RESEARCH ARTICLE

RESPONSE OF PRECISION APPLICATION OF WATER AND FERTILIZER ON PRODUCTIVITY AND ECONOMICS OF BT COTTON

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Abstract: A field experiment was conducted during the *kharif* season of 2013-14 and 2014-15 at Agricultural Research Station (MPUAT), Banswara, Rajasthan to find out the response of precision application water and nutrient through drip with fertigation on productivity and economics of Bt cotton hybrid (*Gossypium hirsutum* L.). The treatments comprised of three irrigation regimes viz. 0.6 Etc (I_1), 0.8ET_C (I_2) and 1.0 Etc in main plot and three nutrient management practices viz. 100% RDF (120:60:40kg NPK/ha) (N_1), 75 % RDF (N_2) and 50 % RDF (N_3) in sub plot of spit plot design with three replications. Results indicated that scheduling irrigation at 1.0 Etc was produced significantly higher seed cotton yield (3443kg/ha) over rest irrigation scheduling. Application of 100% RDF gave significantly higher seed cotton yield (3556kg/ha) compared to lower doses of nutrients. The maximum seed cotton yield (3851kg/ha) recorded at the interaction of 1.0 Etc with 100% RDF which was at par with 0.8 Etc with 100% RDF and found significantly superior over rest interactions. Contribution of yield attributes was significantly reflected on economical yield. The water requirement at 0.6, 0.8 and 1.0 was 75.79, 96.45 and 177.77 mm/ha respectively, compared to 183.6 mm/ha under 0.6 IW/CPE ratios. Maximum water use efficiency (6.11kg/ha-mm) recorded at the interaction of 1.0 Etc with 100RDF which was at par with 0.8Etc at 100% RDF and 75% RDF and significantly superior over rest interactions. Highest nitrogen use efficiency (47.62kg/kgN/ha) was recorded at the interaction of 1.0 ETc with 50% RDF which was at par with 0.8Etc at 75% RDF and significantly superior over rest interactions. Maximum B:C ratio (3.40) recorded with interaction of 1.0Etc at 100RDF which was at par with 0.8 Etc at 100RDF and 1.0Etc at 75% RDF and found significantly higher than other interactions. Overall, it is concluded that drip fertigation at 0.8 Etc with 75% RDF found more precision technique for Bt cotton hybrid under humid condition of Rajasthan.

Keywords: Seed cotton yield, Bt cotton, Fertigation, Water use efficiency, B:C ratio

INTRODUCTION

India annually cultivates more than eleven million hectares of cotton which is the largest in the world. Around 60 million people are estimated to depend on it one way or the other to make out their living. Bt. Cotton was released in 2002-03 for commercial cultivation in India. Since the release of Bt. Cotton technology, it has emerged as an effective alternative to traditional cotton varieties by inhibiting bollworm attack, thereby improving yield and income. This has resulted in fast adoption of Bt cotton over conventional cotton. Cotton production in India has accelerated more than 4 times and reached a peak of 359.02 lakh bales during 2013-14 as compared to 86.24 lakh bales in 2002-03. Introduction of Bt cotton has played a catalytic role in enhancing cotton production in India. During 2013-14, the production of cotton received was 359.02 lakh bales which was all time high in cotton history. In 2014-15 and 2015-16, the cotton production kept reducing to 348.05 and 301.47 lakh bales respectively due to drought condition in main area of cotton in the country. Water and nutrient are most important production factors for crop production. Days to day availability of both inputs are scarce; hence its judicious use in a scientific manner is essential for increasing the productivity. Introduction of drip irrigation can help to bring more area under cotton irrigation with substantially improved crop yield. Method of application along with appropriate schedule is one of the several factors that affect fertilizer efficiency. Application water soluble fertilizers through drip irrigation has gained widespread popularity as an efficient method for fertilizer application (Mmolawa and Or 2000). The roots are developed extensively in a restricted volume of the soil wetted zone by drip irrigation. Thus, the drip fertigation system can place nutrients efficiently in wetted zone and are used by the plant from the soil easily. It helps in achieving higher productivity and enhancing of the crop (Zhenam et al 2007 and Mark et al (2009). However, several basic principles must be followed in applying nutrients through the irrigation system in order to place the fertilizer currently, decrease potential nutrient losses, avoid excessive fertilizer application and prevent clogging of the system by precipitating compounds. Cotton is a long duration and widely spaced crop, drip irrigation and fertigation offers much scope in enhancing the productivity of water and yield/unit area. Application of irrigation based on crop evapotranspiration (Etc.) and fertigation are the new approaches for water and nutrient management Adoption of micro-irrigation might help in increasing, productivity of crop, irrigated area and water use efficiency (Pawar *et al*,2013). In view of the above, it was carried out to standardize fertigation schedule for Bt cotton cultivation under humid condition of southern Rajasthan.

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MATERIAL AND METHOD

A field experiments was conducted in two consecutive rainy season (June-October) of 2014 and 2015 at Agricultural Research Station (MPUAT), Banswara (Rajasthan) located at 23^0 33' N latitude, 74^0 27'E longitude, and altitude of 220M above Mean Sea Level. It is covered under humid southern plain agro-climatic zone of Rajasthan. The soil of experimental field was clay loam in texture, slightly alkaline in reaction with low in organic carbon (0.48%), low in available N (218kg ha^{-1}), medium in available P ($18k_g$/ha) and high in available K (362 kg /ha) content. The treatments comprised of three irrigation regimes viz. I_1: 1.0 ETc, I_2: 0.8 ETc and I_3: 0.6 ET_C in main plots and three nutrient level viz. N_1: 100% RDF (100% recommended dose of 120+60+30 kg NPK/ha) , N_2: 75% RDF and N_3: 50% RDF in sub-sub plots were randomized in split plot design with three replications. Bt cotton hybrids Jai Bt were sown on first fortnight of June by dibbling at 90X45cm plant spacing on the leveled bed for single row planting. Fertilizers were applied as per treatments. The half dose of P and K and 1/5 dose of N were applied as basal dose and remaining dose of P and K was applied in two splits at square formation and boll development stages and N dose was applied in 4 splits with irrigation water. water soluble fertilizers viz. Urea (46:0:0), NPK grade (18:18:18) and sulphate of potash (0:0:50) were used for fertigation. Out-line lateral dripper were fixed at 45cm spacing of seed dibbling place**.** It maintained the lateral to lateral spacing of 90 cm. The fertigation was done using atomized fertilizer system at 15 days interval as per schedule. Adequate plant protection measures were adopted as and when required. The amount of water (litre/day) to be applied through drip irrigation was calculated by using following formula:
V= Eo X Kc X Kp
Whereas, V= Volume of water to be given /dripper (litres); Eo= Pan evaporation of two days (mm); Kc= Crop factor as per growth stages of cotton; Kp, pan factor.
For cotton Kc values were 0.45, 0.75, 1.15 and 0.70 for seedling (0-25 DAS), crop development stage (26-70 DAS), boll development (71-120 DAS) and maturity stage (>121 DAS) respectively as per FAO irrigation water management training manual no 3 (Brouwer and Heibloem1986).Based on the above formula quantity of water was calculated on alternate days and irrigation was scheduled. Time for irrigation was decided as per the discharge of water per dripper. The out-line having emitters of 4lph discharge capacity were operated at pressure of 1kg/cm^2. The average emission uniformly of drip irrigation system was estimated as 91% for all treatments. For conventional irrigation 6cm depth of irrigation was considered and irrigation given on basis of cumulative pan evaporation (100 mm CPE). The irrigation was cut off after starting the boll brusting. The field capacity of the soil was 35.5 and permanent wilting point was 18.0%. The irrigation at 0.6, 0. water requirement 8, 1.0 Etc and 0.6 IW/CPE WR=ETc 75.79, 96.45 and 177.77 mm/ha respectively.

RESULT AND DISCUSSION

Yield and yield attributes

The pooled data of two years presented in Table 1 revealed that plant height was varied with irrigation regimes. Maximum plant height (167cm) observed at 1.0 Etc which was at par with 0.8 Etc and significantly superior over 0.6 ETc . 100% RDF gave significantly higher plant height (167cm). The interaction effect of irrigation at 1.0 ETc with 100% RDF attended the highest plant height (187cm) which was found significantly superior over rest interactions. Numbers of bolls per plant were significantly influenced due to application of water and nutrients. Maximum number of bolls/plant (48.41) recorded with 1.0ETc followed by 0.8ETc and significantly superior over 0.6 ETc. Among the nutrient levels, 100% RDF produced highest bolls/plant (47.06) which was significantly higher than other nutrient levels. The interaction of 1.0ETc at 100% RDF recorded maximum bolls/plant (54.33) followed by 0.8 ETc at 100% RDF and significantly superior over other interaction. Boll weight was also influenced with water and nutrient levels. Irrigation regimes at 1.0 ETc gained maximum boll weight (4.69g/boll) followed by 0.8 ETc and significantly higher than 0.6 ETc. Among, the nutrients levels, maximum boll weight (4.69g/boll) gained by 100% RDF followed by 75%RDF and significantly higher over 50%RDF. Interaction of irrigation and nutrient was influenced boll weight, the highest boll weight(4.84g/boll) at 1.0ETc with 100% RDF which was significantly higher than 0.6 ETc at 75% RDF and 0.8 ETc at 50% RDF. Maximum plant growth parameters and yield attributes were recorded with irrigation regime at 1.0 ETc (through drip) with 100% RDF followed by 1.0 ETc with 75% RDF and significantly more than other interactions. This might be due to favorable micro-climate. These results are confirmatory with reported by Aruna and Reddy (2009).Irrigation applied at 1.0 ETc recorded significantly higher seed cotton yield (3443kg/ha) other irrigation levels. Halemani *et al*. (2003) and Bhatoo *et al*. (2009) also reported that drip irrigation at 1.0 ETc produced maximum yield than other levels of drip irrigation and furrow irrigation. Irrigation at 0.8 ETc significantly superior to 0.6 Etc. Similar results were reported by Bhalerao et at (2011). Application of 100% RDF recorded significantly higher seed cotton yield (3556kg/ha) than other nutrient levels. Seed cotton yield was significantly influenced by interaction of irrigation and nutrient levels. Highest seed cotton yield (3851kg/ha) was recorded with application of

irrigation at 1.0 ETc through drip with 100% RDF followed by 0.8 ETc with 100% RDF and significantly superior over other interactions. Nalayini et al. (2006) at Coimbatore reported that scheduling of irrigation at 1.0 ETc was on par 0.8 Etc through drip for cotton crop. Mark et al (2009) also reported increase seed cotton yield under fertigation. Results are might be due moisture conserved in root to supply adequate amount of nutrient to the plant.

Table 1. Effect of irrigation regimes and nutrient levels on growth parameters, yield attributes and yield of cotton.

Treatment	Plant height (cm)	Bolls/plant	Boll weight (g)	Seed cotton yield (kg/ha)
Irrigation regimes				
I_1: 0.6ETc	**125**	**29.65**	**4.25**	2723
I_2: 0.8ETc	**157**	**45.00**	**4.58**	3274
I_3: 1.0ETc	**167**	**48.41**	**4.69**	3443
CD (P=0.05)	10.28	4.71	0.42	138
Nutrient levels				
N_1: 100% RDF	**167**	**47.06**	**4.69**	3556
N_2: 75% RDF	**152**	**42.65**	**4.56**	3376
N_3: 50% RDF	**131**	**33.35**	**4.26**	2508
CD (P=0.05)	7.02	3.40	0.30	102
I x N Interaction				
$I_{1X}N_1$	**137**	**36.23**	**4.47**	**3107**
$I_{1X}N_2$	**123**	**33.01**	**4.30**	**2989**
$I_{1X}N_3$	**114**	**19.69**	**3.97**	**2072**
$I_{2X}N_1$	**176**	**50.60**	**4.77**	**3710**
$I_{2X}N_2$	**159**	**46.92**	**4.67**	**3517**
$I_{2X}N_3$	**137**	**37.46**	**4.30**	**2595**
$I_{3X}N_1$	**187**	**54.33**	**4.84**	**3851**
$I_{3X}N_2$	**174**	**48.00**	**4.72**	**3622**
$I_{3X}N_3$	**141**	**42.89**	**4.51**	**2857**
CD (P=0.05)	12.16	5.89	0.50	176

Input use efficiency

The pooled data of two years presented in Table 2 revealed that water use efficiency (WUE), nitrogen uptake and nitrogen use efficiency (NUE) influenced with irrigation and nutrient levels. Highest WUE (5.46) was recorded with application of irrigation at 1.0 ETc followed by 0.8 and significantly superior over 0.6 ETc. The enhanced water use efficiency (WUE) in drip system is due to moisture availability in root zone to decrease surface evaporation; runoff and percolation losses of water.WUE might be higher in 1.0 ETc followed by 0.8ETc due higher yield production. These results are in agreement with Oweis and Hachum (2002). Water use efficiency (5.87) was significantly higher with 100%RDF as compared to other levels. It is might be due to higher yield gained to plant response at nutrient availability. This is conformed to the findings of Ramamurthy *et al* (2009) and Pawar *et al* (2013). Maximum WUE (6.11) was recorded with interaction of 1.0 ETc at 100% RDF fallowed by 0.8 ETc at 100% RDF which significantly higher than rest interaction. It is might be due to yield response at the availability of water and nutrients. Nitrogen availability was improved with fertigation. Maximum nitrogen uptake (217.14 kg/ha) recorded at 1.0ETc followed by 0.8ETc and significantly higher than 0.6 ETc. It may be cleared that N availability is reduced with water availability in root zone of plant. 100% RDF gave significantly higher N uptake (226.14kg/ha) than other nutrient levels. It might be due to adequate quantum availability of nutrient in soil. Maximum N uptake (250kg/ha) was recorded with the interaction of 1.0 ETc at 100% RDF followed by interaction of 0.8 ETc at 100% RDF which significantly higher to rest interaction of water and nutrients. The results conformed to the finding of Results conformed to the finding of Panwar *et al* (2013). It might be due availability of nutrient at adequate soil moisture to uptake by plant. Maximum NUE (41.80) recorded with 1.0 ETc which was significantly higher than other irrigation levels. It might be due to optimum utilization of N at adequate moisture availability. The interaction of 1.0 ETc at 50% RDF gave significantly

higher NUE (47.62) compared to other interactions. Similar results were rep[orted by Nalayini et al (2013).

Table 2. Effect of irrigation regimes and nutrient levels on water use efficiency, nitrogen uptake and nitrogen use efficiency of Bt cotton.

Treatment	Water use efficiency (kg/ha-mm)	Nitrogen uptake (kg/ha)	Nitrogen use efficiency (kg/kg N)
Irrigation regimes			
I_1: 0.6ETc	**4.70**	**152.53**	**31.20**
I_2: 0.8ETc	**5.41**	**204.32**	**37.75**
I_3: 1.0ETc	**5.46**	**217.14**	**41.80**
CD (P=0.05)	**0.23**	14.80	2.11
Nutrients			
N_1: 100% RDF	**5.87**	**226.75**	**29.64**
N_2: 75% RDF	**5.57**	**203.29**	**37.15**
N_3: 50% RDF	**4.13**	**143.94**	**41.80**
CD (P=0.05)	0.17	9.40	1.35
IxN interaction			
$I_{1X}N_1$	**5.37**	**187.81**	**25.89**
$I_{1X}N_2$	**5.16**	**167.37**	**33.21**
$I_{1X}N_3$	**3.58**	**102.40**	**34.53**
$I_{2X}N_1$	**6.14**	**241.50**	**30.92**
$I_{2X}N_2$	**5.82**	**217.69**	**39.08**
$I_{2X}N_3$	**4.29**	**153.76**	**43.25**
$I_{3X}N_1$	**6.11**	**250.94**	**32.09**
$I_{3X}N_2$	**5.74**	**224.82**	**40.25**
$I_{3X}N_3$	**4.53**	**175.67**	**47.62**
CD (P=0.05)	0.29	16.30	2.35

Economics

Pooled data of two year presented in Table 3 revealed that maximum gross return (Rs 1, 37,740/ha) recorded at 1.0 ETc which was significantly higher than rest irrigation levels. Among, the nutrient levels, 100% RDF gave maximum gross return (Rs 1, 42,249/ha) which was significantly higher than other levels. The interaction of 1.0 ETc at 100% RDF recorded maximum gross return (Rs 1, 48,416/ha) followed by 1.0 ETc at 50% RDF which was significantly higher than rest interactions. Maximum Net return (Rs, 1,03.523/ha) was found significantly higher at 1.0 ETc than other irrigation regimes. Among nutrient levels, maximum net return (Rs 1,07,452/ha) was recorded at 100% RDF followed by 75% RDF and significantly higher than 50% RDF. Irrigation at 1.0ETc obtained significantly higher B:C ratio (3.02) than other irrigation regimes. Among, the nutrient levels.100% RDF found significantly higher B:C (3.09) than other levels. Interaction of 1.0 ETc at 100% RDF gained higher B:C ratio (3.40) followed by interaction of 0.6 ETc at 100% RDF and 1.0 ET at 75% RDF which was found significantly higher than rest interactions. Economic returns might be increased with response inputs on yield of crop. Results are conformed with finding of Bhatoo et al (2009) and Ramamurthy et al (2009).

Table 3. Effect of irrigation regimes and nutrient levels on economics of Bt cotton

Treatment	Gross return (Rs/ha)	Net return (kg/kg N)	B:C ratio
Irrigation regimes			
I_1: 0.6ETc	**108901**	**75126**	**2.22**
I_2: 0.8ETc	**130969**	**96974**	**2.84**
I_3: 1.0ETc	**137740**	**103523**	**3.02**
CD (P=0.05)	**5343**	**5509**	**0.17**

Nutrients			
N_1: 100% RDF	**142249**	**107452**	**3.09**
N_2: 75% RDF	**135039**	**191943**	**2.97**
N_3: 50% RDF	**100322**	**67128**	**2.02**
CD (P=0.05)	**4243**	**4010**	**0.11**
IxN interaction			
$I_{1X}N_1$	**124284**	**89707**	**2.59**
$I_{1X}N_2$	**119542**	**85766**	**2.54**
$I_{1X}N_3$	**82878**	**49904**	**1.51**
$I_{2X}N_1$	**148416**	**113619**	**3.27**
$I_{2X}N_2$	**140690**	**106695**	**3.14**
$I_{2X}N_3$	**103801**	**70608**	**2.13**
$I_{3X}N_1$	**148416**	**119030**	**3.40**
$I_{3X}N_2$	**140690**	**110668**	**3.23**
$I_{3X}N_3$	**103801**	**80872**	**2.42**
CD (P=0.05)	**7305**	**6946**	**0.21**

CONCLUSION

Based on two years study, it can be concluded that high yielding Bt cotton hybrid responded to water and nutrients. The drip irrigation at 0.8 ETc with 75% RDF through festigation of nutrient in splits is found precision use of inputs for realizing yield and economics of Bt cotton and save the input over surface irrigation and manual application of fertilizers in the crop under humid condition of Southern Rajasthan.

Table 1: Effect of irrigation regimes and nutrient levels on growth parameters, yield attributes and yield of cotton

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