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EFFECT OF FERTILIZER LEVELS AND SULPHUR ON SOIL PROPERTIES IN CLAY LOAM SOIL

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Abstract

A field experiment was conducted during *Kharif*, 2013 at Agricultural college farm, Bapatla. The experimental soil was clay loam in texture, non saline, slightly alkaline in soil reaction with low organic matter and available nitrogen, medium phosphorus, very high potassium and sufficient in micronutrients. The initial and final soil samples were analyzed for soil physical, chemical and biological properties *viz*., pH, EC, bulk density, organic carbon, CEC, macro and micro nutrient status, microbial biomass carbon, plate count agar and populations of functional bacterial groups. The treatments had no significant impact on soil physical and physico-chemical properties. When compared to non sulphur treatments, sulphur applied treatments were superior in available macro and micro nutrient contents in soil. Application of higher doses of fertilizers in combination with sulphur significantly influenced the microbial properties. Treatments, which received 125 and 150% RDF + S @ 30 kg ha^{-1} were on par and higher in microbial activity over the 100% RDF treatment.

Key words : Bt cotton, soil physical properties, chemical properties, biological properties, microbial biomass carbon, plate count agar, bacterial populations.

Introduction

The chemical fertilizers are one of the key factors contributing to increase in agricultural production of our farming system, but these are known to exhibit deleterious effect on soil environment, if used injudiciously. The continued high and imbalanced use of nutrients is one of the prime areas of concern for agricultural sustainability. Soil quality is related with nutrient status, physical and chemical properties of soil. Study of biological activities in soils is also important as they indicate the potential of soil to support biochemical processes which are essential for maintenance of soil fertility. Considering the paramount significance of soil quality this study was designed to study the effect of inorganic inputs on soil physical, chemical and biological properties.

Materials and Methods

A field study was conducted during Kharif 2013-2014 at Agricultural College Farm, Bapatla on *Bt* cotton whose fertilizer recommendation is 150-60-60-30 kg N, P_2O_5, K_2O, S, respectively. The experiment was laid out in Randomized block Design with nine treatments *viz*., Control (**T_1**); Farmer's practice (**T_2**); 100% recommended dose of fertilizers (RDF) (**T_3**); 100% RDF + sulphur @30 kg ha^{-1} (**T_4**); Soil test based fertilizer recommendation (**T_5**); 125% RDF (**T_6**); 125% RDF + sulphur @ 30 kg ha^{-1} (**T_7**); 150% RDF (**T_8**); 150% RDF + sulphur @ 30 kg ha^{-1} (**T_9**) replicated thrice. Nitrogen and potassium were applied in four splits in the form of urea and muriate of potash. Phosphorus and Sulphur in the form of Single super phosphate and elemental sulphur were applied completely as basal dose. 125 per cent RDN, 150 per cent RD P_2O_5 and 100 RD K_2O were applied in treatment **T_2** as per the data collected in survey in Guntur district. For soil test based treatment (**T_5**) 125 percent RDN, 100 per cent RD P_2O_5 and 75 per cent RD K_2O were applied as the initial soil was low in nitrogen (181 kg ha^{-1}), medium in phosphorus (25 kg ha^{-1}) and high in potassium (739 kg ha^{-1}).

The initial and final soil samples were analysed for soil physical, chemical and biological properties *viz*., Bulk density, pH, EC, CEC, Organic carbon, Available N, P, K, S, micronutrients, microbial biomass carbon, Plate count agar and populations of functional bacterial groups like Azotobacter, Rhizobium and Phosphate solubilising bacteria.

Results and Discussion

Physical and physico-chemical properties

Bulk density

Bulk density of the soil (table 1) was not significantly influenced with the treatments imposed but in sole N, P, K fertilizer treatments it was relatively more than sulphur applied treatments.

Soil reaction (pH)

Application of fertilizers at different levels had no significant impact on soil reaction (table 1). However, the plots treated with sulphur recorded lower pH values (7.5, 7.4 and 7.4 respectively) when compared to non sulphur treatments as shown by Chouliaras and Tsadilas (1996) and Jamal *et al*. (2010). The oxidation of S compounds to sulphates decreased the pH of soil.

Electrical conductivity

With the increase in fertilizer levels, EC increased. Highest EC (0.523 dS m^{-1}) was recorded in farmers practice (**T_2**) and the lowest (0.393 dS m^{-1}) in control (**T_1**). All the treatments except T_2 were on par with control (**T_1**). Presence of soluble salts in mineral fertilizers increased EC of soil with their application (Kumar *et al*., 2012) sulphur application further enhanced EC (Spiers and Braswe, 1992 and Heydarnezhad *et al*., 2012).

Organic carbon

The treatments imposed had no significant effect on the organic carbon content of soil (table 1). However, numerically higher carbon content (0.48 per cent) was recorded with 150 per cent RDF and sulphur @ 30 kg ha^{-1} (**T_9**), followed by **T_7** (125 per cent RDF + S @ 30 kg ha^{-1}) with 0.47 per cent. The increase in organic carbon content in soil with application of N, P, K and S had also been reported by Vandana *et al.* (2009) and Yadav *et al.* (2010).

Cation exchange capacity (CEC)

There was no significant difference in CEC (table 1) due to the treatments imposed. The CEC values ranged from 35.36 to 39.13 cmol (p^+) kg^{-1}. The highest CEC (39.13 cmol (p^+) kg^{-1}) was recorded in **T_9** while the lowest value (35.36 cmol (p^+) kg^{-1}) was recorded in control (**T_1**). Sunitha *et al*. (2010) reported the increase in CEC of soil with application of 100 per cent RDF over the control. The build up of organic carbon in sulphur applied plots might have increased the CEC of soil (Gaurishankar *et al*., 2002).

Soil available nutrient status

The results in table 2 showed that **T_9** recorded the maximum (229 kg ha^{-1}) and **T_1** (control) recorded the lowest (163 kg ha^{-1}) available nitrogen content in soil. At all fertilizer levels, there was a no significant increase in available N content in sulphur treatments. Increase in available nitrogen content with application of sulphur was quoted by Sujatha *et al*. (2007) and Jamal *et al.* (2010). soil test based recommendation (**T_5**) and farmers practice (**T_2**) respectively, were comparable and also on par with all the other treatments except **T_1** *i.e.*, control.

The results (table 2) indicated increase in soil P content with increasing fertilizer levels. (Dixit and Gupta, 2000 and Ahmad *et al*., 2013). This could be attributed to the increase in root activity. Plant roots excrete organic acids and chelating organic compounds in rhizosphere which form multiple complex compounds with Ca, Mg and/or Fe and thereby increase phosphorus availability in soil. Significantly highest (31 kg ha^{-1}) and Lowest (20 kg ha^{-1}) available P_2O_5 content were recorded in Farmers practice (**T_2**) and control (**T_1**), respectively. The positive effect of sulphur on phosphorus availability by reducing the rate of $CaCO_3$ in soil was also reported by Chouliaras and Tsadilas (1996) and Heydarnezhad *et al.* (2012).

Different fertilizer levels and sulphur application had no significant effect on available potassium content of soil (table 2). Sulphur application increased the available potassium content of soil by an average of 2 per cent in **T_4**, **T_6** and **T_9** treatments, over sole N, P, K fertilizer treatments *i.e.* **T_3**, **T_5** and **T_8**. The decrease in pH of soil due to S application resulted in higher exchangeable potassium in soil solution (Chouliaras and Tsadilas, 1996).

There was an increase in available sulphur content in soil with N, P, K and S application (Sujatha *et al*., 2007 and Vandana *et al*., 2009). Highest (47 ppm) and lowest (35 ppm) available sulphur were observed in **T_4** (100% RDF+ Sulphur @ 30 kg/ha) and **T_1** (control), respectively. Lal *et al.* (1997) stated a slight decrease in sulphur availability with P application.

Micronutrients (table 2)

A nonsignificant increase in zinc availability was recorded in sulphur treatments over the sulphur free ones. **T_9** and **T_1** treatments, recorded significantly highest (1.46ppm) and lowest (1.12 ppm) zinc content, respectively.

Iron availability in soil also followed the trend similar to available zinc content in soil. All the sulphur free treatments (**T_3**, **T_6** and **T_8**) were on par with each other indicating the poor response of iron to increase in fertilizer level.

The treatments imposed had no significant effect on available copper content in soil. But the sulphur application and enhanced fertilizer levels increased available copper content in soils. Highest available copper (3.67 ppm) was recorded in $\mathbf{T_9}$ treatment and the lowest was recorded in $\mathbf{T_1}$ (2.96 ppm) treatment.

Maximum and minimum available manganese content of 8.38 ppm and 6.22 ppm were recorded in $\mathbf{T_9}$ (150 per cent RDF + sulphur @ 30 kg ha^{-1}) and $\mathbf{T_1}$ (control) (table 3). $\mathbf{T_9}$ treatment was on par with all the treatments of the study except $\mathbf{T_3}$ (100 per cent RDF) and $\mathbf{T_1}$.

Though not significant, increased levels of fertilizer NPK increased the available micronutrient status in soil. This was more pronounced with sulphur application. The increased availability of micronutrients (Fe, Cu, Zn and Mn) can be attributed to their high solubility under reduced soil pH associated with use of NPK and S fertilizer. (Brady and Weil, 1999; Akbari *et al*., 1999; Havlin *et al*., 2005 and Heydarnezhad *et al*., 2012).

Microbial biomass carbon

Increase in the fertilizer levels had no significant effect on biomass carbon content of soil (table 3). $\mathbf{T_7}$ and $\mathbf{T_1}$ which received 125 per cent RDF + S @ 30 kg ha^{-1} and no fertilizers respectively, recorded highest (532.7 $\mu g\ g^{-1}$ soil) and lowest (435.7 $\mu g\ g^{-1}$ soil) microbial biomass carbon. There was No significant impact of sulphur on microbial biomass carbon (Gupta *et al.*, 1988). The increased root biomass and root exudates with the application of fertilizers and sulphur might have resulted in higher microbial biomass carbon over control treatment as reported by Nakhro and Dkhar (2010) and Ritu and Sanjay (2012).

Bacterial population

Plate count agar (PCA) is a microbiological growth medium commonly used to assess "total" or viable bacterial growth of a sample. PCA is not a selective medium. Sulphur application enhanced the total bacterial population, but higher doses of fertilizers had no significant effect. All the sulphur applied treatments ($\mathbf{T_9}$, $\mathbf{T_7}$ and $\mathbf{T_4}$) were on par with each other. Similar trend was observed in non sulphur treatments ($\mathbf{T_8}$, $\mathbf{T_6}$ and $\mathbf{T_3}$). Farmers practice ($\mathbf{T_2}$) (243×10^3 CFU g^{-1} soil) was also at par with soil test based recommendation ($\mathbf{T_5}$) (217×10^3 CFU g^{-1} soil).

Maximum counts of PSB and *Azotobacte*r (24×10^3 and $42\text{x}10^3$ CFU g^{-1} soil) were recorded in treatments $\mathbf{T_5}$ (soil test based recommendation) and $\mathbf{T_7}$ (125 per cent RDF + S @ 30 kg ha^{-1}) respectively and the minimum of 15×10^3 and 26×10^3 CFU g^{-1} soil of PSB and *Azotobacter*, respectively were recorded in $\mathbf{T_1}$. Sulphur applied treatments ($\mathbf{T_9}$, $\mathbf{T_7}$, $\mathbf{T_4}$) and sulphur free treatments ($\mathbf{T_8}$, $\mathbf{T_6}$, $\mathbf{T_3}$) were on par with each other.

The populations of *Rhizobium* had followed a significant trend with the treatments imposed as shown in table 3. Among the sulphur applied treatments, $\mathbf{T_7}$ (41×10^3 CFU g^{-1} soil) and among the sulphur free treatments, $\mathbf{T_6}$ where 125 per cent RDF were applied were significantly superior. Soil test based recommendation ($\mathbf{T_5}$) (37×10^3) was significantly better than farmers practice ($\mathbf{T_2}$) ($27\text{x}10^3$).

Table 1 : Effect of fertilizer levels on soil physical and physico-chemical properties at harvest.

Treatments	Bulk density ($Mg\ m^{-3}$)	pH	EC ($dS\ m^{-1}$)	Organic carbon (%)	CEC (cmol (p^+) kg^{-1})
$\mathbf{T_1}$ - Control	1.39	7.7	0.393	0.37	35.36
$\mathbf{T_2}$ - Farmers practice	1.36	7.6	0.523	0.40	36.09
T_3 - 100% recommended dose of fertilizers	1.35	7.6	0.387	0.41	37.39
$\mathbf{T_4}$ - 100% recommended dose of fertilizers + sulphur @30 kg ha^{-1}	1.33	7.5	0.413	0.46	38.39
$\mathbf{T_5}$ - Soil test based recommendation	1.33	7.6	0.397	0.42	35.58
$\mathbf{T_6}$ - 125% recommended dose of fertilizers	1.36	7.6	0.407	0.44	37.75
$\mathbf{T_7}$ - 125% recommended dose of fertilizers + sulphur @ 30 kg ha^{-1}	1.33	7.4	0.463	0.47	38.55
$\mathbf{T_8}$ - 150% recommended dose of fertilizers	1.36	7.6	0.437	0.46	37.97
$\mathbf{T_9}$ - 150% recommended dose of fertilizers + sulphur @ 30 kg ha^{-1}	1.34	7.4	0.483	0.48	39.13
S.Em.±	**0.02**	**0.07**	**0.03**	**0.03**	**2.32**
CD @ 0.05	**NS**	**NS**	**0.096**	**NS**	**NS**
CV (%)	**2.13**	**1.6**	**12.78**	**10.62**	**10.76**

Table 2 : Effect of fertilizer levels on nutrient content of soil at harvest.

Treatments	Nitrogen	P_2O_5	K_2O	Sulphur	Zinc	Iron	Copper	Manganese
	(kg ha^{-1})			(ppm)				
T_1 - Control	163	20	638	35	1.12	7.67	2.96	6.22
T_2 - Farmers practice	207	31	882	35	1.30	8.44	3.36	7.61
T_3 - 100% recommended dose of Fertilizers	191	22	840	41	1.24	8.15	3.03	7.14
T_4 - 100% recommended dose of fertilizers + sulphur @30 kg ha^{-1}	205	24	856	47	1.34	8.20	3.11	7.42
T_5 - Soil test based recommendation	212	22	769	43	1.27	7.91	3.20	7.88
T_6 - 125% recommended dose of Fertilizers	208	25	846	42	1.28	8.58	3.19	7.48
T_7 - 125% recommended dose of fertilizers + sulphur @ 30 kg ha^{-1}	210	27	865	45	1.35	8.77	3.21	7.93
T_8 - 50% recommended dose of fertilizers	217	30	888	36	1.37	8.55	3.50	8.24
T_9 - 150% recommended dose of fertilizers + sulphur @ 30 kgha^{-1}	229	30	910	43	1.46	9.51	3.67	8.38
S Em ±	**9.58**	**1.32**	**23.57**	**1.50**	**0.06**	**0.35**	**0.25**	**0.39**
CD @ 0.05	**29**	**4.0**	**71**	**5.0**	**0.17**	**1.06**	**NS**	**1.16**
CV (%)	**8.11**	**8.90**	**4.90**	**6.38**	**7.64**	**7.24**	**13.06**	**8.86**

Table 3 : Effect of fertilizer levels on microbial population (x10^3 CFU g^{-1} soil) in soil.

Treatments	MBC (µg g^{-1} soil)	PCA (× 10^3)	PSB (× 10^3)	*Rhizobium* (× 10^3)	*Azotobacter* (× 10^3)
T_1 - Control	435.7	155	15	23	26
T_2 - Farmers practice	452.0	243	16	27	36
T_3 - 100% recommended dose of fertilizers	485.7	181	19	32	31
T_4 - 100% recommended dose of fertilizers + sulphur sulphur @30 kg ha^{-1}	496.0	230	23	33	37
T_5 - Soil test based recommendation	481.7	217	24	37	30
T_6 - 125% recommended dose of fertilizers	527.7	185	17	39	33
T_7 - 125% recommended dose of fertilizers + sulphur @ 30 kg ha^{-1}	532.7	255	21	41	42
T_8 - 150% recommended dose of fertilizers	508.0	174	16	34	30
T_9 - 150% recommended dose of fertilizers + sulphur @ 30 kg ha^{-1}	518.3	234	18	35	37
S Em ±	17.43	14	2.0	2.0	2.0
CD @ 0.05	52.24	43	5.0	6.0	7.0
CV (%)	6.12	12	16	10	13

The positive effect of fertilizer application on bacterial growth was also proved by Nakhro and Dkhar (2010), Basu *et al.* (2011) and Lazcano *et al.* (2013). Sulphur functions as a nutritional source for microbes and increases their population (Gupta *et al.*, 1988 and Lal and Twari, 2014).

Conclusion

The treatments imposed had no significant impact on soil physical and physico-chemical properties. When compared to non sulphur treatments, sulphur applied treatments were superior in case of available nutrient status in soil. Among the sulphur applied treatments, though 150 per cent RDF + sulphur @ 30 kg ha^{-1} (**T_9**) recorded highest available macro and micronutrient status in soil, it was on par with 125% RDF + sulphur @ 30 kg ha^{-1} (**T_7**) and 100% RDF + sulphur @ 30 kg ha^{-1} (**T_4**). Inorganic fertilizer application enhanced the microbial biomass carbon, plate count agar and functional bacterial population. Combination of sulphur had a positive effect on soil microbes. But, application of higher dose of fertilisers over the optimum dose can reduce the biological activity in the soil. What is important is not the absence, but the balance of chemical and organic inputs

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