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Impact of Fertigation Scheduling on Physiological and Root Attributes of Cotton under High Density Planting System

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ABSTRACT: Field experiments were carried out at Eastern Block Farm, Centre for Water and Geospatial Studies, Tamil Nadu Agricultural University, Coimbatore during the winter and summer seasons (2022 - 2023) to evolve the optimum fertigation scheduling in high density cotton through Crop Growth Curve Nutrition Approach (CGCNA). The experiments were laid out in RBD and replicated thrice. The treatments comprises of different combination of NPK fertilizers levels (75% RDF, 100% RDF, 125% RDF) that are being supplied through fertigation in a definite ratio at the peak growth stages *viz*., seedling stage (10 % NPK), vegetative stage (20 % NPK), square formation (30 % NPK), 50 % flowering (20 %NPK), boll formation and boll development stages ((10% NPK) and its comparative study with drip and conventional irrigation practice with STCR based recommendations of fertilizer NPK and 100 % RDF NPK as soil application in the same split ratios (i.e., seedling stage (10 % NPK), vegetative stage (20 % NPK), square formation (30 % NPK), 50 % flowering (20 % NPK), boll formation and boll development stages (10% NPK)) to cotton planted under HDPS. The physiological attributes like leaf area index, crop growth rate and root attributes like root length, root dry weight and root volume were significantly influenced by the combination of different levels of fertilizer NPK, which were scheduled at the peak growth stages. Among the treatments the maximum leaf area index, crop growth rate and significantly highest values of root length, root dry weight and root volume were recorded with the fertigation of 125 % K with 100 % of N & P during both the seasons of study.

Keywords: Drip fertigation, STCR, HDPS, conventional irrigation, RDF, NPK.

INTRODUCTION

Cotton (*Gossypium* sp.) is the king of the fiber crop and popularly known as white gold. It is also the major cash crop, grown worldwide plays a significant role in the agricultural and industrial economy. It is cultivated in the tropical as well as sub-tropical regions of more than seventy countries of the World. India ranks first in the world with 130.49 lakh hectares area under cotton cultivation and the total estimated cotton production and productivity is around 329.96 lakh bales and 337.23 kgha^{-1}. Among the cotton producing states, Maharashtra is the largest producer with an area of 42.29 lakh ha followed by Gujarat (25.49 lakh ha) and Telangana (20.24 lakh ha) (Ministry of textile, 2023). However, in India, despite having a larger area under cotton cultivation, the productivity is very low. Under this, circumstances, the high density planting system (HDPS) have a great relevance in the present scenario of cotton cultivation. HDPS is now being considered as an alternate production system having a greater potential for improving productivity and profitability by reducing the input cost and minimising the risks associated with cotton production system (Kumar *et al.*, 2017). The Central Institute of Cotton Research, Nagpur initiated research trials on High Density Planting System (HDPS) in cotton with early maturing, semi compact genotypes for realizing higher yields mainly under rainfed conditions with low production costs. This resulted in evolving a genotype suiting to high density planting (more than one lakh plants per hectare) having uniformity in boll development, maturation and bursting, also more adoptable to the given climatic condition with better nutrient ultilization. Variety CSH 3075 was the first cotton variety released for HDPS in India. Subsequently, research got momentum and Tamil Nadu Agricultural University (TNAU) has also released two varieties *i.e.*, TCH 1705 as CO 15 and TCH 1819 as CO17 for HDPS. This variety CO17 (TCH 1819 culture) was developed

during the year 2020 through hybridization involving Khandwa 2 and LH 2220 followed by pedigree breeding. This culture was also evaluated in All India Coordinated Cotton Improvement Project trials for two years during 2016-17 and 2017-18 across ten locations. Gunasekaran *et al*. (2020) reported that the culture TCH 1819 has been performing well under rice fallow conditions of Cavery delta zone of Tamil Nadu, where seed cotton yield of 2051 kg ha^{-1} which was 13.8 % increase in yield compared to the Suraj under summer irrigated conditions and also recorded 1604 kg ha^{-1} of seed cotton yield under winter rainfed and was 20.1% increase in yield over the check Suraj.

Water and fertilizers were the key limiting factors affecting the agricultural production. Efficient utilization of water and nutrient resources, is also a major concern as far as the cotton production is considered. In fact the cotton cultivation over the globe is confined to water constrained environments and necessitates for rational use of available water resources for achieving sustainability in productivity. Fertigation is a hi-tech technology in modern irrigation where we can maintain a balanced nutrient supply and optimum moisture levels according to the specific needs of the crop in a particular soil type, this will improves the nutrient use efficiency and enhances the crop productivity. However, this requires standardization of nutrient doses and fertigation schedules (Pawar *et al.*, 2013). The proper scheduling of fertilizers in accordance with the peak growing stages of crop is vital because at these stages the maximum demand and uptake of nutrient occurs, which is essential for the plant growth and development. The hitech irrigation technique like drip fertigation technique helps in overcoming the production limits imposed by poor water and fertilizer management. Drip fertigation helps in achieving 90 percent nutrient use efficiency, with a leaching losses as low as 10 percent compared to the conventional irrigation practice, where the nutrient use efficiency is around 50 percent (Prakash *et al.*, 2019). Drip fertigation in cotton farming has improved the resource use efficiency by savings of 20-30 per cent fertilizer costs (Chen *et al.*, 2010). Besides this, drip fertigation can induce drought tolerance and will improve the seed cotton yield. This research study has been carried out to optimise drip fertigation technique in HDPS for increasing the productivity of cotton.

MATERIALS AND METHODS

The field experiments were conducted at Eastern Block Farm, CWGS, TNAU, Coimbatore during winter and summer seasons (2022-2023) to study the impact of fertigation scheduling in high density cotton through crop growth curve nutrition approach. The area is geographically located in Western Agro-Climatic Zone of Tamil Nadu with the coordinates of 11° N latitude, 77° E longitude and an altitude of 426.7 m above mean sea level. The soil characteristics of the experimental site is clay loam in texture, slightly alkaline pH (8.34 & 8.12) with low soluble salts (EC = 0.63 & 0.76) and with low in available nitrogen (212 & 207 kg/ha), medium in available phosphorus (15 & 17kg/ha) and high in available potassium (395 & 386 kg/ha) during 2022-2023. A total rainfall of 348.0 mm and 287.5mm and mean solar radiation 324.5 cal/cm^2/day and 347.7 cal/cm^2/day were received during the winter and summer cropping periods (Sept 2022 – July 2023). The mean maximum and minimum temperature recorded during winter season were 30.5°C and 21.0°C and summer season were 33.7°C and 23.3°C, respectively. The experimental trial was laid out in Randomized Block Design with three replications. The variety chosen for the study is CO17 zero monopodial variety of cotton. The recommended cultural practices were carried out. The treatments comprises of different levels of RDF NPK (75%, 100% and 125%) that are being supplied through fertigation in a definite ratio at the peak growing stages *viz*., seedling stage (10% NPK), vegetative stage (20% NPK), square formation (30% RDF NPK), 50 % flowering (20% NPK), boll formation and boll development stages ((10% NPK) (T_1: DF with 75 % RDF NPK , T_2: DF with 100 % RDF NPK, T_3: DF with 125 % RDF NPK, T_4: DF with 75 % N + 100 % P & K of RDF, T_5: DF with 125 % N + 100 % P & K of RDF, T_6: DF with 75 % P + 100 % N & K of RDF, T_7: DF with 125 % P + 100 % N & K of RDF, T_8: DF with 75 % K + 100 % N & P of RDF, T_9: DF with 125 % K + 100 % N & P) and these combinations were compared with the drip and conventional furrow irrigation practice with STCR based recommendations of fertilizer NPK and 100 % RDF NPK as soil application in the same split ratios (i.e., seedling stage (10 % NPK), vegetative stage (20 % NPK), square formation (30 % NPK), 50 % flowering (20 % NPK), boll formation and boll development stages (10% NPK) to cotton planted under HDPS (T_{10}: DI with soil application of STCR based NPK, T_{11}: DI with soil application of 100 % RDF NPK, T_{12}: CI with soil application of STCR based NPK, T_{13}: CI with soil application of 100 % RDF NPK).

RESULT AND DISCUSSION

The fertigation scheduled with different combination of RDF NPK in split ratios at the peak growth stages significantly influenced the physiological and root attributes of cotton under HDPS. The biometric observations such as leaf area index recorded at 30 DAS, 60 DAS, 90 DAS, 120 DAS and at harvest and the crop growth rate recorded at critical growth intervals (30-60 DAS, 60-90 DAS, 90-120 DAS, 120 DAS - At harvest) and root length, root dry weight and root volume that has been recorded at harvest stage and the valid findings were discussed here under:

A. Physiological attributes

(i) Leaf Area Index (LAI). Leaf area index is defined as the projected area of leaves over unit land area, which characterizes plant canopies. Maximum LAI (0.98, 2.95, 5.86, 5.94 and 2.83) during winter season and summer season (0.97, 2.87, 5.25, 5.48 and 2.62) were recorded at 30 DAS, 60 DAS, 90 DAS and 120 DAS and at harvest respectively with the fertigation of

125 % K along with 100% of N and P (T_9) when compared to other treatments (Table 1). The leaf area index recorded maximum in plants which were grown under HDPS system when compared to plant grown under wider spacing, this is might be due to the better light interception have resulted in more phyotosynthates assimilation and increased the leaf area development. These results were in agreement with the findings of Parihar *et al*. (2018); Kumar *et al.* (2020). In addition to this, under HDPS, plant to plant spacing is very narrow due to this less availability of horizontal space for individual plant, plants have attributed more towards attainment of vertical growth, and produced more number of leaves which resulted in higher leaf area index. These results are in conformity with the findings of Sisodia and Khamparia (2007).

Table 1: Impact of fertigation scheduling on LAI of cotton under high density planting system.

Treatments	Winter cotton (2022)					Summer cotton (2023)				
	30DAS	60DAS	90DAS	120DAS	At harvest	30DAS	60 DAS	90 DAS	120 DAS	At harvest
T_1	0.62	1.81	3.50	3.73	1.48	0.58	1.77	3.55	3.75	1.35
T_2	0.84	2.47	4.75	4.93	2.20	0.75	2.26	4.67	4.86	2.14
T_3	0.95	2.74	5.52	5.64	2.77	0.95	2.73	5.19	5.32	2.55
T_4	0.67	2.15	3.75	3.97	1.53	0.62	1.95	3.86	4.01	1.43
T_5	0.86	2.53	4.98	5.06	2.35	0.80	2.32	4.88	5.03	2.27
T_6	0.79	2.35	4.43	4.64	2.18	0.73	2.19	4.24	4.47	2.04
T_7	0.88	2.62	5.25	5.38	2.54	0.84	2.58	5.01	5.27	2.48
T_8	0.75	2.28	4.10	4.22	1.74	0.68	2.05	4.05	4.29	1.65
T_9	0.98	2.95	5.86	5.94	2.83	0.97	2.87	5.25	5.48	2.62
T_{10}	0.59	1.78	3.47	3.62	1.45	0.56	1.64	3.23	3.45	1.32
T_{11}	0.56	1.69	2.98	3.07	1.36	0.49	1.53	2.85	3.09	1.28
T_{12}	0.51	1.52	2.79	2.88	1.25	0.45	1.48	2.53	2.64	1.16
T_{13}	0.48	1.45	2.56	2.75	1.16	0.41	1.36	2.40	2.43	1.07
SEd	**0.02**	**0.07**	**0.12**	**0.13**	**0.06**	**0.02**	**0.07**	**0.12**	**0.10**	**0.09**
CD (P=0.05)	**0.04**	**0.15**	**0.22**	**0.27**	**0.13**	**0.05**	**0.14**	**0.24**	**0.21**	**0.18**

(ii) Crop growth rate (CGR). In general, the lowest crop growth rate is recorded at 30-60 DAS and the maximum crop growth rate is attained at 90-120 DAS and declined thereafter. The crop growth rate of cotton were significantly influenced by the fertigation scheduling under HDPS at the critical growth stages. The CGR recorded significantly higher values (5.05, 9.87, 15.52 and 0.97 $g^{-1}m^{-2}day^{-1}$) during winter and summer seasons (4.83, 8.75, 15.35 and 0.89 $g^{-1}m^{-2}day^{-1}$) at 30-60 DAS, 60-90 DAS, 90-120 DAS and 120DAS-at harvest, respectively with the fertigation of 125 % of K along with 100% of recommended dose of N and P (T_9) and the lower CGR values (Table 2) were recorded where the direct soil application of STCR based recommendations (T_{12}) and 100 % RDF NPK (T_{13}) under conventional irrigation was practiced during both the seasons of successive years. The improvement in crop growth rate under HDPS might be due to better interception of solar radiation which have improved the photosynthesis and resulted in effective translocation of assimilates from source to sink and which ultimately increased the dry matter accumulation. This is in concordance with the findings of Bhalerao *et al.* (2010); Anbarasi and Rajendran (2017).

Table 2: Impact of fertigation scheduling on CGR (g m^{-2} day^{-1}) of cotton under high density planting system.

Treatments	Winter cotton (2022)				Summer cotton (2023)			
	30-60 DAS	60 -90 DAS	90-120 DAS	120-Harvest	30-60 DAS	60 -90 DAS	90-120 DAS	120-Harvest
T_1	3.54	6.34	11.91	0.48	3.45	4.25	10.93	0.38
T_2	4.35	8.01	13.26	0.77	4.15	7.56	12.10	0.59
T_3	4.76	9.53	14.40	0.92	4.46	8.42	13.23	0.84
T_4	3.72	6.48	12.22	0.56	3.57	5.41	11.10	0.45
T_5	4.46	8.29	13.55	0.81	4.26	8.13	12.58	0.74
T_6	4.28	7.25	12.93	0.72	3.87	7.19	11.45	0.53
T_7	4.59	8.42	14.06	0.85	4.32	8.28	12.76	0.77
T_8	4.12	7.08	12.54	0.64	3.66	6.32	11.23	0.48
T_9	5.05	9.87	15.52	0.97	4.83	8.75	15.35	0.89
T_{10}	3.33	5.44	11.56	0.39	3.32	3.54	10.65	0.33
T_{11}	3.15	5.23	11.32	0.35	2.87	3.37	10.33	0.27
T_{12}	2.98	4.86	10.21	0.26	2.54	3.28	9.87	0.25
T_{13}	2.54	4.44	10.18	0.24	2.21	3.10	9.15	0.21
SEd	**0.14**	**0.28**	**0.48**	**0.03**	**0.14**	**0.28**	**0.50**	**0.02**
CD (P=0.05)	**0.28**	**0.57**	**1.00**	**0.06**	**0.28**	**0.58**	**1.03**	**0.05**

(iii) Root attributes. The fertigation with the water soluble fertilizers (Urea, MAP and MOP)which scheduled at critical growth stages in definite ratios seedling (10% NPK), vegetative (20% NPK), squaring (30% NPK), 50% flowering (20% NPK), boll formation and development stages (10% NPK) have significantly influence the root attributes of cotton during both the years of study. The highest root length, root dry weight and root volume were recorded with the fertigation of 125 % K along with 100 % of N and P (39.9cm, 25.4g, 89.2cc and 38.4cm, 23.3g, 86.5cc) during both winter and summer seasons respectively. The lowest values of root attributes were recorded under the direct soil application of fertilizers where conventional irrigation was practiced (Table 3). The increased root growth and root biomass accumulation might be due to the fact that the timely availability of nutrients directly to the root zone area in right proportions at the peak growth stages helped the crops in effective nutrients assimilation, improved the nutrient use efficiency and thereby reduced the chances of leaching and volatilization losses. Similar findings were reported by Tindall *et al*. (2008) and Kosterna (2014).

Table 3: Impact of fertigation scheduling on root length (cm), root dry weight (g) and root volume (cc) of cotton under high density planting system.

Treatments	Winter cotton (2022)			Summer cotton (2023)		
	Root length (cm)	Root dry weight (g)	Root Volume (cc)	Root length (cm)	Root dry weight (g)	Root Volume (cc)
T_1	29.5	16.5	66.5	28.9	14.3	64.4
T_2	34.1	21.5	78.8	34.5	19.5	75.9
T_3	39.3	24.6	88.8	36.9	22.6	85.0
T_4	30.6	17.3	70.2	29.1	15.5	68.9
T_5	35.4	22.7	82.4	34.3	20.6	80.7
T_6	33.6	20.6	75.6	31.4	18.9	73.1
T_7	36.7	23.7	84.3	35.6	21.5	82.4
T_8	32.3	19.5	72.5	30.5	16.3	70.3
T_9	39.9	25.4	89.2	38.4	23.3	86.5
T_{10}	28.8	15.6	65.7	27.5	13.2	61.3
T_{11}	27.5	14.8	63.6	26.9	12.8	58.5
T_{12}	25.6	13.4	60.3	23.4	11.6	55.6
T_{13}	23.4	12.9	58.6	21.3	10.5	50.4
SEd	**1.0**	**0.8**	**2.7**	**1.1**	**0.6**	**3.0**
CD (p=0.05)	**2.2**	**1.7**	**5.6**	**2.3**	**1.2**	**6.3**

CONCLUSIONS

The results of the experiment revealed that the application of enhanced dose of fertilizers and fertigation scheduling at the peak growth stages in split ratios had a significant influence over the physiological and root attributes of cotton under HDPS during both winter and summer seasons of 2022-2023. Based on the research outcome, the fertigation of 125 % K with 100 % N and P (T_9) though drip fertigation at the peak growth stages in splits ratios recorded maximum leaf area index (0.98, 2.95, 5.86, 5.94 , 2.83 and 0.97, 2.87, 5.25, 5.48, 2.62), crop growth rate (5.05, 9.87, 15.52, 0.97 $g^{-1}m^{-2}$ day^{-1} and 0.97, 4.83, 8.75, 15.35, 0.89 $g^{-1}m^{-2}$ day^{-1}) and root attributes (39.9cm, 25.4g, 89.2cc and 38.4cm, 23.3g, 86.5cc) and the direct soil application of STCR based recommendation of fertilizers (T_{12}) and 100 % RDF NPK (T_{13}) were the where the conventional irrigation was practiced was found to be inferior as compared to the fertigation treatments during both the seasons of study.

FUTURE SCOPE

The adoption of high tech drip fertigation technique in high density planted compact cotton genotypes is a viable option to break the current trend of stagnating yield under upland cotton growing areas. This is due to the fact that the fertigation scheduling at the critical growth stages with right proportions of nutrients helps in realizing higher yield with better resource use efficiency thereby reduces the cost involved in production and improves the profit margin.

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Conflict of Interest. None.

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