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Effect of nutrient management practices on seed cotton yield (*Gossypium hirsutum* L.) and physiological disorders

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Abstract
On vertisol at Agricultural College Farm, Raichur during 2010-11, field experiment was laid out with fertilizer levels in main-plots and foliar applications of nutrients in sub-plots with three replications in split-plot design. Effect of nutrient management practices differed significantly on physiological disorders and seed cotton yield. Fertilizer levels of 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} with 12.5 t ha^{-1} of farm yard manure recorded significantly higher seed cotton yield (17.06 q ha^{-1}) with higher reproductive structures and reduced physiological disorders over other fertilizer levels. Besides, foliar applications of 0.5 % tracel (Zn, Fe, Mn and B) recorded significantly higher seed cotton yield (17.52 q ha^{-1}) with higher reproductive structures and reduced physiological disorders against control. In addition, interaction effect due to fertilizer levels of 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} with 12.5 t ha^{-1} of farm yard manure and foliar applications of 0.5 % tracel recorded significantly higher seed cotton yield (19.88 q ha^{-1}) with higher reproductive structures and reduced physiological disorders, besides it was on par with fertilizer levels of 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} with 12.5 t ha^{-1} of farm yard manure and foliar applications of 10 ppm planofix when compared to rest of the other treatment combinations.

Keywords: Fertilizer levels, foliar applications and seed cotton yield

Introduction
meet export and domestic demands, cotton production and productivity has to be increased considerably, besides, factors responsible for low productivity are losses due to pests (cotton bollworms), imbalanced use of fertilizers, deficiency of micronutrients and physiological disorders (shedding of floral parts like squares, flowers and bolls). Cotton being a heavy feeder and medium to long duration, needs proper supply of plant nutrients during various growth stages as a soil application, in addition to foliar scheduling for its successful cultivation. Inadequate and improper nutrient scheduling during peak nutrient requirement of cotton i.e. grand growth, flowering and boll development stages reduces square, flower and boll load on plant which ultimately reduces seed cotton yield. Fertilizer with different levels was studied to know the quantity of nutrients required for growth and development for higher seed cotton yield i.e. due to increased chlorophyll content, higher root to shoot ratio and increased fibre qualities with nitrogen, phosphorus and potassium, respectively. Further, scheduling of secondary nutrients, micronutrients and growth regulators during flowering and boll formation stage reduces square, flower and boll dropping which further increased reproductive structure and increased seed cotton yield. Hence the present was conducted to know the effect of nutrient management practices under supplemental irrigations.

Material and Methods
The experiment was laid out in split plot design with three fertilizer levels in main-plots (93.75:56.25:56.25 kg $N:P_2O_5:K_2O$ ha^{-1} with 7.5 t ha^{-1} of farm yard manure, 125:75:75 kg $N:P_2O_5:K_2O$ ha^{-1} with 10 t ha^{-1} of farm yard manure and 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} with 12.5 t ha^{-1} of farm yard manure). Whereas, six water soluble nutrients *i.e.*, control, 0.5 % mahazinc ($ZnSO_4$), 10 ppm planofix (NAA), 0.5 % nutriment ($FeSO_4$), 1 % mangala $MgSO_4$ ($MgSO_4$) and 0.5 % tracel (Zn, Fe, Mn and B) in sub-plots with three replications. Experimental soil was clayey textured with available nitrogen (218.0 kg ha^{-1}), phosphorus (35.0 kg ha^{-1}), potassium (345.0 kg ha^{-1}) and organic carbon (0.70 %). Experiment was conducted during *Kharif*, 2010-11 at Agricultural College Farm, Raichur situated in North

Eastern Dry Zone (Zone-2) of Karnataka. Fertilizer doses *i.e.*, half of the nitrogen dose, entire dose of phosphorus and potassium in the form of urea, diammonium phosphate and muriate of potash were applied as basal dose and remaining half of the nitrogen in the form of urea was top dressed in three equal splits at 50, 80 and 110 days after sowing in the ring formed 5 cm away from the plant. Whereas, foliar applications of nutrients was imposed at flowering (90 DAS) and boll formation stages (110 DAS). Crop was managed as per package of practices recommended for Zone 2. Fisher's method of analysis of variance was applied for analysis and interpretation of data as per by Panse and Sukhatme (1967) [3] and MSTATC.

Results and discussion

Effect of fertilizer levels on seed cotton yield and physiological disorders differed significantly (Table 1, 2 and 3). Fertilizer levels due to 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} with 12.5 t ha^{-1} of farm yard manure recorded significantly higher seed cotton yield (17.06 q ha^{-1}) over 93.75:56.25:56.25 kg $N:P_2O_5:K_2O$ ha^{-1} with 7.5 t ha^{-1} of farm yard manure (13.39 q ha^{-1}) and 125:75:75 kg $N:P_2O_5:K_2O$ ha^{-1} with 10 t ha^{-1} of farm yard manure (14.70 q ha^{-1}). Higher nutrient content in fertilizer doses increased chlorophyll content in plants, increased root volume and improved fibre growth and development. Increased seed cotton yield might be due to higher reproductive structures i.e. squares, flowers and seed cotton bolls. Number of bolls differed significantly with higher number of bolls recorded in 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} and 12.5 t ha^{-1} of farm yard manure, besides higher boll load during boll formation stages (16.18 $plant^{-1}$) when compared to flowering stages (14.53 $plant^{-1}$). Likewise, fertilizer levels did not differ significantly on number of squares and flowers. Similarly, fertilizer levels did not differ significantly on various physiological disorders i.e. dropping of flowers and bolls, except squares dropping at flowering stages with higher dropping (11.99 $plant^{-1}$) in 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} and 12.5 t ha^{-1} of farm yard manure, besides, on par with 93.75:56.25:56.25 kg $N:P_2O_5:K_2O$ ha^{-1} and 7.5 t ha^{-1} of farm yard manure. Similar results were also reported by Tayade and Dhoble (2010) [6] and Parminder Kaur *et al.* (2010) [4].

Effect due to foliar applications of nutrients on seed cotton yield and physiological disorders differed significantly (Table 1, 2 and 3). Foliar applications of 0.5 % tracel (Zn, Fe, Mn and B) recorded significantly higher seed cotton yield (17.52 q ha^{-1}) against control (12.53 q ha^{-1}) and other treatments. Foliar scheduling of micronutrients at flowering and boll formation stages increased yield attributes which reflected in higher seed cotton yield as a result of cumulative effect of Zn, Fe, Mn and B. Higher yield might be due to higher reproductive parts i.e. squares and flowers, during flowering stages (40.80 and 11.29 $plant^{-1}$, respectively) when compared to boll formation stages (29.69 and 7.76 $plant^{-1}$, respectively). Similarly, number of bolls was higher during boll formation stages (17.22 $plant^{-1}$) against flowering stages (15.58 $plant^{-1}$). Foliar nutrient scheduling differed significantly on square and boll dropping, except on flowers dropping. Foliar applications of tracel micronutrient at flowering and boll formation stage reduced dropping of squares (9.40 and 8.71 $plant^{-1}$, respectively) and bolls (2.27 and 2.02 $plant^{-1}$, respectively). Besides, control recorded higher number of squares and boll dropping at flowering stages (15.33 and 3.24 $plant^{-1}$, respectively) when compared to boll formation stage (11.8 and 2.84 $plant^{-1}$, respectively). Similar reports were also recorded by Prakash Koler *et al.* (2010) [5] and Vishwanath (2007) [7].

Interaction effect of fertilizer levels and foliar applications of nutrients on seed cotton yield and physiological disorders differed significantly (Table 1, 2 and 3). Interaction effect due to fertilizer levels of 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} with 12.5 t ha^{-1} of farm yard manure and foliar applications of 0.5 % tracel recorded significantly higher seed cotton yield (19.88 q ha^{-1}), besides it was on par with fertilizer levels of 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} with 12.5 t ha^{-1} of farm yard manure and foliar applications of 10 ppm planofix when compared to rest of the other treatment combinations. Higher yield might be due to cumulative effect of higher nitrogen, phosphorus and potassium content present in fertilizer doses with foliar scheduling of Zn, Fe, Mn and B micronutrients at flowering and boll formation stages which resulted in balanced and adequate nutrients during crop growth stages. Significant difference in yield is due to reduced dropping of squares at flowering stage (9.27 $plant^{-1}$) and bolls at boll formation stages (2.27 $plant^{-1}$). Similarly, different levels of fertilizer with control recorded higher dropping of squares (11.40 to 12.23 $plant^{-1}$) and bolls (3.00 to 3.40 $plant^{-1}$) which further reflected in lower seed cotton yield. Besides, number of squares, flowers and bolls did not differ significantly with different nutrient management practices. Similar results were also recorded by Jagdish Kumar *et al.* (2010) [1] and Lalitha Kumari *et al.* (2010) [2].

Table 1: Effect of nutrient management practices on number of squares, flowers and bolls at different growth stages

Treatments	Number of squares $plant^{-1}$		Number of flowers $plant^{-1}$		Number of bolls $plant^{-1}$	
	Flowering stage	Boll formation stage	Flowering stage	Boll formation stage	Flowering stage	Boll formation stage
Main plots						
F_1	35.87	24.17	9.76	6.89	11.42	13.00
F_2	36.72	25.08	10.22	6.90	13.18	14.62
F_3	39.04	27.34	10.33	6.79	14.53	16.18
Mean	37.21	25.53	10.10	6.86	13.04	14.60
S.Em.±	0.69	0.65	0.35	0.14	0.39	0.39
C.D. at 5%	NS	NS	NS	NS	1.53	1.51
Sub plots						
S_1	29.29	15.07	8.22	5.22	10.18	11.91
S_2	35.89	24.54	9.82	6.58	11.53	13.31
S_3	39.53	28.36	10.27	6.93	13.67	15.58
S_4	37.31	25.92	10.26	7.11	13.16	14.07
S_5	40.44	29.60	10.76	7.56	14.16	15.51
S_6	40.80	29.69	11.29	7.76	15.58	17.22
Mean	37.21	25.53	10.10	6.86	13.04	14.60

S.Em.±	0.83	0.81	0.29	0.19	0.23	0.28
C.D. at 5%	2.40	2.34	0.85	0.54	0.66	0.81
S at the same F level						
S.Em.±	1.44	1.40	0.51	0.32	1.40	0.49
C.D. at 5%	NS	NS	NS	0.93	NS	NS
F at the same or different S levels						
S.Em.±	1.48	1.44	0.59	0.32	0.53	0.59
C.D. at 5%	NS	NS	NS	0.99	NS	NS

Treatment details, Main-plots: F_1 - 75 % RDF	Sub-plots: S_1 : control	S_4 : foliar spray of 0.5 % nutriment ($FeSO_4$)
F_2 - 100 % RDF	S_2 : foliar spray of 0.5 % mahazinc ($ZnSO_4$)	S_5 : foliar spray of 1 % mangala $MgSO_4$ ($MgSO_4$)
F_3 - 125 % RDF	S_3 : foliar spray of 10 ppm planofix (NAA)	S_6 : foliar spray of 0.5 % tracel (Zn, Fe, Mn and B)
NS : Non Significant, RDF includes 125:75:75 kg $N:P_2O_5:K_2O$ ha^{-1} with 10 t ha^{-1} of farm yard manure		

Table 2: Effect of nutrient management practices on physiological disorders at different growth stages and seed cotton yield

Treatments	Dropping of squares (plant^{-1})		Dropping of flowers (plant^{-1})		Dropping of bolls (plant^{-1})		Seed cotton yield (q ha^{-1})
	Flowering stage	Boll formation stage	Flowering stage	Boll formation stage	Flowering stage	Boll formation stage	
Main plots							
F_1	10.41	9.29	4.97	2.91	2.47	2.19	13.39
F_2	10.14	9.24	5.00	3.06	2.72	2.40	14.70
F_3	11.99	9.31	5.37	3.14	2.66	2.34	17.06
Mean	10.85	9.28	5.11	3.04	2.61	2.31	15.05
S.Em.±	0.31	0.22	0.17	0.16	0.06	0.08	0.26
C.D. at 5%	1.24	NS	NS	NS	NS	NS	1.00
Sub plots							
S_1	15.33	11.82	5.87	3.40	3.24	2.84	12.53
S_2	10.36	8.94	5.22	3.13	2.87	2.47	13.76
S_3	9.96	8.78	4.93	2.89	2.27	2.04	16.44
S_4	10.47	8.99	5.01	2.93	2.78	2.38	14.42
S_5	9.58	8.44	4.76	2.96	2.27	2.11	15.64
S_6	9.40	8.71	4.89	2.91	2.27	2.02	17.52
Mean	10.85	9.28	5.11	3.04	2.61	2.31	15.05
S.Em.±	0.68	0.29	0.26	0.19	0.05	0.07	0.31
C.D. at 5%	1.95	0.84	NS	NS	0.15	0.20	0.89
S at the same F level							
S.Em.±	1.17	0.51	0.45	0.33	0.09	0.12	0.54
C.D. at 5%	NS	1.46	NS	NS	0.25	NS	1.55
F at the same or different S levels							
S.Em.±	1.11	0.51	0.44	0.34	0.10	0.14	0.55
C.D. at 5%	NS	1.58	NS	NS	0.33	NS	1.72

Treatment details, Main-plots: F_1 - 75 % RDF	Sub-plots: S_1 : control	S_4 : foliar spray of 0.5 % nutriment ($FeSO_4$)
F_2 - 100 % RDF	S_2 : foliar spray of 0.5 % mahazinc ($ZnSO_4$)	S_5 : foliar spray of 1 % mangala $MgSO_4$ ($MgSO_4$)
F_3 - 125 % RDF	S_3 : foliar spray of 10 ppm planofix (NAA)	S_6 : foliar spray of 0.5 % tracel (Zn, Fe, Mn and B)
NS : Non Significant, RDF includes 125:75:75 kg $N:P_2O_5:K_2O$ ha^{-1} with 10 t ha^{-1} of farm yard manure		

Table 3: Interaction effect of nutrient management practices on reproductive parts at different growth stages and seed cotton yield

Treatments	Dropping of squares (plant^{-1}) at flowering stages							Number of flowers plant^{-1} at boll formation stages						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
F_1	11.40	8.47	8.13	9.97	9.07	8.73	9.29	5.47	6.00	7.13	7.13	7.33	8.27	6.89
F_2	11.73	9.80	9.53	8.07	8.20	8.13	9.24	5.33	6.87	7.47	7.20	7.47	7.07	6.90
F_3	12.23	8.57	8.67	8.93	8.07	9.27	9.31	4.87	6.87	6.20	7.00	7.87	7.93	6.79
Mean	11.82	8.94	8.78	8.99	8.44	8.71		5.22	6.58	6.93	7.11	7.56	7.76	
	S.Em.±			C.D. at 5%				S.Em.±			C.D. at 5%			
F	0.22			NS				0.13			NS			
S	0.29			0.84				0.19			0.54			
F at the same or different S	0.51			1.58				0.32			0.99			

Treatments	Dropping of bolls (plant^{-1}) at boll formation stages							Seed cotton yield (q ha^{-1})						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
F_1	3.00	2.73	2.13	2.13	2.40	2.20	2.47	12.26	12.35	14.25	12.87	13.64	15.00	13.39
F_2	3.33	3.00	2.27	2.27	3.13	2.33	2.72	12.12	13.20	15.48	14.30	15.43	17.69	14.70
F_3	3.40	2.87	2.40	2.40	2.80	2.27	2.66	13.20	15.73	19.60	16.10	17.85	19.88	17.06
Mean	3.24	2.87	2.27	2.78	2.27	2.27		12.53	13.76	16.44	14.42	15.64	17.52	
	S.Em.±			C.D. at 5%				S.Em.±			C.D. at 5%			

F	0.06	NS	0.26	1.00
S	0.05	0.16	0.31	0.89
F at the same or different S	0.10	0.33	0.55	1.72

Treatment details, Main-plots: F_1 - 75 % RDF	**Sub-plots:** S_1 : control	S_4 : foliar spray of 0.5 % nutriment ($FeSO_4$)
F_2 - 100 % RDF	S_2 : foliar spray of 0.5 % mahazinc ($ZnSO_4$)	S_5 : foliar spray of 1 % mangala $MgSO_4$ ($MgSO_4$)
F_3 - 125 % RDF	S_3 : foliar spray of 10 ppm planofix (NAA)	S_6 : foliar spray of 0.5 % tracel (Zn, Fe, Mn and B)
NS : Non Significant, RDF includes 125:75:75 kg $N:P_2O_5:K_2O$ ha^{-1} with 10 t ha^{-1} of farm yard manure		

Conclusion

From the present investigation, it may concluded that fertilizer levels with respect to 156.25:93.75:93.75 kg $N:P_2O_5:K_2O$ ha^{-1} with 12.5 t ha^{-1} of farm yard manure, foliar applications of 0.5 % tracel and their interaction recorded significantly higher seed cotton yield with increased number of reproductive parts and lower physiological disorders when compared to rest of the other treatment combinations.

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