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Effect of fertigation on yield, quality and soil fertility status under cotton grown in Vertisol

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Abstract
The experiment was conducted to study the effect of fertigation on yield, quality and soil nutrient status under cotton grown in Vertisol at Akola during kharif season of 2009-10 to 2011-12. The experiment consists of various levels of fertilizers through drip fertigation along with Zn laid out in randomized block design with three replications. The results of the present experiment revealed that, the maximum values of nutrient uptake, fibre quality parameters, economics and highest seed cotton (18.19 q ha^{-1}) and stalk (41.89 q ha^{-1}) yield was recorded with 100% RD (100:50:50 kg N:P_2O_5:K_2O ha^{-1}) along with combined application of Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip from water soluble fertilizers (WSF). The higher values of N, P, K Zn and Fe was recorded with 100 % recommended dose of fertilizer alongwith combined application of Zn (4 kg Zn ha^{-1}) + Fe (5 kg Fe ha^{-1}) through soil application from conventional fertilizer (Urea,DAP, MOP). Application of 75% RD + (3 kg ha^{-1}) + Fe (3.75 kg Fe ha^{-1}) through drip (WSF) recorded higher Gross monetary returns (Rs. 74914 ha^{-1}), net monetary returns (Rs. 34447 ha^{-1}) and B:C ratio (1.85). The performance of treatment 75% RD + Zn (3 kg ha^{-1}) + Fe (3.75 kg ha^{-1})through drip from water soluble fertilizers was found at par with the treatment giving the highest yield showing its importance in saving of 25% N, P_2O_5, K_2O, Zn and Fe through drip from water soluble fertilizers.

Keywords: cotton, fertigation, nutrient uptake, nutrient status, fibre quality, yield, economics

Introduction
In India, area under cotton cultivation is 11.06 million ha while area of the World is 30.44 million ha. The productivity of cotton in India is low (503 kg lint ha^{-1}) as compared to World average productivity (742 kg ha^{-1}). Maharashtra ranks first in acreage (39.73 lakh ha) with the production of 67.60 lakh bales while the productivity is very low (329 kg lint ha^{-1}) as compared to national average. In Vidarbha, area under cotton is 15.27 lakh hectares with productivity of 325 kg lint ha^{-1} (Anonymous, 2011) [1]. Maharashtra has large scope to increase its production. The cultural practices along with balanced use of fertilizer and optimum use of irrigation water helps to increase productivity of cotton. As water and fertilizers are limited and costly inputs in agriculture, its proper utilization is very essential. Fertigation found most important in this case.

Fertigation implies application of water soluble fertilizers along with irrigation water near the root zone as per need of crop, which results into better utilization of fertilizers along with higher yields of better quality of cotton. The experimental evidences have clearly demonstrated that the system economizes the use of fertilizer and water ranging from 40 to 60 per cent (Nanda, 2010) [11]. Hence, the experiment was conducted to work out effect of nutrient application through drip irrigation on seed cotton yield, uptake of nutrients, fiber quality and economics of cotton.

Materials and Methods
The field experiment was conducted on very fine, smectitic, hyperthermic family of Typic Haplustert at Research Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during kharif season of 2009-10 to 2011-12. The soil of experimental site was moderately alkaline in reaction (pH - 8.12), free from soluble salts (EC- 0.29 dS m^{-1}), medium in organic carbon content (4.19 g kg^{-1}), available nitrogen was low (189.30 kg ha^{-1}), medium in available P (15.88 kg ha^{-1}), high in available K (338.32 kg ha^{-1}), deficient in available Zn (0.53 mg kg^{-1}) and medium in available iron (4.84 mg kg^{-1}). The seeds were sown dry and irrigation was given through drip. The irrigations were given as per need of the crop.

The fertilizers were applied through drip irrigation as per the treatments.

The treatments comprised of T_1-100% RD through drip from water soluble fertilizer (WSF), T_2 -75% RD through drip (WSF), T_3-100% RD soil application (Urea, DAP, MOP), T_4-100% RD + Zn (4 kg ha^{-1})+Fe(5 kg ha^{-1})through drip ZnSO4, FeSO4 (WSF), T_5-75% RD + Zn (3 kg ha^{-1}) + Fe (3.75 kg ha^{-1}) through drip $ZnSO_4$, $FeSO_4$ (WSF), T_6-100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) soil application (Urea, DAP, MOP) and T_7 - 75% RD through drip (Urea, Phosphoric acid, MOP). The land was ploughed once followed by three harrowing and it was brought to fine tilth and experiment was laid into 20 x 3 m^2 plot size in paired row plots. Cotton hirsutum hybrid (PKV Hy-5) was dibbled at 90 cm x 60 cm. The seed was treated with imidachloprid and then sown by dibbling at 5 cm depth and covered with soil. The recommended dose of 100:50:50 N, P_2O_5 and K_2O ha^{-1} was given as per treatments. Nitrogen and potassium was applied in five splits (20% in each split) at sowing, 35 DAS, 55 DAS, 75 DAS and 95DAS. Phosphorus was applied in four splits (25% in each split) at sowing, 35 DAS, 55 DAS and 75 DAS. Twenty five per cent each of zinc and iron was applied at sowing, 35 DAS, 55 DAS and 15 per cent of zinc and iron applied at 75 DAS and remaining 10 per cent at 95 DAS. The yield of cotton was recorded in five pickings.

The plot wise soil samples (0-20 cm) were collected after harvest of cotton. These samples were analyzed for pH (1:2.5 soil: water suspension), electrical conductivity by conductivity meter (Jackson, 1967) [4], organic carbon by rapid titration method (Walkley and Black, 1936) [23], available N by alkaline permanganate method (Subbiah and Asija, 1956) [19], available P by Olsen's method (Olsen *et al*. 1954) [12], available K by ammonium acetate extraction method (Jackson, 1967) [4] and available micronutrients *viz*., Zn, Fe by extracting soil with 0.005 M DTPA (Lindsay and Norvell, 1978) [7]. The plant samples were analyzed at harvest stage for N, P, K and micronutrients by acid digestion technique (Piper 1966 [14] and Isaac and Kerber, 1971) [3]. The ginning percentage was determined and the fiber quality parameter *viz*., 2.5 per cent span length, uniformity ratio, fineness micronaire, bundle strength tenacity were evaluated at Ginning Training Centre, Central Institute for Research on Cotton Technology, Regional Quality Evaluation Unit, Nagpur. Fertilizer use efficiency was calculated by using the formula given by (Mohanty and Singh, 2002) [10].

Results and Discussion

Seed cotton yield

The pooled results indicated that the seed cotton yield was recorded significantly highest (18.19 q ha^{-1}) under 100% recommended dose + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip from water soluble fertilizer (18.19 q ha^{-1}) (T_4), which was at par with T_5, 75 % recommended dose + Zn(3 kg ha^{-1}) + Fe (3.75 kg ha^{-1}) fertilizer through drip irrigation (16.99 q ha^{-1}) and T_1 100%recommended dose of fertilizer through drip from water soluble fertilizer (16.68 q ha^{-1}) (Table 1).

The treatment T_4 showed 7 and 9 % increase in yield over T_5 and T_1 treatments, respectively. Similarly, T_4 showed 13% increase in yield over 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through soil application (T_6). The treatment T_4, T_5 and T_1 were higher in yield over soil application of fertilizers. It is indicated that fertigation through water soluble fertilizers can increase seed cotton yield and save the fertilizers. These results are in conformity with Raskar *et al*. (2001) [17], Patil *et al*. (2009) [13], Veeraputhiran and Chinnusamy (2009) [21] and Wadatkar *et al*. (2001) [22]. As regards cotton stalk yield almost more or less similar trend was noticed as that of seed cotton yield.

Uptake of Nutrients

The data regarding uptake of N, P, K, Zn and Fe are presented in Table 2. The pooled results revealed that, treatment (T_4) of 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip from water soluble fertilizers showed significantly higher total N (100.4 kg ha^{-1}), P (27.94 kg ha^{-1}), K (106.65 kg ha^{-1}), Zn (347.8 g ha^{-1}) and Fe (1620.5 g ha^{-1}) over all the treatment except T_5 which was at par in case of P uptake by cotton. The similar results were also reported by Bharambe *et al*. (1997) [2], Rao and Janawade (2009) [15].

Soil Properties

The soil pH, electrical conductivity and organic carbon (Table 3) were not influenced significantly due to various treatments. The findings are line with the results reported by Singh *et al.* (1980) [18] and Halemani *et al*. (2004) [5].

Soil fertility status

The available N (Table 4) in soil was recorded significantly highest in the treatment of soil application of 100 % recommended dose of fertilizer + Zn (4 kg Zn ha^{-1})+ Fe (5 kg Fe ha^{-1}) from conventional fertilizer (T_6) followed by 100 % recommended dose of fertilizer through drip + Zn (4 kg Zn ha^{-1}) + Fe (5 kg Fe ha^{-1}) from water soluble fertilizer (T_4) and at par with 100 % recommended dose of fertilizer through soil (T_3) and application of 75 % recommended dose of fertilizer + Zn (3 kg Zn ha^{-1}) + Fe (3.75 kg Fe ha^{-1}) (T_5) through drip in the form of water soluble fertilizer. The treatment of 75 % recommended dose of fertilizer through drip from conventional fertilizer (T_7) recorded less available nitrogen due to low nutrient use efficiency of conventional fertilizers through drip system. Similar trend was noticed in case of available P and K. The higher availability of nitrogen, phosphorus and potassium after harvest of cotton might be attributed to the less uptake by the cotton crop during growth and development due to their less availability. These results are inconformity with Mathur *et al.* (1997) [8], Katkar *et al.* (2007) [6] and Rao and Janawade (2009[a]) [16].

The available zinc & iron (Table 5)in soil was recorded highest in the treatment of soil application of 100 % recommended dose of fertilizer + Zn (4 kg Zn ha^{-1}) + Fe (5 kg Fe ha^{-1}) through conventional fertilizer (T_6) followed by 100 % recommended dose of fertilizer through drip + Zn (4 kg Zn ha^{-1}) + Fe (5 kg Fe ha^{-1}) from water soluble fertilizer (T_4) and application of 75 % recommended dose of fertilizer + Zn (3 kg Zn ha^{-1})+ Fe (3.75 kg Fe ha^{-1}) (T_5) through drip using water soluble fertilizer. These results are inconformity with Mathur *et al.* (1997) [8], Katkar *et al.* (2007) [6] and Rao and Janawade (2009[a]) [16].

Fiber quality

The fibre quality parameters *viz*., 2.5 per cent span length, uniformity ratio, fineness micronaire was found non significant due to different treatments (Table 6). However, the bundle strength tenacity at 3.2 mm gauge was significantly higher (23.03 g tex^{-1}) due to application of 100% RD+ Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip from water soluble fertilizers treatment T_4 which was on par with T_5 and T_6 treatments. Bharambe *et al*. (1997) [2], Raskar *et al*. (2001) [17], Suresh and Chellamuthu (2004) [20], Mehta *et al*. (2009) [9] and Patil *et al*. (2009) [13] also reported slight improvement in fibre quality of cotton in fertigation.

Economics

The data presented in Table 7 clearly indicate that application of 75% RD + (3 kg ha^{-1}) + Fe (3.75 kg Fe ha^{-1}) through drip (WSF) recorded higher Gross monetary returns (Rs. 74914 ha^{-1}), net monetary returns (Rs.34447 ha^{-1}) and B:C ratio (1.85) with saving of 25% NPK, Zn and Fe dose.

Conclusion

From the three years of study, it could be concluded that, application of 100 % recommended dose of fertilizer (100:50:50 NPK kg ha^{-1}) along with micronutrients Zn (4 kg Zn ha^{-1}) + Fe (5 kg Fe ha^{-1}) through drip (WSF) (18.19 q ha^{-1}) & 75 % recommended dose of fertilizer (75:37.5:37.5 NPK kg ha^{-1}) along with micronutrients (3 kg Zn ha^{-1} + 3.75 kg Fe ha-^{1}) in the form of water soluble fertilizer through drip recorded significantly higher seed cotton yield (16.99 q ha^{-1}). Uptake of nutrients was found higher and improved soil fertility status. the application of 75 % RD + Zn (3 kg ha^{-1}) + Fe (3.75 kg Fe ha^{-1}) through drip irrigation using water soluble fertilizer (WSF) was beneficial for increasing cotton yield and economic benefit beside improvement in span length, uniformity ratio, fineness micronaire and bundle strength.

Table 1: Seed cotton yield as influenced by various treatments

Treatment	Seed cotton (q ha^{-1})			Pooled	Cotton stalk (q ha^{-1})			Pooled
	2009-10	2010-11	2011-12	mean	2009-10	2010-11	2011-12	mean
T_1 - 100% RD through drip (WSF)	16.45	17.58	16.01	16.68	36.78	38.80	38.07	37.88
T_2 - 75% RD through drip (WSF)	14.90	15.43	14.74	15.02	36.42	36.78	33.75	35.65
T_3 - 100% RD soil application	15.80	15.00	14.19	15.00	38.66	36.00	35.78	36.81
T_4 - 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip (WSF)	18.10	18.69	17.78	18.19	42.40	43.08	40.21	41.89
T_5 - 75% RD + Zn (3 kg ha^{-1}) + Fe (3.75 kg Fe ha^{-1}) through drip (WSF)	16.50	17.63	16.85	16.99	39.30	41.30	37.86	39.49
T_6 - 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) soil application	17.50	16.12	14.56	16.06	41.48	35.92	33.44	36.94
T_7 - 75% RD through drip (Urea, Phosphoric acid, MOP)	14.00	14.45	13.72	14.05	34.67	33.14	29.45	32.42
SE (m) ±	1.20	0.75	0.77	0.70	1.73	1.71	1.99	1.72
CD at 5%	3.57	2.24	2.28	2.09	4.87	5.08	5.93	5.11
C.V	14.87	9.21	9.99		9.01	9.10	11.16	

Table 2: Uptake of nutrients by cotton as influenced by various treatments (pooled 2009 to 2011-12)

Treatment	Nutrient uptake (kg ha^{-1})			Nutrient uptake (g ha^{-1})	
	N	P	K	Zn	Fe
T_1 - 100% RD through drip (WSF)	85.77	23.91	93.73	292.3	1381.8
T_2 - 75% RD through drip (WSF)	80.25	21.89	86.86	264.7	1276.9
T_3 - 100% RD soil application	79.27	20.65	85.40	268.6	1322.7
T_4 - 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip (WSF) `	100.40	27.94	106.65	347.8	1620.5
T_5 - 75% RD + Zn (3 kg ha^{-1}) + Fe (3.75 kg Fe ha^{-1}) through drip (WSF)	92.46	25.47	100.02	316.2	1505.1
T_6 - 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) soil application	87.62	24.42	95.25	293.9	1403.0
T_7 - 75% RD through drip (Urea, Phosphoric acid, MOP)	72.84	19.56	82.08	238.2	1183.4
SE (m) ±	1.76	0.89	2.04	10.10	40.36
CD at 5%	5.23	2.64	6.07	30.03	111.92

Table 3: Chemical properties of soil after harvest of cotton as influenced by various treatments (2011-12)

Treatments	pH (1: 2.5)	EC (dSm^{-1})	Organic carbon(g kg^{-1})
T_1 -100% RD through drip (WSF)	8.15	0.31	4.28
T_2 -75% RD through drip (WSF)	8.14	0.28	4.25
T_3 -100% RD soil application	8.15	0.27	4.27
T_4 -100% RD through drip + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip (WSF)	8.21	0.28	4.33
T_5 -75% RD through drip + Zn (3 kg ha^{-1}) + Fe (3.75 kg ha^{-1}) through drip (WSF)	8.23	0.26	4.27
T_6 -100% RD soil application + soil application of Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1})	8.21	0.30	4.36
T_7 -75% RD through drip (Urea, Phosphoric acid, MOP)	8.22	0.31	4.27
SE(m)±	0.03	0.02	0.05
CD at 5%	-	-	-
Initial status	8.12	0.29	4.19

Table 4: Soil fertility status (kg ha^{-1}) of soil after harvest of cotton as influenced by various treatments (2011-12)

Treatments	Available nutrients (kg ha^{-1})		
	Nitrogen	Phosphorous	Potassium
T_1 –100 % RD through drip (WSF)	227.2	16.15	416.9
T_2 –75 % RD through drip (WSF)	220.1	13.32	398.7
T_3 –100 % RD soil application (Urea, DAP, MOP)	225.2	15.19	403.4
T_4 –100 % RD through drip + Zn(4 kg Zn ha^{-1})+Fe (5 kg Fe ha^{-1}) through drip (WSF)	229.0	18.00	429.9
T_5 –75 % RD through drip + Zn (3 kg Zn ha^{-1})+ Fe (3.75 kg Fe ha^{-1}) through drip (WSF)	221.3	13.95	400.6
T_6 –100 % RD soil application + soil application of Zn (4 kg Zn ha^{-1}) + Fe (5 kg Fe ha^{-1}) (Urea, DAP, MOP)	231.0	19.22	406.1
T_7 –75 % RD through drip (Urea, Phosphoric acid, MOP)	211.1	10.91	342.3
SE (m) ±	3.43	0.31	7.94
CD at 5 %	10.51	0.94	23.61
Initial status	189.3	15.88	338.32

Table 5: Available zinc and iron status (mg kg^{-1}) of soil after harvest of cotton as influenced by various treatments (2011-12)

Treatments	Available Zinc & Iron (mg kg^{-1})	
	Zinc	**Iron**
T_1 – 100 % RD through drip (WSF)	0.50	4.81
T_2 – 75 % RD through drip (WSF)	0.49	4.80
T_3 – 100 % RD soil application (Urea, DAP, MOP)	0.47	4.78
T_4 – 100 % RD through drip + Zn(4 kg Zn ha^{-1})+Fe (5 kg Fe ha^{-1}) through drip (WSF)	0.64	5.09
T_5 – 75 % RD through drip + Zn (3 kg Zn ha^{-1})+ Fe (3.75 kg Fe ha^{-1}) through drip (WSF)	0.63	5.05
T_6 –100 % RD soil application + soil application of Zn (4 kg Zn ha^{-1}) + Fe (5 kg Fe ha^{-1}) (Urea, DAP, MOP)	0.66	5.14
T_7 – 75 % RD through drip (Urea, Phosphoric acid, MOP)	0.48	4.82
SE (m) ±	0.06	0.58
CD at 5 %	NS	NS
Initial status	0.53	4.48

Table 6: Fiber quality parameters of cotton as influenced by various treatments

Treatment	2.5% span length (mm)	Uniformity ratio (5)	Fineness micro-naire (10-6 g $inch^{-1}$)	Bundle strength tenacity at 3.2 mm gauge (g tex^{-1})
T_1 - 100% RD through drip (WSF)	26.40	53.25	3.05	20.13
T_2 - 75% RD through drip (WSF)	26.88	53.75	3.20	20.03
T_3 - 100% RD soil application	27.08	52.00	3.23	20.65
T_4 - 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip (WSF)`	27.00	55.00	3.13	23.03
T_5 - 75% RD + Zn (3 kg ha^{-1}) + Fe (3.75 kg Fe ha^{-1}) through drip (WSF)	27.15	54.25	3.05	22.18
T_6 - 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) soil application	27.10	52.45	3.20	21.48
T_7 - 75% RD through drip (Urea, Phosphoric acid, MOP)	26.93	53.00	3.05	19.95
SE (m) ±	0.26	0.90	0.18	0.5
CD at 5%	NS	NS	NS	1.71

Table 7: Monetary return of cotton as influenced by various treatments

Treatment	Yield (q ha^{-1})	GMR (Rs.)	NMR (Rs.)	B:C ratio
T_1 - 100% RD through drip (WSF)	16.68	71571	31794	1.72
T_2 - 75% RD through drip (WSF)	15.02	65393	28477	1.77
T_3 - 100% RD soil application	15.00	64914	26696	1.69
T_4 - 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) through drip (WSF)`	18.19	78956	34444	1.77
T_5 - 75% RD + Zn (3 kg ha^{-1}) + Fe (3.75 kg Fe ha^{-1}) through drip (WSF)	16.99	74914	34447	1.85
T_6 - 100% RD + Zn (4 kg ha^{-1}) + Fe (5 kg ha^{-1}) soil application	16.06	69224	29246	1.73
T_7 - 75% RD through drip (Urea, Phosphoric acid, MOP)	14.05	61020	25180	1.70
SE (m) ±	0.70	1624.0	1258.7	
CD at 5%	2.09	4825.4	3740.1	

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