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Effect of soil and foliar fertilization of potassium on growth characters, yield attributes, yield and economics of summer irrigated cotton in Southern agroclimatic zone of Tamil Nadu

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Abstract
Field experiments were carried out at Cotton Research Station, Srivilliputtur during Summer, 2013 and 2014 to study the effect of soil and foliar fertilization of potassium on growth characters, yield attributes, yield and economics of summer irrigated cotton. The result revealed that four equal split application of potassium (30 kg/ha) has registered higher plant height, sympodial branches per, bolls per plant, seed cotton yield of (1846 and 1861 kg/ha) and stalk yield. This treatment was followed by 3 spray of 3 % KNO_3 spray which has recorded (1706 and 1720kg/ha). Lowest kapas yield (1406 and 1462 kg/ha) and stalk yield were obtained under four spraying of 3 % KNO_3 treatment.

Keywords: Kcl, KNO_3, Foliar spray, Summer Irrigated cotton

Introduction
Cotton (*Gossypium hirsutum* L.) is one of the most important commercial and industrial crop. In India, cotton is cultivated in 108.28 lakh hectares with a productivity of 511 kg/ha whereas it is grown in 1.42 lakh hectares with 430 kg/ha during 2016-17 (Anonymous, 2018). Cotton is a heavy feeder and removes a large quantity of nutrients from the soil thus crop nutrition forms a crucial component of cotton production. To cater the uptake needs of the crop, soil reserves alone are not sufficient, hence needs to supply them through chemical fertilizers. Nitrogen and phosphorus fertilizers are more frequently use by the farmers from several years leading to an imbalanced nutrient supply ratio. As a result, potassium status in soil was depleted remarkably from high to medium status. Potassium plays important role in production and improving the quality of cotton. The beneficial effect of potassium was reported in cotton (Kaur *et al*., 2007) [6]. Potassium is required in larger amount than any other mineral element except nitrogen but in crop like cotton particularly during the boll formation stage, potassium uptake is more than that of nitrogen. Further, foliar nutrient when used as supplement to the recommended soil fertilizer application is highly beneficial, as crop gets benefitted from foliar applied nutrients when the roots are unable to meet the nutrient requirement of the crop as its critical growth stage (Ebelhar and Ware, 1998) [4]. Hence, the experiment was conducted to work out the effect of levels of potassium application through soil and foliar on growth characters, yield parameters, seed cotton yield and economics of summer irrigated cotton.

Materials and Methods
Field experiments were carried out at Cotton Research Station, Srivilliputtur during Summer, 2013 and 2014. The climate of this tract was semi-arid, sub-tropical with hot and dry summer. The cropping history of field from 2012 was rice in rabi was grown. The cotton variety SVPR 2 was sown on 22.02.2013 in field No: C8 and 21.02.2014 in field No: B1. The experimental fields were alkaline in nature (pH more than 8.0) with texture of clay loam. The soil was low in available nitrogen status (205.6 kg/ha) as well as phosphorus status (10.2 kg/ha) and medium in available potassium status (172.4 kg/ha). The organic carbon content was also low (0.34 %). The treatments consisted of T_1: Control (Water spray), T_2: 2 spray of 2 % KNO_3 (75, 90 DAS), T_3: 3 spray of 2 % KNO_3 (60, 75, 90 DAS), T_4: 4 spray of 2 % KNO_3 (60, 75, 90, 105 DAS), T_5: 2 spray of 3 % KNO_3 (75, 90 DAS), T_6: 3 spray of 3 % KNO_3 (60, 75, 90 DAS), T_7: 4 spray of 3 % KNO_3 (60, 75, 90, 105 DAS), T_8: Split application of K (¼ sowing + ¼ at seeding stage + ¼ flowering + ¼ at BDS), T_9: 100 % K applied basally, T_{10}: DAP 2 % spray at flowering and BDS, T_{11}: KCl 1% spray (75, 90 DAS), T_{12}: KCl 1% spray (60, 75, 90 DAS), T_{13}: KCl 1% spray (60, 75, 90, 105 DAS), T_{14}: No soil K application + 3 spray of

KNO_3 2 % (60, 75, 90 DAS) and T_{15}: No soil K application + 3 spray of 3 % KNO_3 (60, 75, 90 DAS). The field experiment was arranged in randomized block design with three replications. The last picking was completed on 24.08.2013 during 2013 and on 09.09.2014 during 2014. A total rainfall of 202.8 and 153.1 mm was received in 16 and 11 rainy days during cropping season of 2013 and 2014 respectively. All recommended cultural practices were followed during the crop season. Growth and yield attributes like plant height, monopodial branches per plant, sympodial branches per plant, number of bolls per plant, boll weight, seed cotton yield and stalk yield per hectare were determined. The data were analyzed statistically by applying the analysis of variance technique as suggested by Cochran and Cox (1968) [3]. The critical differences were obtained at 5 % level of significance as described by Panse and Sukhatme (1961) [8].

Results and Discussion

Growth parameters

The data on various growth parameters indicated that there was significant differences for plant growth characters due to different potassium levels (Table 1). Among the treatments tested, three spray schedule of 1 % KCl (T_{12}) and 3 % KNO_3 (T_6) had registered significantly taller cotton plants compared to other treatments. Four equal split application of potassium (30 kg/ha) (T_8) treatment has recorded taller cotton plants but it was comparable with other treatments. Number of monopodial branches/ plant and number of sympodial branches /plant were also significantly influenced by the potassium foliar nutrition. Three spray schedule of 3 % without basal potassium application (T_{15}) has produced higher monopodial branches (1.68 and 1.65) and sympodial branches per plant (20.5 and 13.92) followed by 3 spray schedule of 2 % KNO_3 (T_{14}). When soil K levels are insufficient, the cotton crop moves more quickly (earlier) from the vegetative to the reproductive phase resulting in a decline in yield (Pettigrew, 2008) [9]. In the present study, growth parameters were significantly enhanced by K application both soil and foliar applied, compared to control.

Table 1: Influence of potassium foliar nutrition on growth parameters of summer irrigated cotton

Treatments	Plant height (cm)		Monopodial branches/ plant		Sympodial branches/ plant	
	2013	2014	2013	2014	2013	2014
Control (water spray)	83.8	60.9	1.27	1.00	16.40	11.13
2 % KNO_3 (2 spray)	84.6	73.8	1.53	1.11	18.70	12.20
2 % KNO_3 (3 spray)	83.6	73.4	1.40	1.11	17.40	12.78
2 % KNO_3 (4 spray)	85.9	71.1	1.40	1.08	17.50	12.89
3 % KNO_3 (2 spray)	85.2	69.3	1.00	1.22	18.50	12.13
3 % KNO_3 (3 spray)	94.6	67.9	1.25	1.59	19.60	13.00
3 % KNO_3 (4 spray)	89.3	64.7	1.20	1.00	17.50	10.80
Soil application of K (4 splits)	91.1	70.4	1.20	1.53	18.90	13.10
100 % K applied basally	88.3	66.0	1.53	1.10	17.0	11.43
DAP 2 % spray at flowering and BDS	83.2	65.2	1.01	1.07	17.1	11.56
1% KCl (2 spray)	86.9	66.4	1.60	1.09	19.1	11.73
1 % KCl (3 spray)	98.5	68.1	1.13	1.11	18.6	11.81
1 % KCl (4 spray)	88.9	67.8	1.13	1.10	18.3	11.63
No basal K (3 spray of 2 % KNO_3	89.9	62.5	1.57	1.56	19.8	12.86
No basal K (3 spray of 3 % KNO_3)	86.1	64.4	1.68	1.65	20.5	13.92
SEd	5.67	4.2	0.27	0.21	1.28	0.66
CD	11.01	8.3	0.52	0.41	2.61	1.32

Yield parameters

The data on various yield attributes showed that significant differences for yield characters due to different potassium levels imposed to summer irrigated cotton (Table 2). In medium K fertility field, yield parameters were increased gradually in response to K application, probably due to some relative improvement in soil K status. Three spray schedule of 1 % KCl (T_{12}) recorded more number of bolls per plant (23.2 and 13.62 /plant) which was on par with split soil application of K (T_8) (23.2 and 12.07 during 2013 and 2014 respectively) and three spray of 3 % KNO_3 without basal potassium application (T_{15}). Lowest number of bolls per plant (15.30 and 10.08) was observed under control treatment. Boll weight of summer irrigated cotton was not affected significantly due to differential potassium application. These results provide additional evidence for the critical role of K fertilization for enhancing yield parameters of cotton grown on poor arid soils in Pakistan (Karim *et al.*, 2016) [5]. The supply of sufficient K quantities at critical periods, particularly during the boll development stage, resulted in retention of greater numbers of bolls per plant, as compared to the non-sprayed controls (Channakeshava *et al.*, 2013) [2].

Table 2: Influence of potassium foliar nutrition on yield parameters and yield of summer irrigated cotton

Treatments	Bolls/ plant		Boll weight (g)		Kapas yield (kg/ha)	
	2013	2014	2013	2014	2013	2014
Control (water spray)	15.30	10.08	3.7	3.26	1468	1422
2 % KNO_3 (2 spray)	19.70	10.56	3.1	3.20	1656	1475
2% KNO_3 (3 spray)	16.50	11.61	3.4	3.30	1456	1673
2 % KNO_3 (4 spray)	20.50	11.14	4.2	3.46	1662	1668
3 % KNO_3 (2 spray)	20.50	11.37	3.3	3.26	1580	1601
3% KNO_3 (3 spray)	20.40	11.31	3.4	3.50	1706	1720
3 % KNO_3 (4 spray)	18.70	9.74	3.7	3.46	1406	1462
Soil application of K (4 splits)	22.0	12.07	3.3	3.63	1846	1861

100 % K applied basally	19.8	11.64	3.4	3.13	1612	1595
DAP 2 % spray at flowering and BDS	16.5	10.22	3.5	3.31	1539	1596
1 % KCl (2 spray)	20.5	10.24	3.4	3.31	1594	1476
1% KCl (3 spray)	23.2	13.62	3.6	3.36	1650	1563
1% KCl (4 spray)	19.3	10.51	3.3	3.34	1411	1521
No basal K (3 spray of 2% KNo3	21.2	9.65	3.6	3.31	1584	1401
No basal K (3 spray of 3% KNo3)	21.4	9.87	3.2	3.33	1435	1446
SEd	2.19	0.57	0.35	0.32	112	91
CD	5.51	1.27	NS	NS	236	203

Yields

Soil and foliar spraying of potassium significantly improved the seed cotton yield of summer irrigated cotton. Among the treatments, four equal split application of potassium (30 kg/ha) has registered higher seed cotton yield of (1846 and 1861 kg/ha), followed by 3 spray of 3 % KNO_3 spray (T_6) which has recorded (1706 and 1720kg/ha during 2013 and 2014 respectively). This yield increase may be attributed mainly to the significant rise in the number of bolls but also to the slighter surge in boll weight. Beyond the direct influence of the foliar K applications, it appears that this treatment is more constructive where adequate soil K application is provided. Lowest kapas yield (1406 and 1462 kg/ha) were obtained under four spraying of 3 % KNO_3 treatment (T_7). These results demonstrate the significance of synchronizing the nutrient supply at different developmental stages using foliar application to enhance growth and consequent higher yields (Kumar et al., 2011) [7]. Similar trend was noticed with stalk yield of summer irrigated cotton (Table 3).

Table 3: Growth, yield attributes and kapas yield of cotton as influenced by foliar spraying potassium during Summer 2008

	Stalk yield (kg/ha)		**Net return (Rs/ha)**		**B:C ratio**	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**
Control (water spray)	3112	3015	28676	36862	1.43	1.83
2% KNO_3 (2 spray)	3544	3157	31802	37700	1.58	1.86
2% KNO_3 (3 spray)	2927	3363	27632	42578	1.37	2.08
2% KNO_3 (4 spray)	3540	3553	31379	42178	1.54	2.05
3% KNO_3 (2 spray)	3381	3426	30050	40706	1.48	1.99
3 % KNO_3 (3 spray)	3685	3715	35102	47395	1.77	2.32
3% KNO_3 (4 spray)	3065	3187	25847	32282	1.27	1.75
MOP in four splits	4061	4094	36047	48276	1.80	2.41
100% K as basal	3579	3541	31484	41360	1.58	2.06
2% DAP (2 spray)	3401	3527	29940	41266	1.50	2.05
1% KCl (2 spray)	3528	3266	31073	38206	1.55	1.90
1% KCl (3 spray)	3661	3468	34135	46438	1.71	2.28
1% KCl (4 spray)	3090	3331	27445	39316	1.37	1.95
2 % KNO_3 (3 spray) without K application	3453	3054	30628	36006	1.57	1.78
3 % KNO_3 (3 spray) without K application	3127	3151	27318	36771	1.35	1.80
SEd	158	144	-		-	-
CD (P= 0.05)	312	294	-		-	-

Monterey return

Lower net return (Rs. 25847 and 32282/ha) and B:C ratio (1.27 and 1.75) were obtained under four spraying of 3 % KNO_3 treatment (T_7) in the two years respectively. Soil application of 30 K_2O (in four equal splits) registered the highest net return (Rs.36407 and 48726/ha) and B:C ratio (1.80 and 2.41 in the two years respectively) which was followed by the three spraying of 3 % KNO_3 and three spraying of 1 % KCl. This might be due improved growth characters, yield parameter and yield under these treatments because of adequate supply of potassium nutrient at critical crop growth stages of cotton. The advantage of foliar application is, however, in the precise delivery of nutrients to target tissues and organs (Saravanan *et al.*, 2013) [10].

Conclusion

From these field experiments, it can be concluded that three foliar spraying of 3 % KNO_3 at 60, 75 and 90 DAS was sufficient to get higher yield which was comparable to the soil application of recommended K (at ¼ sowing + ¼ at seeding stage + ¼ flowering + ¼ at BDS.

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