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Effect of methods of application and scheduling in nitrogen on nitrogen use efficiency and seed cotton yield of *Bt* cotton in semi arid regions of Haryana

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ABSTRACT: The present investigation was carried out at Cotton Research Area of CCS Haryana Agricultural University, Hisar, during *kharif* season of 2018 to study the effect of application method and scheduling of nitrogen on yield attributes, yield, economics and nitrogen use efficiency in *Bt* cotton. The result revealed that with spot application of 75 per cent recommended nitrogen in four splits (sowing, squaring, flowering and boll development) along with incorporation of two rows of moong at 50-55 days after sowing gave the higher number of bolls/m (135), boll weight (4.2 g) and highest seed cotton yield (5259 kg/ha). Also nitrogen use efficiency (18.38 %), net return (Rs. 145519/ha) and benefit cost ratio (2.05) was found highest with this treatment but all these parameters are statistically *at par* with application of 100 per cent recommended dose of nitrogen (175 kg/ha) in two splits, Although there was no significant difference found among various treatments for monopodial branches/plant, sympodial branches/plant and seed index.

Key words: Cotton, economics, nitrogen scheduling, nitrogen use efficiency

Cotton is an international crop grown by about 80 countries across the world over an area of 32.95 m ha. India with first rank contributes about 33.23 per cent of cotton at world level. The area, production and productivity of cotton in India is 12.2 m ha, 37.7 m bales, 524 kg/ha, respectively (Anonymous, 2018). Cotton is an important cash crop of *kharif* season in Haryana state which plays an important role in state's economy through employment and export earnings. The four major cotton growing districts of Haryana *viz;* Sirsa, Hisar, Jind and Fatehabad form the cotton belt of the state. The major area about 90 % or around 5.90 lakh ha is under American cotton *Gossypium hirusutum* whereas desi cotton (*G. arbarium*) comprises 0.91 per cent (around 6000 ha). Area under *Bt* cotton, increased in Haryana from year 2016 (4.98 lakh ha) to 2017 (6.56 lakh ha) (Anonymous, 2018).

Bt cotton hybrids and their scope for extensive coverage in the country in coming years, necessitated for change in the nutrient management of *Bt* cotton hybrids. The agronomic factors responsible for low yield of cotton in the country are numerous among which inappropriate fertilizer management is considered major one. Nitrogen is the most limiting essential plant nutrient in the world and it needs to be supplied in appropriate amount and at right time. Nitrogen is considered to be the most important nutrient for increasing the cotton yield. Nitrogen is an important element for photosynthesis and canopy area development. Providing the right amount of N during the plant growth will provide healthy leaves with the photosynthetic capacity needed to support the development of the reproductive components. On other hand an inadequate supply of N will slow or stop leaf development. Surplus N application encourages excessive vegetative growth, resulting in poor boll set caused by vegetative shading and insect attractiveness, late maturity and difficulty in defoliation. Insufficient dose of nitrogen and its application at improper time result in slow growth of boll development and provide more favourable environment for growth of insects pests and delay the maturity which collectively adversely affect the seed cotton yield. Over-fertilization results in excessive vegetative growth, decreased lint turn out, increased wilt-disease incidence, delay in maturity which may result in immature and poor quality of fiber (Main *et al.*, 2011).

Nitrogen requirement of crops is usually more than those of P and K, yet N has higher losses due to leaching, volatilization therefore resulting in lower use efficiency and greater potential to pollute the environment (Jan *et al.,* 2007). Inadequate supply of nitrogen affects the growth and development of cotton, results in a reduction of leaf area index (LAI), chlorophyll concentration in leaves, photosynthetic rate, biomass production (Zhao and Oosterhuis, 2000), as well as reduced lint yield and quality parameters (Reddy *et al.*, 2004).

Nutritional stress and imbalanced application of nutrients affect vegetative as well as reproductive growth that ultimately lowers the yield and quality of cotton. Split application of nutrients is considered to be one of the best ways to enhance the nutrient use efficiency in cotton crop. As N requirement is more, losses of N are higher and potential cause of environmental pollution. Nitrogen uptake efficiency increased with its application in splits (Bhati and Singh, 2015).

Application of higher amount of N than the recommended dose not only increases cost of production but also causes environmental problems, like ground water contamination by NO_3 leaching (Zhao *et al.*, 2009). The nitrogen efficiency depends on the various factors such as amount applied, sources used, time and method of application, soil and climatic conditions, intensity of cultivation area, availability of phosphorus, potassium, calcium and magnesium, cropping system, and use of growth regulators (Castro, 2004).

The present study was conducted on *Bt* cotton hybrid (RCH 650) at cotton research area, CCS Haryana Agricultural University, Hisar. There were 7 treatments including the control. Sowing was done by dibbling method on well prepared bed with row to row spacing of 100 cm and plant to plant spacing of 45cm. Thinning was done to keep the good crop stand. All the recommended package of practices were followed.

Observations were recorded as per standard procedures. Total numbers of bolls harvested/m was counted in each plot from five tagged plants by adding the mean number of good and bad opened bolls harvested/m. Similarly, five fully opened bolls from tagged plants in each plot were picked randomly and weighed and averaged to give boll weight per plant in grams. Sympodial and monopodial branches were also counted from the five tagged plants in each plot at maturity stage and mean was calculated and expressed on/plant basis and weight of 100 cotton seeds randomly taken after ginning from each plot was expressed in grams.

Total seed cotton harvested from all the pickings (two)/plot was recorded and expressed as seed cotton yield in kg/ha. Nitrogen use efficiency is the fraction of difference in the yield from fertilized plot and from unfertilized plot/amount of nitrogen applied. It was calculated as follows:

$$\text{Nitrogen use efficiency} = \frac{\text{Yield from fertilized plot (kg/ha)} - \text{yield from unfertilized plot (kg/ha)}}{\text{Amount of nitrogen applied}}$$

The expenditure incurred on individual treatment was worked out from the detail assessment of the fixed and variable costs involved such as land preparation, seed, plant protection, fertilizers, herbicide and labour engaged in different operations. Gross income for all treatments was calculated separately taking into consideration seed cotton yield of crop. Thereafter, net returns were calculated after subtracting expenditure incurred on the individual treatment from the gross income of the same treatment. The benefit: cost ratio was calculated as follows.

$$\text{B:C} = \frac{\text{Gross return (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}$$

The experiment was conducted in RBD design along with three replications.

The maximum bolls/m was recorded (Table 1) in T_7 (T_5+ raising of moong between rows incorporated before flowering (50-55 DAS)) treatment which was *at par* with T_2 (100% of RDN band application in 2 splits at sowing and flowering) and T_6 (T_5+ foliar application of 1% urea 3 times at squaring, flowering, boll development) treatment and significantly higher as compared to other treatments. Higher number of bolls in T_7 (T_5+ raising of moong between rows incorporated before flowering (50-55 DAS)) could be due to intercropping of moong in cotton which change the microclimate of cotton crop and leads to less shedding of bolls. This was well demonstrated by Hassan *et al.,* (2003) and Sankat *et al.,* (2013)

The results revealed that boll weight/plant was significantly affected by application method and scheduling of N. Highest boll weight was obtained in T_6 treatment which was *at par* with T_2 (100% of RDN band application in 2 splits at sowing and flowering), T_7 (T_5+ raising of moong between rows incorporated before flowering (50-55 DAS)) and significantly greater than all other treatments (Table 1). Timely availability of adequate amount of nitrogen at boll development stage increased its weight. Similar findings were reported by Bharathi *et al.*, (2016).

Monopodial branches (Table 1) are the vegetative branches which arise from the lower nodes of plant. All the treatments were statistically *at par* with each other in case of number of monopodial branches/plant. These results are in conformity with the findings of Reddy and Kumar (2010).

Sympodial branches are those branches on which fruiting points are located. All the treatments were statistically *at par* with each other in case of sympodial branches/plant (Table 1). The number of sympodial branches in cotton again depends on the availability of resources especially nitrogen. These results are in conformity with the findings of Reddy and Kumar (2010).

Cotton yield is a function of many yield attributing parameters such as bolls/m, boll weight, monopodial branches and sympodial branches etc. The results (Table 1) revealed that N application method and its scheduling had a significant effect on seed cotton yield. The seed cotton yield in T_7 (T_5+ raising of moong between rows incorporated before flowering (50-55 DAS)) treatment which was *at par* with T_2 (100% of RDN band application in 2 splits at sowing and flowering) and T_6 (T_5+ foliar application of 1% urea 3 times at squaring, flowering, boll development) but was significantly higher as compared to all other treatments. It might be due to reduced leaching losses under more split application and better reserve of nitrogen during the maximum utilization period of crop growth and development, which resulted in adequate food supply to sink and ultimately reflected on better development of yield attributes. This was well demonstrated by Mariyappan *et al.*, (2004) and Bharathi *et al.*, (2016).

The results indicated (Table 1) that various treatments were statistically at par with each other for seed index. Similar results have been reported by Bharathi *et al.,* (2016).

Nitrogen use efficiency : The data pertaining to nitrogen use efficiency (Fig. 1) showed significant differences among various treatments. Highest nitrogen use efficiency was found in T_7 (T_5+ raising of moong between rows incorporated before flowering (50-55 DAS)) treatment which was statistically at par with T_6 (T_5+ foliar application of 1% urea 3 times at squaring, flowering, boll development) treatment and significantly higher than other treatments. This might be due to less losses of nitrogen by using spot split application of nitrogenous fertilizer, foliar

Table 1. Effect of various treatments on yield attributes and seed cotton yield of *Bt* cotton hybrid

Treatments	Bolls/m	Boll wt. (g)	Monopodial branches/ plant	Sympodial branches/ plant	Seed index	Cotton yield (kg/ha)
T_1- Control	87.2	3.94	2.13	30	9.0	2759
T_2- 100 per cent of RDN (band application in 2 splits at sowing and flowering)	125	4.20	2.66	32	9.0	4943
T_3- 75 per cent of RDN (band application in 2 splits at sowing and flowering)	102	4.10	2.46	36	9.5	4214
T_4- 75 per cent of RDN + Placement (spot application in 2 splits at sowing and flowering)	104	4.10	2.40	34	9.5	4374
T_5 - 75 per cent of RDN + Placement (spot application in 4splits at sowing, squaring, flowering and boll development)	105	4.10	2.20	37	9.0	4413
T_6- T_5+ foliar application of 1 per cent urea (3 times at squaring, flowering and boll development)	134	4.25	2.13	33	10.0	5006
T_7 -T_5+ raising of moong between rows incorporated before flowering (50-55 DAS)	135	4.22	2.13	30	9.5	5259
SEm ±	4.98	0.05	0.19	2.51	0.31	138.18
CD (p=0.05)	15.51	0.14	NS	NS	NS	430

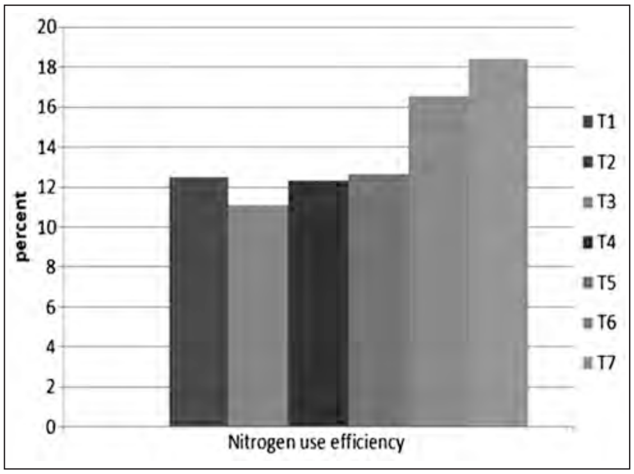

Fig. 1. Effect of various treatments on nitrogen use efficiency of *Bt* cotton hybrid

application of urea and intercropping with legume. This was in conformity with the observations of Desai *et al.*, (2014).

Economics : Cost of cultivation, gross returns, net returns and benefit cost ratio differed due to different methods and scheduling of nitrogen at various growth stages (Fig. 2). Highest value of all these were obtained in treatment T_7 (T_5+ raising of moong between rows incorporated before flowering (50-55 DAS)) and lowest in T_1 (control). This might be due to higher yields of seed cotton and stalk of crop. Similar finding

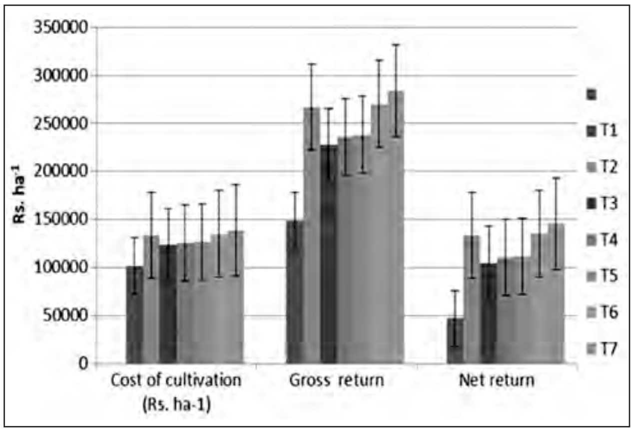

Fig. 2. Effect of various treatments on economics of *Bt* cotton hybrid

were observed by Srinivasan (2003) and Usadadia *et al.*, (2013).

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