosynthate and photosynthate sink development in cotton has been reported by many researchers because of its importance to yield. The reproductive sink removal increased plant height [Patterson *et al.* 1978, Kennedy *et al.* 1986], increased nodal development and branching [Kennedy *et al.* 1986], increased total vegetative dry weights [Ungar *et al.* 1987]. Concurrent with these increases in vegetative growth, fruit removal increased square production [Dale 1959, Kletter and Wallach 1982, Ungar *et al.* 1987]. Fruit removal caused decrease in reproductive growth and reproductive/vegetative ratio [Jones *et al.* 1996b].

Therefore, under abnormal field conditions, cotton plants exhibit altered relationship between the production of photosynthate and photosynthate sink development, which effects yield potential of crop. Keeping this in view, experiments were conducted to study the effects of flower bud removal during squaring and bloom stages on plant structure, dry matter production, intra-plant dry matter allocation and fruit shedding.

MATERIALS AND METHODS

The experiments were conducted at Central Cotton Research Institute, Multan for two consecutive cotton seasons (1999-2001). Cotton cultivar CIM-482 (*Gossypium hirsutum* L.) was planted during the last week of May at a spacing of 75 cm between rows and 30 cm between plants. The layout of experiment was split plot having three replications. The area of each plot was 96 m^2. The treatments consisted of three levels of simulated flower bud loss, i.e. check, partial (50%), complete (100%), inflicted at two phases of growth, i.e. squaring and bloom phases. The fruit pruning was performed weekly in the respective phases of growth. Nitrogen in the form of urea was applied at the rate of 150 kg N ha^{-1} either at squaring and/or bloom stages of cotton. Each treatment also received an equivalent of 50 kg P_2O_5 ha^{-1} as single superphosphate and 50 kg K_2O ha^{-1} as potassium sulphate. Crop received normal irrigation and standard production practices of the area throughout the season. Pest infestation was controlled through scheduled sprays.

The measurements on plant structure, dry matter production and fruit shedding were made by harvesting plants at one square meter area from each treatment at maturity stage. The plants were brought to laboratory and data on main stem height, number of nodes on main stem, and fruit shedding were recorded. The plants were then partitioned into leaves, stalks and fruit. The plant material was dried in forced air oven at 80^{o}C and dry matter yield estimated on per unit land area basis. The statistical analysis of data was done according to methods [Gomez and Gomez 1984].

Table 1: Effect of Flower Bud Removal on Plant Structure at Maturity

Treatments			Main stem height (cm)	Number of nodes on main stem	Internodal Length (cm)
Period of Nitrogen Application	Flower Bud Removal				
	Intensity	Stage			
Squaring	Check	-	144.5	33	4.38
	Partial	Squaring	173.5	36	4.83
		Bloom	156.0	35	4.46
	Complete	Squaring	194.3	39	4.98
		Bloom	172.2	37	4.67
Blooming	Check	-	147.1	32	4.60
	Partial	Squaring	181.3	37	4.90
		Bloom	161.0	35	4.60
	Complete	Squaring	200.0	40	5.00
		Bloom	185.0	39	4.74
LSD (p< 0.05)					
Period of N Application (P)			NS	NS	NS
Intensity of Square Removal (I)			0.96**	0.74**	0.14**
Stage of Square Removal (S)			3.53**	0.64**	0.09**
P x I			NS	NS	NS
P x S			NS	NS	NS
I x S			2.47**	0.76**	0.17**
P x I x S			NS	NS	NS

RESULTS AND DISCUSSION

The plant structure is a useful tool in understanding general crop behavior, crop production potential in a given environment and to evaluate nutrient efficiency. This is an approximate expression of net photosynthesis over a season. Data presented in Table 1 indicate that main stem height, number of nodes on main stem and internodal length differed significantly due to simulated flower bud loss during squaring and bloom stages and at various levels of simulation. There were no differences in main stem height and number of nodes due to period of nitrogen application. These results closely demonstrate that application of nitrogen fertilizer during squaring and /or blooming period could cater the needs of cotton crop for realization of its yield potential. The complete flower bud removal during squaring stage caused the greatest increase in main stem height and number of nodes on main stem compared to other treatments. Increase in number of nodes on main stem was mainly responsible for increased plant height. These data suggest that simulation of flower bud loss near the critical time trigged photosynthates from

reproductive sinks to vegetative sinks and this ended up in large plant structure. The main stem height ranged from 144.5 to 200.0 cm in various treatments. These data are in agreement with other researchers [Patterson *et al.* 1978, Kennedy *et al.* 1986].

Table 2: Effect of Flower Bud Removal on Dry Matter Production and Reproductive-Vegetative ratio at Maturity

Treatments			Total dry weight gm^{-2}	Vegetative dry weight (VDW) gm^{-2}	Reproductive dry weight (RDW) gm^{-2}	RDW/ VDW ratio
Period of Nitrogen Application	Flower Bud Removal					
	Intensity	Stage				
Squaring	Check	-	863	411	452	1.10
	Partial	Squaring	854	431	423	0.98
		Bloom	756	406	350	0.86
	Complete	Squaring	838	438	400	0.93
		Bloom	763	453	310	0.68
Blooming	Check	-	876	419	457	1.09
	Partial	Squaring	862	439	423	0.96
		Bloom	735	418	317	0.76
	Complete	Squaring	853	457	396	0.87
		Bloom	728	458	270	0.59
LSD ($p< 0.05$)						
Period of N Application (P)			NS	NS	NS	NS
Intensity of Square Removal (I)			9.1**	8.04**	7.72**	0.11**
Stage of Square Removal (S)			6.82**	4.62**	4.79**	0.22**
P x I			NS	NS	NS	NS
P x S			NS	NS	NS	NS
I x S			16.1**	7.8*	12.8*	0.09**
P x I x S			NS	NS	NS	NS

The partial or complete removal of flower buds during squaring and bloom stages caused significant differences in dry matter production per unit land area at maturity stage (Table 2). There were non-significant differences in dry matter production due to period of application of nitrogen fertilizer. The complete removal of flower buds treatments caused increase in vegetative dry weight compared to reproductive dry weights at all stages of simulation of flower bud removal. The values of total dry weights ranged from 728 to 876 gm^{-2} in various treatments. It has been shown that relatively high sink/source ratio during squaring phase was an important factor controlling subsequent vegetative growth [Kerby *et al.* 1990]. The complete removal treatments had lower reproductive dry weights than all other treatments. This is because of shifting of fruiting position to more distant along sympodia and on vertical positions during mid-season removals compared to early season ones [Jones *et al.* 1996b]. The reason being that production of fruiting positions is dependent on vertical and horizental growth of cotton plant. Moreover, plants must grow vegetatively to produce fruiting sites until subjected to internal or external stress, viz; temperature, moisture, nutrients, boll load and interaction of these factors can cause cessation of growth [Kohel and Benedict 1987]. The fruiting positions along a fruiting branch varies, i.e., the first, second and third sympodial positions contribute about 60%,

30%, and 10% of the total seed cotton yield respectively. Any deviation from the normal pattern of fruit production results in increased vegetative dry weights [Jenkins *et al.* 1990].

The early flower removal treatments were able to eventually initiate bolls and higher reproductive-vegetative ratio (RVR). The low reproductive dry weights coupled with a slight increase in vegetative dry weights caused a reduction in the RVR for the mid-season removal treatments. It has been studied that early maturing cultivars produce a larger lint yield by two major processes. The first is a greater partitioning of dry matter to reproductive organs. The second is an increased amount of reproductive development occurring when maximal leaf mass and area are present. It was found that RVR was highly correlated with the yield [Wells and Meredith 1984]. Since mid-season removal treatments significantly reduced RVR values which are related to the termination of reproductive development with no opportunity for further boll initiation to compensate ratio for the loss [Jones *et al.* 1996a]. These results are similar with the findings that lower RVR values for plants exposed to different early, mid and late-season square removal treatments [Pettigrew *et al.* 1992].

Table 3: Effects of Flower Bud Removal on Fruit Shedding Percentage at Maturity

Treatments		Stage of Square Removal		
Period of N Application	Intensity of Square Removal	Squaring	Bloom	Mean
Squaring	Check	73		73
	Partial	75	78	77
	Complete	77	81	79
Blooming	Check	74		74
	Partial	75	82	80
	Complete	77	80	
	Mean	76	80	
LSD (p< 0.05)				
Period of N Application (P)		NS		
Intensity of Square Removal (I)		0.42**		
Stage of Square Removal (S)		0.39**		
P x I		NS		
P x S		NS		
I x S		0.81**		
P x I x S		NS		

Data presented in Table 3 indicated significant increase in fruit shedding percentage due to flower bud removal during squaring and bloom stages. The removal of flower buds during bloom stage had higher fruit shedding percentage compared to squaring stage. The crop simulated to flower bud coupled with complete removal during bloom stage could not compensate for its fruit loss compared to partial removals during squaring phase. The loss of flower buds at squaring and bloom stages of reproductive growth caused shifts in partitioning of dry matter from reproductive to vegetative structures. The imbalance caused due to source-sink relationships resulted in heavy fruit shedding at either stage

of growth. These results corroborates with the others [Ungar *et al.* 1987, Jones *et al.* 1996b]

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