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Effect of Long-Term Fertilization on Nutrient Content, Uptake and yield of Cotton

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ABSTRACT

The experiment was under taken during 2013-14 to study the effect of long-term use of manures and fertilizers on nutrient content and uptake in cotton at harvest stage. The results of the investigation indicated that the application of 100% recommended dose of NPK + FYM 10 t ha^{-1} recorded significantly higher kapas yield and uptake of nutrients by cotton crop which was followed by 150 per cent recommended dose of NPK. The kapas yield of cotton,with 100% NPK + FYM 10 t ha^{-1} was 132.3 per cent increase over control. Application of recommended dose of 100% N alone through fertilizers decreased the yield and uptake of nutrients significantly over 100% recommended dose of NPK + FYM 10 t ha^{-1}. Maximum content and accumulation of N, P, K, Fe, Mn and Cu in cotton were noticed in the treatment of 100% NPK + FYM 10 t ha^{-1}.

Key words : FYM, Long-term fertilization, Kapas yield, Nutrient content, Uptake.

Soil fertility is the important constraint for crop production in dry land agriculture. Increase in the number of nutrient deficiencies year after year reflects the non sustainability of the present crop production practices. Use of organic manures proved to retain the soil fertility to some extent. Organics act as a host of plant nutrients and some extent alleviate the deficiencies and stabilize the crop production.

Balanced fertilization through integrated use of manures and fertilizers has been found sustainable in cotton crop production. Hence in order to investigate the long-term influence of fertilization on nutrient content in plant and uptake by crop as well as on crop productivity, a study was undertaken with cotton crop in Vertisol.

MATERIAL AND METHODS

The long-term manures and fertilizer experiment is being conducted at Regional Agricultural Research Station, Lam, Guntur in Andhra Pradesh (Altitude of 31.5 m above mean sea level, 16^0 2' N latitude and longitude of 80^0 3' E). The present investigation was undertaken during 2013-14, after 22nd cropping cycles of the long-term experiment. The experiment consisted of eleven treatments *viz*., T_1 - Control, T_2 - 50% of the recommended dose of NPK, T_3 - 100% of the recommended dose of NPK, T_4 - 150% of the recommended dose of NPK, T_5 - 100% of the recommended dose of NP, T_6 - 100% of the recommended dose of N, T_7 - T_3+FYM @ 10 t ha^{-1}, T_8 - T_3+ $ZnSO_4$ @ 50 kg ha^{-1}, T_9 - T_3+$MgSO_4$ @ 50 kg ha^{-1}, T_{10} - 200% of the recommended dose of NPK and T_{11} - T_3+gypsum @ 5 q ha^{-1}.

The recommended dose of 90:45:45 kg N, P2O5 and K2O ha^{-1} was applied through urea (46 % N), single superphosphate (16 % P2O5) and muriate of potash (60 % K2O), as per the treatments. FYM was applied 10 days before sowing in the respective treatment. Phosphorus, $ZnSO_4$ and MgSO4 and gypsum (soil application) were done before sowing. Nitrogen and potassium were applied as three splits.

During the year of study, cotton (L-799) was sown during first fortnight of August and harvested in second fortnight of January (1st picking). The plant samples were collected from above the ground portion of the plant and stored in labeled brown paper bags for further analysis after processing.

Total nitrogen in plant sample was determined by MicroKjeldahl method by using distillation units (Piper, 1966). Di-acid extract was prepared as per the method outlined by Jackson (1973). It was carried out using a 9:4 mixture of

HNO_3:$HClO_4$. The pre-digestion of sample was done by using 10 ml of di acid mixture g^{-1} sample. This di-acid extract was used to determine P, K, S, Ca, Mg and micronutrient content in the plant sample. Phosphorus was determined spectrophotometrically by Vanadomolybdate phosphoric acid yellow colour method as described by Jackson (1973). Potassium was estimated from di-acid extract and reading was recorded using flame photometer (Jackson, 1973). Total sulphur was estimated by turbidimetrically (Piper, 1966). Calcium and magnesium were estimated by EDTA method by Hesse (1971). Micronutrients were estimated by using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Dry matter accumulation

The data table 1 reveled that highest dry matter accumulation of 6511 kg ha^{-1} and lowest of 2775 kg ha^{-1} were recorded in T_7 (100 per cent recommended dose of NPK+Farm yard manure @ 10 t ha^{-1}) and T_1 (control), respectively. The treatments T_7, T_4, T_{10} and T_{11} registered 134.6, 129.3, 112 and 100.0 per cent higher dry matter accumulation, respectively over control (T_1). The increase in dry matter production up to super optimal dose level *i.e.* 150 per cent RDF might be owing to better uptake of different nutrients and their translocation to the sink. Control plot showed a drastic reduction in the dry matter accumulation due to the removal of nutrients with continuous cropping without fertilization, which caused deficiency and thus reduction in dry matter accumulation (Bharadwaj and Omanwar, 1994).

Seed cotton yield (kg ha^{-1})

Cotton seed yield was significantly influenced leg different nutrient management practices (Table 1). Among the combined treatments, the treatment which received Farm yard manure @ 10 t ha^{-1} along with 100% recommended dose of NPK (T_7) showed significantly higher seed cotton yield (2181 kg ha^{-1}) over T_8 (100% recommended dose of NPK+$ZnSO_4$ @ 50 kg ha^{-1}) with 1806 kg ha^{-1}, T_9 (100% RD of NPK+$MgSO_4$ @ 50 kg ha^{-1}) with 1797 kg ha^{-1} and T_{11} (100 % RD of NPK+gypsum @ 5 q ha^{-1}) with 1862 kg ha^{-1}. The treatments T_8, T_9 and T_{11} were on par with each other. The seed cotton yield was 92.3, 91.4, 98.3 and 132.3 per cent more by T_8, T_9, T_{11} and T_7 over control treatment, respectively. The use of organic manures like FYM increases the microbial activity which in turn helps in transformation of nutrients making them more available to plants. Similar observations were reported by Lalithakumari *et al.* (2010), Solunke *et al.* (2011) and Uday *et al.* (2013).

Nitrogen, Phosphorus and Potassium content in cotton at harvest stages.

At harvest stage, the highest N, P and K content in plant (Table 2) was noticed in T_7 (100% NPK + 10 t FYM ha^{-1}) but N and P content were found at par with 150% RD of NPK and 200% RD of NPK treatments. Increasing dose of inorganic fertilizers showed enhanced primary nutrient content in cotton upto 150% RD of NPK. The treatments 100% NPK+$ZnSO_4$ @ 50 kg ha^{-1} (T_8), 100% NPK+$MgSO_4$ @ 50 kg ha^{-1} (T_9) and 100% RD of NPK + gypsum 5 q ha^{-1} (T_{11}) recorded more nitrogen content in cotton plant over 100% RD of NPK treatment (T_3). The higher nutrient content resulted on integrated management of organic and inorganic sources (T_7) might be the cause for increased concentration of nutrients mainly nitrogen in cotton (Nawlakhe and Mankar, 2011).

Phosphorus content in cotton was highest (0.50%) in treatment T_7 that received (100% RD of NPK + 10 t FYM ha^{-1}). The increased content of phosphorus with conjunctive use of FYM and inorganics might be due to the formation of phosphohumic complexes, which are more easily assimilated by the plants.

The highest K content was recorded in the treatment T_7 (100 per cent recommended dose of NPK+FYM @ 10 t ha^{-1}) with 2.73 per cent followed by T_4 (150 per cent recommended dose of NPK) with 2.65 per cent.

Calcium, Magnesium and Sulphur content in cotton at harvest stage

Ca, Mg and S content in cotton plant (Table 2) were significantly influenced with the application of different fertilizers like gypsum, $MgSO_4$ and $ZnSO_4$. Application of gypsum 5 q ha^{-1} along with 100% RD of NPK (T_{11}) recorded highest Ca (3.15%) and with application of $MgSO_4$ @ 50 kg

Table 1 Effect of long-term use of manures and fertilizers on dry matter accumulation (kg ha^{-1}) and yield of cotton.

Treatments	Dry matter accumulation (kg ha^{-1})	% increase over control	Seed cotton yield (kg ha^{-1})	% increase over control
T1: Control	2775	-	939	-
T2: 50% RD of NPK	4066	46.5	1370	46.0
T3: 100% RD of NPK	5169	86.3	1735	84.8
T4: 150% RD NPK	6363	129.3	2135	127.4
T5: 100% RD of NP	4553	64.0	1527	62.6
T6: 100% RD of N	4164	50.0	1399	49.0
T7: T3 + FYM @ 10 t ha^{-1}	6511	134.6	2181	132.3
T8: T3 + $ZnSO_4$ @ 50 kg ha^{-1}	5393	94.3	1806	92.3
T9: T3 + $MgSO_4$ @ 50 kg ha^{-1}	5359	93.1	1797	91.4
T10: 200% RD of NPK	5893	112.3	1980	110.9
T11: T3 + gypsum @ 5 q ha^{-1}	5548	100.0	1862	98.3
SEm±	260.7		104.9	-
CD (0.05)	769		316	-
CV (%)	8.9		11.2	-

ha^{-1} recorded highest (0.52%) Mg content in cotton plant over all the treatments. The highest sulphur content (0.51%) was recorded in the treatment 100% RD of NPK coupled with $MgSO_4$ @ 50 kg ha^{-1} (T_9) followed by gypsum applied treatment. The lowest content of Ca, Mg and S was recorded in control.

Fe, Mn, Cu and Zn (Micronutrients content) at harvest stage

A perusal of data in table 2 indicate that the highest iron content at both the stages were in T_7 (181.7 ppm) with application of 100 per cent recommended dose of NPK+FYM @ 10 t ha^{-1}. But it was not significantly varying with other treatments. The Mn and Cu content was higher (69.1 ppm and 21.9 ppm) in T_7 with application of 100 per cent recommended dose of NPK+FYM @ 10 t ha^{-1}. The highest zinc content of 43.7 ppm was recorded in T_8 (NPK+$ZnSO_4$ @ 50 kg ha^{-1}) and followed by T_7 (100 % RD of NPK with FYM @ 10 t ha^{-1}). The lowest Fe, Mn, Cu and Zn content was observed in T_1 control which was on par with T_{10}.

The results were in agreement with the findings of Banerjee *et al*. (2006) who reported that higher content of micronutrients with the addition of organics over chemical fertilizer at all the stages of the crop could be due to release of these nutrients into soil solution by mineralization.

Uptake of nutrient by cotton at harvest stage

Continuous manuring and fertilization at the same site for long period affects the soil fertility and there by uptake of nutrient by crop (presented in the table 3). In this present study increasing trend in uptake of primary nutrient by cotton was observed with increasing fertilizer levels from 50 to 150 per cent of RDF and slightly decreased at 200% RDF. The highest uptake of N, P and K (176.5, 31.6 and 173.9 kg ha^{-1} respectively) were recorded with the application of 100% RD of NPK + FYM 10 t ha^{-1} followed by 150% RD of NPK.

The lowest total uptake of N, P and K were observed i.e. 61.5, 7.0 and 63.1 kg ha^{-1} respectively by cotton in control treatment. Application of super optimal dose (T_4 150% RD of NPK) of treatment showed significant increase in N, P and K uptake by cotton over 50%, 100% RDF and control.

The application of 100% RD of NPK in conjunction with 10 t FYM (T_7) recorded significantly highest uptake of S, Ca and Mg by cotton (30.5, 197.6 and 31.8 kg ha^{-1} respectively). The lowest uptake of secondary nutrients by cotton plant was observed in control. The incorporation of 10 t ha^{-1} FYM along with 100% RDF recorded

Table 2 Effect of long-term use of manures and fertilizers on nutrient content of cotton at harvesting stage.

Treatments	N	P	K	S	Ca	Mg	Fe	Mn	Cu	Zn
	%						ppm			
T1: Control	2.22	0.26	2.28	0.22	2.68	0.35	152.9	45.2	10.2	23.0
T2: 50% RD of NPK	2.30	0.32	2.43	0.31	2.74	0.38	169.3	57.4	16.3	31.4
T3: 100% RD of NPK	2.45	0.40	2.50	0.35	2.85	0.42	162.2	54.0	14.4	29.9
T4: 150% RD NPK	2.63	0.47	2.65	0.46	3.04	0.46	160.8	51.4	13.4	26.9
T5: 100% RD of NP	2.42	0.38	2.44	0.35	2.81	0.41	165.3	52.6	15.9	29.9
T6: 100% RD of N	2.40	0.34	2.38	0.32	2.79	0.39	161.0	53.9	15.1	27.7
T7: T3 + FYM @ 10 t ha^{-1}	2.77	0.50	2.73	0.48	3.07	0.50	181.7	69.1	21.9	42.7
T8: T3 + $ZnSO_4$ @ 50 kg ha^{-1}	2.48	0.42	2.53	0.50	2.82	0.43	164.6	54.8	16.6	43.7
T9: T3 + $MgSO_4$ @ 50 kg ha^{-1}	2.47	0.41	2.51	0.49	2.85	0.52	166.2	54.3	17.0	32.9
T10: 200% RD of NPK	2.60	0.44	2.60	0.44	2.99	0.47	160.4	51.6	13.2	25.1
T11: T3 + gypsum @ 5 q ha^{-1}	2.52	0.40	2.54	0.51	3.15	0.45	168.2	56.8	19.2	33.4
SEm±	0.08	0.03	0.09	0.02	0.09	0.02	5.09	2.21	1.04	1.46
CD (0.05)	0.23	0.09	NS	0.06	0.27	0.07	NS	6.5	3.1	4.3
CV (%)	5.4	13.4	5.9	9.4	5.4	9.8	5.3	7.0	11.4	8.0

Table 3. Effect of long-term use of manures and fertilizers on nutrient uptake of cotton at harvesting stage.

Treatments	N	P	K	S	Ca	Mg	Fe	Mn	Cu	Zn
	kg ha^{-1}						g ha^{-1}			
T1: Control	61.5	7.0	63.1	6.1	74.3	9.7	424.3	124.8	28.5	64.0
T2: 50% RD of NPK	93.8	13.1	99.0	12.5	111.6	15.3	688.1	233.5	66.1	127.6
T3: 100% RD of NPK	126.9	20.7	129.4	18.1	147.5	21.7	838.3	279.3	74.3	155.0
T4: 150% RD NPK	171.8	30.3	171.9	30.3	195.5	30.1	1051.3	334.7	86.7	174.6
T5: 100% RD of NP	110.1	17.2	110.5	16.1	127.5	19.0	753.4	238.9	72.7	136.0
T6: 100% RD of N	99.8	14.1	99.2	13.5	116.2	16.4	670.7	224.2	62.8	115.3
T7: T3 + FYM @ 10 t ha^{-1}	176.5	31.6	173.9	30.5	197.6	31.8	1156.0	439.6	139.5	271.5
T8: T3 + $ZnSO_4$ @ 50 kg ha^{-1}	133.7	22.1	136.5	27.0	152.1	23.2	887.7	295.8	89.4	235.7
T9: T3 + $MgSO_4$ @ 50 kg ha^{-1}	132.4	21.9	134.6	26.4	152.7	27.9	890.1	291.8	91.6	175.6
T10: 200% RD of NPK	153.5	25.7	152.9	25.7	176.2	27.5	945.6	304.0	78.0	147.6
T11: T3 + gypsum @ 5 q ha^{-1}	140.1	22.7	141.1	28.2	174.6	24.7	932.7	313.9	105.9	184.7
SEm±	8.3	1.8	6.9	1.7	8.2	1.6	55.7	19.5	5.9	9.4
CD (0.05)	24.5	5.5	20.6	5.0	24.4	4.8	164.5	57.6	17.6	27.8
CV (%)	11.3	15.7	9.4	13.9	9.7	12.6	11.5	12.1	12.6	10.0

significantly higher uptake of calcium and magnesium over control. Similar results were noticed by Jagadeeswari and Kumaraswamy (2000).

Uptake of micronutrients at harvest, among the treatments uptake of Iron, Manganese, Copper and Zink by T_7 with combined application of 100% RD of NPK with FYM @ 10 t ha^{-1} was 1156.0, 439.6, 139.5 and 271.5 g ha^{-1} followed by 150% RD of NPK. The increase in the uptake of cationic micronutrients with the application of FYM along with inorganic nitrogen might be due to the release of micronutrients on mineralization or production of organic acids during their decomposition which aids in solubilization of insoluble micronutrient compounds in soil or due to supply of natural chelating agents which renders it more available.

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