Biological Forum – An International Journal **14(2a): 311-315(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Irrigation Regimes and Split Application of N and K on Crop Growth Rate, Relative Growth Rate and Net Assimilation rate of *Bt* and *Non- Bt* Cotton Genotypes

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(Received 12 April 2022, Accepted 23 June, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: A field experiment was carried out to assess the effect of different irrigation regimes and split application of nitrogen and potassium on crop growth rate, relative growth rate and net assimilation rate of *Bt* and *Non- Bt* cotton genotypes at Agricultural College and Research Institute, Madurai. The experiment was laid out in split plot design and replicated thrice with treatment combinations of 16 *viz.*, with two different irrigation regimes based on IW/CPE ratio (0.8 and 0.4) and two genotypes (RCH 659 hybrid and its conventional RCH 659 BG II). The sub plot consists of N and K split application upto 90 days in various proportions *viz.*,N_1 - 50 % N and K as basal + 25% N and K at 45 DAS + 25% N and K at 60 DAS, N_2 - 25% N and K as basal+ 25% N and K at 45 DAS + 25% N and K at 60 DAS + 25% N and K at 75 DAS, N_3 - 50 % N and K as basal + 12.5% N and K at 45 DAS + 12.5% N and K at 60 DAS+ 12.5% N and K at 75DAS + 12.5% N and K at 90 DAS, N_4 - 0 % N and 50% K in basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS. The experimental results revealed that CGR, RGR and NAR were higher with the treatment combination of scheduling of irrigation at 0.8 IW/CPE ratio with RCH 659 BG II compared to other levels and non – Btgenotypes. Four splits of nitrogen application upto 90 days skipping basal registered maximum values of CGR, RGR and NAR during 90-120 days which coincide with boll development and maturity stages. Among the interactions, irrigation at 0.8 IW/CPE ratio along with four splits of N skipping basal and two splits of K during basal and 45 DAS recorded significantly higher values.

Keywords: Irrigation, split application, nitrogen, potassium, cotton, growth analysis.

INTRODUCTION

Cotton, king of fiber or white gold is an important commercial fiber crop which contributes 75 per cent of raw material for textile industry. India is one among the major cotton producers of world having the largest area (11.7 m.ha) under cotton (Roopashree *et al.,* 2020). Cultivation of *Bt* cotton (*Bacillus thuringiensis*) is becoming popular within two decades and nearly 95 per cent of total cultivable area under cotton is converted to *Bt* cotton. *Bt* cotton has got remarkable momentum among farmers due to its better growth, production and productivity over non- *Bt* counterpart. Optimum irrigation scheduling along with split application of chemical fertilizers has positive role I influencing the CGR, RGR and NAR of cotton at different stages. Water stress affects the vegetative growth as well as the main metabolic activities such as photosynthetic activity, net assimilation as a result of reduced leaf area and dry matter production ultimately declining yield (Fahad *et al.*, 2017). Nitrogen plays a prominent role in

governing the growth processes due to its integral part of chlorophyll molecule, as well as constituent of enzymes, protein synthesis and production of nucleicacids (Marschner, 1986). The N demand of cotton is high for the entire growth period and is well documented in earlier research findings. N supplement at proper time and quantity determines the growth of cotton, hence, split application at critical periods is ideal for enhancing higher assimilation of photosynthates owing to enhanced crop growth rate and leaf area as reported by Hallikeri *et al.* (2010). Potassium being one among the essential macronutrients is involved in various physiological as well as biochemical processes in plants affecting the growth of plants and its development. It governs osmotic adjustment, regulation of stomata, activation of enzymes, charge balance maintenance in the membranes of cell and resistance to abiotic as well as biotic stress in plants. Application of nitrogen and potassium as split doses during different growth stages of crop was found to increase the CGR, RGR and NAR leading to higher dry matter production as a result of increased production of photosynthetic assimilates during boll formation, development and maturity stages. The objective of the present investigation was to analyze the effect of different moisture regimes and split application of nitrogen and potassium on crop growth rate, relative growth rate and net assimilation rate of *Bt* and non-*Bt* genotypes.

MATERIALS AND METHODS

A field experiment was conducted at the Central Farm of Agricultural College and Research Institute, Madurai during summer 2021 for assessing the effect of irrigation regimes and split application of N and K on Crop Growth Rate (CGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) of cotton. The experiment was laid out in split plot design and replicated thrice. The main plot comprised of two different irrigation regimes based on IW/CPE ratio (0.8 and 0.4) and two genotypes (RCH 659 hybrid and its conventional RCH 659 BG II). The sub plot consisted of N and K split application upto 90 days in various proportions *viz.*,N_1 - 50 % N and K as basal + 25% N and K at 45 DAS + 25% N and K at 60 DAS, N_2 - 25% N and K as basal+ 25% N and K at 45 DAS + 25% N and K at 60 DAS + 25% N and K at 75 DAS, N_3 - 50 % N and K as basal + 12.5% N and K at 45 DAS + 12.5% N and K at 60 DAS+ 12.5% N and K at 75DAS + 12.5% N and K at 90 DAS, N_4 - 0 % N and 50% K in basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS. The crop was sown with 90 × 60 cm spacing during second week of February, 2021. The recommended dose of N and K were applied as per treatment schedule *viz.*, 120: 60: 60 kg NPK ha^{-1}, whereas, the entire dose of phosphorus was applied basally. The CGR, RGR and NAR were calculated using the formula as given below;

Crop growth rate (CGR) (gm^{-2} day^{-1}) Watson (1947).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1 P}$$

Where, W_1 and W_2 -Plant whole dry weight at times t_1 and t_2

t_1 and t_2 – Time interval in days

P -land area occupied by the plant

Relative growth rate (RGR) (mg g^{-1} day^{-1}) Williams (1946)

$$RGR = \frac{\log e\, W_2 - \log e\, W_1}{t_2 - t_1}$$

Where,

W_1 and W_2– Plant whole dry weight at times t_1 and t_2

t_1 and t_2 – Time interval in days

Net assimilation rate (NAR) (mg cm^2 day^{-1}) Williams (1946)

$$NAR = \frac{(W_2 - W_1) \times \ln L_2 - \ln L_1)}{(t_2 - t_1) \times (L_2 - L_1)}$$

Where,

L_1 and W_1- Leaf area and whole plant dry weight at t_1,

L_2 and W_2 are leaf area and whole plant dry weight at t_2

t_1 and t_2 – Time interval in days

RESULTS AND DISCUSSION

Crop Growth Rate (g m^{-1} day^{-1}) of cotton. Irrigation scheduling based on 0.8 IW/CPE ratio with *Bt* cotton RCH 659 BG II recorded maximum values of CGR (1.98, 5.77 and 4.89 g m^{-1} day^{-1}), while, the minimum values were recorded with non-Bt cotton genotype irrigated at 0.4 IW/CPE ratio (1.36, 3.19 and 3.82g m^{-1} day^{-1}) at 30-60, 60-90 and 90-120 days after sowing respectively. The significant increase in CGR at 0.8 IW/CPE ratio could be due to the availability of sufficient moisture in plants which governs stomatal closure, electron transport, photo-inhibition in favour of increased assimilation of CO_2, enhanced rate of net photosynthesis, electron transfer, production of photosynthetic pigments which inturn increases the leaf area and drymatter production (Abarna and Srinivasan 2019). In addition, better performance of *Bt* cotton over non – Bt may be due to the genetic trait which is in conformity with the findings of Jana (2005). Higher CGR was observed (4.74g m^{-1} day^{-1}) at 90-120 days with skipping basal application of N and 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS(N_4) and lower (3.95 g m^{-1} day^{-1}) with application of 50 % N and K as basal + 25% N and K at 45 DAS + 25% N and K at 60 DAS(N_1). Applying N and K in splits till 90 days after sowing enhanced the availability of nutrients for better crop canopy development, leaf area, higher assimilation of photosynthates thereby resulting in production of higher plant dry mass contributing to higher crop growth rate at boll setting, developing and maturity stages. The results are in conformity with the

findings of Abarna and Srinivasan (2019) in cotton. Interaction effect was found to be statistically significant. The treatment, Bt cotton irrigated at 0.8 IW/CPE ratio along with skipping basal application of N and 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS documented higher values (2.27 and 8.36g m^{-1} day^{-1}), while, Non Bt cotton irrigated based on 0.4 IW/CPE ratio during 30-60 and 60-90 DAS ($I_2V_2N_4$) recorded lower values (1.02 and 2.21 g m^{-1} day^{-1}). Bt cotton irrigated at 0.8 IW/CPE ratio with split application of 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS skipping basal N($I_1V_1N_4$) recorded significantly higher value (5.76g $m^{-1}day^{-1}$) and non – Bt cotton irrigated at 0.4 IW/CPE ratio with application of 50 % N and K as basal + 25% N and K at 45 DAS + 25% N and K at 60 DAS($I_2V_2N_1$) recorded lower CGR (3.26g g^{-1} day^{-1}) at 90-120 days after sowing.

Relative growth rate (g g^{-1} day^{-1}). Higher values for relative growth rate (0.0554, 0.0211 and 0.0170g g^{-1} day^{-1}) were recorded when irrigation was given at 0.8 IW/CPE ratio for *Bt* cotton RCH 659 BG II compared to non- *Bt* hybrid cotton RCH 659 irrigated at 0.4 IW/CPE ratio which registered lower values (0.0390, 0.0190 and 0.0136g g^{-1} day^{-1}) at 30-60, 60-90 and 90-120 DAS respectively. The increment in RGR could be due to the supply of adequate amount of irrigation which increased soil moisture content that led to higher leaf area production, besides enhancing photo-assimilation and higher dry biomass accumulation. Earlier findings of Abarna and Srinivasan (2019) are in line with the present results. Superiority of Bt cotton over non-Bt in relation to growth parameter could be due to the genetic factor. Similar results were reported by Gangaiah *et al.* (2013). Higher values for RGR were obtained at 30-60, 60-90 days in 50 % N and K as basal + 25% N and K at 45 DAS + 25% N and K at 60 DAS (N_1). The least was noticed with–Skipping basal application of N and 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS (N_4). Maximum values of NAR (0.0168 g g^{-1} day^{-1}) at 90-120 days was observed with (N_4) and minimum value (0.0139 g g^{-1} day^{-1})with application of 50 % N and K as basal + 25% N and K at 45 DAS + 25% N and K at 60 DAS(N_1) during 90-120 days after sowing. The maximum RGR found in 90-120 DAS in cotton would be due to the split supplement of N upto 90 days facilitating better nutrient availability and uptake consequently increasing the biomass production as a result of better photo-assimilation. The results are in accordance with Ali and Hameed (2011). Among the interactions, Bt cotton when irrigated with 0.8 IW/CPE and application of 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75 DAS + 25% N at 90 DAS skipping basal N($I_1V_1N_1$) recorded higher values (0.0679 and 0.0244g g^{-1} day^{-1}) and lower values (0.0327 and 0.0193 g g^{-1} day^{-1}) with Non-*Bt* cotton irrigated at 0.4 IW/CPE ratio with split application of 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N skipping basal during 30-60 and 60-90 DAS ($I_2V_2N_4$). At 90-120 days, $I_1V_1N_4$, Bt cotton irrigated at 0.8 IW/CPE ratio with split application of 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS skipping basal N registered significantly maximum value (0.0199g$g^{-1}day^{-1}$) and lower value (0.0127g g^{-1} day^{-1}) with the treatment, non – Bt cotton irrigated at 0.4 IW/CPE ratio with application of 50 % N and K as basal + 25% N and K at 45 DAS + 25% N and K at 60 DAS ($I_2V_2N_1$).

Net Assimilation Rate (mg cm^{-1} day^{-1}). Bt cotton when irrigated at 0.8 IW/CPE ratio recorded significantly higher values (0.6157, 0.2511 and 0.2267 mg cm^{-1} day^{-1}) of NAR among the treatments. Lower values (0.4576, 0.1763 and 0.1700mg cm^{-1} day^{-1}) of NAR were documented by non- Bt, RCH 659 hybrid irrigated at 0.4 IW/CPE ratio during 30-60, 60-90 and 90-120 DAS respectively. Bt registering higher values could be ascribed to the account of the genetic potential in exploiting the resources for their better growth and development compared to non- Bt. The results were in conformity with the research findings of Shukla *et al.* (2013). NAR was maximum (0.5936 and 0.2404 g g^{-1} day^{-1}) during 30-60, 60-90 days with 50 % N and K as basal + 25% N and K at 45 DAS + 25% N and K at 60 DAS. The minimum values (0.4891 and 0.1927 g g^{-1} day^{-1}) were noticed with skipping basal application of N and application of 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS. However, maximum values for NAR (0.2205g g^{-1} day^{-1}) at 90-120 days after sowing with (N_4) and minimum value (0.01790 g g^{-1} day^{-1}) with N_1 were observed. Increased rate of net assimilation found at 90-120 days might be due to the enhanced photosynthetic capacity by leaves with increased leaf area which resulted in enhanced availability and uptake of nutrients by split application of nutrients upto 90 DAS. Similar findings were reported by Ali and Hameed (2011). Among the interactions, *Bt* cotton when irrigated with 0.8 IW/CPE skipping basal application of N and application of 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75, DAS + 25% N at 90 DAS($I_1V_1N_1$) recorded higher values (0.7026g g^{-1} day^{-1} and 0.2939 g g^{-1} day^{-1}) and the lower values (0.4243 and 0.1962 g g^{-1} day^{-1}) with Non Bt cotton irrigated at 0.4 IW/CPE ratio during 30-60 and 60-90 DAS ($I_2V_2N_4$). At 90-120 days, $I_1V_1N_4$ registered significantly higher NAR (0.2601g $g^{-1}day^{-1}$), while lower value (0.1493 g g^{-1} day^{-1}) was recorded with the treatment, $I_2V_2N_1$.

Table 1: Irrigation regimes and split application of N and K on crop growth rate (g m^{-1} day^{-1}) of cotton.

Treatments	30 - 60 DAS					60 - 90 DAS				
	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean
N_1	2.27	1.90	1.54	1.63	1.84	8.36	6.22	4.46	3.79	5.71
N_2	2.00	1.89	1.49	1.40	1.70	5.79	5.50	4.25	3.91	4.86
N_3	1.80	1.76	1.40	1.39	1.59	4.57	4.26	3.49	2.38	3.68
N_4	1.70	1.57	1.27	1.02	1.39	4.37	4.04	2.67	2.21	3.32
Mean	1.94	1.78	1.43	1.36		5.77	5.00	3.71	3.07	
	IV	N	I at N	N at I			IV	N	I at N	N at I
S.Ed.	0.03	0.02	0.06	0.06		S.Ed.	0.14	0.08	0.23	0.23
C.D (0.05)	0.08	0.05	0.11	0.11		C.D (0.05)	0.32	0.20	0.43	0.43

Treatments	90 -120 DAS				
	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean
N_1	3.40	4.83	4.31	3.26	3.95
N_2	5.36	3.55	4.08	4.07	4.27
N_3	5.03	4.34	4.57	3.97	4.48
N_4	5.76	5.39	3.83	3.98	4.74
Mean	4.89	4.53	4.20	3.82	
	IV	N	I at N	N at I	
S.Ed.	0.14	0.07	0.21	0.21	
C.D (0.05)	0.33	0.17	0.38	0.38	

Table 2: Irrigation regimes and split application of N and K on relative growth rate (g g^{-1} day^{-1}).

Treatments	30-60					60-90				
	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean
N_1	0.0679	0.0631	0.0443	0.0432	0.0546	0.0244	0.0227	0.0190	0.0190	0.0213
N_2	0.0583	0.0535	0.0421	0.0410	0.0487	0.0211	0.0204	0.0198	0.0198	0.0203
N_3	0.0487	0.0476	0.0399	0.0388	0.0438	0.0195	0.0200	0.0198	0.0199	0.0198
N_4	0.0465	0.0454	0.0377	0.0329	0.0406	0.0195	0.0198	0.0197	0.0173	0.0191
Mean	0.0554	0.0524	0.0410	0.0390		0.0211	0.0207	0.0196	0.0190	
	IV	N	I at N	N at I			IV	N	I at N	N at I
S.Ed.	0.0015	0.0008	0.0024	0.0024		S.Ed.	0.0004	0.0003	0.0009	0.0012
C.D (0.05)	0.0036	0.0020	0.0044	0.0044		C.D (0.05)	0.0009	0.0016	0.0017	0.0023

Treatments	90-120				
	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean
N_1	0.0147	0.0145	0.0135	0.0127	0.0139
N_2	0.0155	0.0151	0.0137	0.0138	0.0145
N_3	0.0177	0.0166	0.0140	0.0139	0.0156
N_4	0.0199	0.0188	0.0143	0.0141	0.0168
Mean	0.0170	0.0163	0.0139	0.0136	
	IV	N	I at N	N at I	
S.Ed.	0.0003	0.0003	0.0006	0.0006	
C.D (0.05)	0.0006	0.0005	0.0012	0.0012	

Table 3: Irrigation regimes and split application of N and K on net assimilation rate (mg cm^{-1} day^{-1}).

Treatments	30-60					60-90				
	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean
N_1	0.7026	0.6662	0.5179	0.4875	0.5936	0.2939	0.2768	0.2029	0.1883	0.2404
N_2	0.6314	0.5946	0.5023	0.4718	0.5500	0.2590	0.2421	0.1981	0.1839	0.2208
N_3	0.5795	0.5614	0.4876	0.4529	0.5203	0.2334	0.2269	0.1924	0.1786	0.2078
N_4	0.5493	0.5333	0.4556	0.4182	0.4891	0.2183	0.2113	0.1865	0.1546	0.1927
Mean	0.6157	0.5889	0.4908	0.4576		0.2511	0.2393	0.1950	0.1763	
	IV	N	I at N	N at I			IV	N	I at N	N at I
S.Ed.	0.0042	0.0060	0.0169	0.0169		S.Ed.	0.0037	0.0039	0.0109	0.0109
C.D (0.05)	0.0100	0.0141	0.0310	0.0310		C.D(0.05)	0.0086	0.0091	0.0200	0.0200

Treatments	90-120				
	I_1V_1	I_1V_2	I_2V_1	I_2V_2	Mean
N_1	0.2025	0.1979	0.1660	0.1493	0.1790
N_2	0.2118	0.2072	0.1809	0.1713	0.1928
N_3	0.2324	0.2186	0.1870	0.1769	0.2037
N_4	0.2601	0.2463	0.1930	0.1825	0.2205
Mean	0.2267	0.2175	0.1817	0.1700	
	IV	N	I at N	N at I	
S.Ed.	0.0037	0.0026	0.0073	0.0073	
C.D (0.05)	0.0086	0.0061	0.0133	0.0133	

CONCLUSION

The crop growth rate, relative growth rate and net assimilation rate were higher when *Bt* RCH 659 BG II was irrigated at 0.8 IW/CPE ratio along with application of 50% K as basal + 25% N and 50% K at 45 DAS + 25% N at 60 DAS + 25% N at 75DAS + 25% N at 90 DAS skipping basal N application of nitrogen in cotton.

FUTURE SCOPE

Conduction of field experiments with drip irrigation based split application of nutrient for enhancing assimilation efficiency and yield of cotton.

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How to cite this article: R. Ariraman, ChelviRamessh, A. Gurusamy, P. Saravana Pandian and T. Sivakumar (2022). Irrigation Regimes and Split Application of N and K on Crop Growth Rate, Relative Growth Rate and Net Assimilation rate of *Bt* and *Non-Bt* Cotton Genotypes. *Biological Forum – An International Journal*, *14*(2a): 311-315.