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Effect of Long Term Fertilization on Nutrient Content and Total Uptake by Crop in Vertisols under Sorghum-Wheat Cropping Sequence

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ABSTRACT

The experiment was under taken during the year 2007-08 to study the effect of long term fertilization on nutrient content and uptake. The research was conducted in the ongoing long term fertilizer experiment initiated since *kharif* 1988 at Akola, Maharashtra. The results of the investigation indicated that the application of 100% recommended dose of NPK + FYM 10 t ha^{-1} recorded significantly higher grain yield and uptake of nutrients by sorghum and wheat crops which was followed by 150% recommended dose of NPK. The increase in the grain yield of sorghum and wheat in the treatment of 100% NPK + FYM 10 t ha^{-1} was recorded to the extent of 31.3 and 26.0 per cent over 100% NPK. Application of 100% NPK through S free fertilizers decreased the yield and uptake of nutrients significantly over 100% NPK containing sulphur. Maximum contents of N, P, K, S, Ca and Mg in grain as well as straw and significantly the highest total uptake were noticed in the treatment of 100% NPK + FYM 10 t ha^{-1} followed by 150% recommended dose of NPK.

Key words : Long term fertilization, Sorghum, Total uptake, Wheat.

The balanced fertilization through integrated use of manures and fertilizers has been found useful in various cropping sequences. 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, the present study was undertaken in sorghum-wheat cropping sequence on Vertisol.

MATERIAL AND METHODS

The long term fertilizer experiment was initiated during *kharif* 1988 on the Research Farm of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in Maharashtra ($22^0$42' N and $77^0$02' E, 307.42 m above mean sea level). The soil is Vertisol with alkaline reaction (pH 8.1), high cation exchange capacity (48 c mol (p^+) kg^{-1}), medium soil organic carbon (4.6 g kg^{-1}), total nitrogen (0.044 %), low available phosphorus (8.4 kg ha^{-1}) and high available potassium (358 kg ha^{-1}). The present investigation was undertaken during 2007-08 after 19th cropping cycle of this long term experiment.

The experiment consisted of twelve treatments *viz.*, T_1- 50 % NPK, T_2- 100 % NPK, T_3- 150 % NPK , T_4- 100 % NPK(S free), T_5- 100 % NPK + 2.5 kg Zn ha^{-1}, T_6-100 NP, T_7- 100 % N, T_8- 100 % NPK+ FYM @10 t ha^{-1}, T_9-100 % NPK (S free) + 37.5 kg S ha^{-1}, T_{10}- FYM @ 10 t ha^{-1}, T_{11}- 75 % NPK and T_{12}-Control. The experiment is laid out in RBD and replicated four times. The experiment is being conducted on same site and same randomization. The nutrients were applied through the fertilizers like urea, single super phosphate, muariate of potash, diammonium phosphate (T_4 and T_9). Sulphur is applied through gypsum (T_9 only) for sorghum crop and zinc is applied through zinc sulphate once in two years for wheat crop only (T_5 only).The farmyard manure was applied every year one month before sowing of sorghum crop.

The recommended fertilizer doses were applied as 100:50:40 and 120:60:60 kg N, P_2O_5 and K_2O ha^{-1} to sorghum and wheat crops, respectively. During the year of study, sorghum (CSH-9) was sown during first week of July and harvested in second week of November and wheat (AKW-1071) was sown during second fortnight of November and harvested in first week of April. The plant samples were ground in willey mill and stored in labeled brown paper bags for further analysis. The grain samples were also processed and stored in similar fashion.

Total nitrogen in plant sample was determined by Modified Kjeldahl's method by using Kel Plus digestion and distillation units (Piper, 1966). Di-acid extract was prepared as per the method outlined by Jackson (1967). 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 HNO_3 g^{-1} sample. This di-

Table 1. Yield of sorghum and wheat under long term fertilization in sorghum-wheat cropping sequence

Treatments	Sorghum (q ha^{-1})		Wheat (q ha^{-1})	
	Grain	Straw	Grain	Straw
T_1 - 50%NPK	26.25	64.57	14.40	18.98
T_2 - 100%NPK	38.71	95.23	27.32	36.57
T_3 - 150%NPK	46.12	113.45	32.16	44.28
T_4 - 100%NPK (S free)	34.67	85.28	24.01	31.65
T_5 - 100%NPK + 2.5 kg Zn ha^{-1}	39.98	98.48	28.07	38.29
T_6 - 100%NP	27.63	68.02	14.35	18.92
T_7 - 100%N	21.69	53.64	10.26	13.88
T_8 - 100%NPK +10 t FYM	50.84	125.81	34.41	46.04
T_9 - 100%NPK + 37.5 kg S ha^{-1}	39.36	97.35	25.73	32.55
T_{10} - FYM only 10 t ha^{-1}	15.84	39.21	3.01	4.33
T_{11} - 75% NPK	30.98	76.63	18.91	25.09
T_{12} – Control	1.98	4.75	0.56	0.83
SE(m)±	0.76	1.86	0.71	0.77
CD at 5%	2.18	5.35	2.03	2.22

acid extract was used to determine P, K, S, Ca, Mg content in the plant sample. Phosphorus was determined spectrophotometrically by Vanadomolybdate phosphoric acid yellow colour method from di-acid extract described by Jackson (1967). Potassium was estimated from di-acid extract and reading was recorded using flame photometer (Jackson .1967). Total sulphur was estimated by Turbidimetric ally (Piper, 1966). Calcium and magnesium were estimated by EDTA method by Hesse (1971).

Simple correlations were calculated and critical difference at 5% level of significance was used for comparison. The treatment differences were tested by F-test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Grain and fodder yield of sorghum

The grain and fodder yield of sorghum are presented in Table 1. The various manuring and fertilization treatments significantly influenced the grain and fodder yield of sorghum. Significantly the highest grain yield of sorghum (50.84 q ha^{-1}) was obtained with application of 100% NPK + 10 t FYM ha^{-1} followed by 150% NPK (46.12 q ha^{-1}) and these treatments were significantly superior over 100% NPK alone whereas the lowest yield was obtained in the control plot (1.98 q ha^{-1}).

Grain yield of sorghum was significantly increased with application of 37.5 kg S ha^{-1} coupled with 100% NPK over 100% NPK (S free). Increasing levels of NPK showed linear and significant increase in grain and fodder yield of sorghum. Significantly lowest grain yield was recorded in the control treatment. This indicates that for sustainability of yield in sorghum, integrated use of organics and inorganic fertilizers are essential which is further substantiated by the results reported by Naphade *et al* ., (1995) and Ravankar *et al.,* (1998). They found that conjunctive use of FYM and NPK are advantageous for achieving higher productivity.The straw yield of sorghum showed similar trend as observed in grain yield.

Grain and straw yield of wheat

The data in respect to grain and straw yield of wheat are presented in Table 1. The treatment 100% NPK + FYM 10 t ha^{-1} exceeded all other treatments and was found superior in respect of grain (34.41 q ha^{-1}) and straw (46.04 q ha^{-1}) yields of wheat and at par with treatment 150% NPK. Use of recommended dose of NPK through sulphur free fertilizers decreased the grain and straw yield of wheat significantly over recommended NPK containing sulphur. Sulphur application enhanced the wheat yield significantly. Similar findings are reported by Kaushik and Sharma (1997). The lowest grain and straw yield (0.56 q ha^{-1}and 0.83 q ha^{-1}) was recorded in control (T_{12}).

The treatment with FYM 10 t ha^{-1} alone recorded significantly higher grain yield (3.01 q ha^{-1}) over control but was inferior to 100% NPK. The residual of nutrients from FYM which applied before sowing of sorghum was reduced for wheat yield as

Table 2. Long term effect of various treatments on macronutrient content in sorghum grain under sorghum-wheat cropping sequence

Treatments	Nutrient content (%)					
	N	P	K	S	Ca	Mg
T_1 - 50%NPK	1.325	0.344	0.419	0.122	0.170	0.107
T_2 - 100%NPK	1.415	0.363	0.472	0.153	0.187	0.118
T_3 - 150%NPK	1.534	0.419	0.545	0.175	0.219	0.138
T_4 - 100%NPK (S free)	1.323	0.363	0.456	0.140	0.171	0.108
T_5 - 100%NPK + 2.5 kg Zn ha^{-1}	1.422	0.371	0.489	0.157	0.183	0.119
T_6 - 100%NP	1.323	0.376	0.479	0.155	0.171	0.108
T_7 - 100%N	1.287	0.338	0.467	0.148	0.166	0.105
T_8 - 100%NPK +10 t FYM ha^{-1}	1.543	0.440	0.563	0.197	0.221	0.139
T_9 - 100%NPK + 37.5 kg S ha^{-1}	1.446	0.375	0.472	0.205	0.194	0.122
T_{10} - FYM only 10 t ha^{-1}	1.276	0.334	0.395	0.148	0.206	0.130
T_{11} - 75% NPK	1.367	0.348	0.442	0.135	0.183	0.115
T_{12} – Control	1.223	0.314	0.352	0.112	0.163	0.103
SE(m)±	0.009	0.009	0.005	0.003	0.001	0.001
CD at 5%	0.024	0.023	0.013	0.008	0.003	0.002

Table 3. Total uptake of macro nutrients by sorghum under long term fertilization in sorghum-wheat cropping sequence

Treatments	Nutrient uptake (kg ha^{-1})					
	N	P	K	S	Ca	Mg
T_1 - 50%NPK	70.3	19.5	103.0	11.2	41.0	26.1
T_2 - 100%NPK	113.5	32.3	156.6	20.6	66.5	42.0
T_3 - 150%NPK	149.9	42.9	205.4	29.2	92.9	58.9
T_4 - 100%NPK (S free)	96.2	28.2	140.9	15.7	54.4	34.5
T_5 - 100%NPK + 2.5 kg Zn ha^{-1}	122.8	33.5	161.1	20.6	67.5	42.8
T_6 - 100%NP	75.3	21.5	112.1	14.1	43.4	27.5
T_7 - 100%N	56.8	15.1	87.5	11.5	33.3	21.1
T_8 - 100%NPK +10 t FYM ha^{-1}	163.8	49.1	234.6	37.4	103.7	65.6
T_9 - 100%NPK + 37.5 kg S ha^{-1}	123.8	34.4	167.0	24.5	70.4	44.6
T_{10} - FYM only 10 t ha^{-1}	43.3	11.1	63.5	7.2	30.2	19.1
T_{11} - 75% NPK	92.7	24.1	122.5	14.5	52.3	33.2
T_{12} - Control	4.5	1.2	7.3	0.8	2.9	1.8
SE(m)±	2.5	1.0	3.3	0.7	1.7	0.9
CD at 5%	6.9	2.6	9.2	2.0	4.8	2.6

compared to sorghum. This might be attributed that the sorghum crop grown in *kharif* absorbed the nutrients and less residual nutrients could be remained and balanced for wheat crop during *rabi* season.

Nitrogen, phosphorus and potassium content in sorghum grain

N, P and K content (Table 1) was noticed significantly superior over all the treatments in T_8 (100% NPK + 10 t FYM ha^{-1}) but N and P content were found at par with 150% NPK treatment. Increasing dose of inorganic fertilizers showed enhanced primary nutrient content in sorghum grain. The treatment 100% NPK + 37.5 kg sulphur (T_9) recorded 9.3 per cent more nitrogen content in grain over 100% NPK (S free) treatment (T_4).

Phosphorus content in grain was significantly higher in treatment that received phosphorus (T_6) than in treatments without phosphorus (T_7). Application of optimal dose of NPK showed significant increase in primary nutrient content in grain over control and the rise was to the extent of 11.5, 15.6 and 34.1 per cent NPK respectively (Walia *et al.,* 1980). The lower phosphorus content in sorghum plant due to the addition of FYM might be due to intense microbial activity in *kharif* season and there by its immobilization (Mali *et al.,* 1997).

Calcium, magnesium and sulphur content in sorghum grain

Ca, Mg and S content in sorghum grain (Table 2) significantly influenced with the application of NPK alone and in combination with FYM. Application of 10 t FYM ha^{-1} along with 100% NPK (T_8) recorded significantly highest Ca and Mg content (0.221and 0.139%) in sorghum grain over all the treatments whereas the highest sulphur content (0.205%) was recorded in the treatment 100% NPK coupled with 37.5 kg S ha^{-1} (T_9).

Sulphur content in grain was recorded significantly higher in 100% NPK treatment (T_2) (0.150%) as compared to 100% NPK (S free) (0.140%) and it was extent of 25 per cent. Lowest content of Ca, Mg and S was recorded in control. There was 46.43 per cent higher sulphur content in treatment 100% NPK + 37.5 kg S than 100% NPK (S free) treatment. FYM treatment only is significantly superior in content of calcium and magnesium over control similar results were noticed by Jagadeeswari and Kumaraswamy (2000).

Total uptake of macronutrient by sorghum

Continuous manuring and fertilization at the same site for long period affects the soil fertility and there by uptake of nutrient by crops. In the present investigation uptake of macro nutrients (N, P, K, S, Ca and Mg) by sorghum plant at harvest were estimated and presented in the Table 3.

In this present study increasing trend in uptake of primary nutrient by sorghum was observed with increasing fertilizer levels from 50 to 150 per cent of RDF. The highest uptake of N, P and K (163.8, 49.1 and 234.6 kg ha^{-1} respectively) were recorded with the application of 100% NPK + FYM 10 t ha^{-1} followed by 150% NPK. The results are supported by the findings reported by Tyagi and Bharadwaj (1994) who revealed that the addition of FYM along with 100% NPK increased the uptake of nutrients.

The lowest total uptake of N, P and K were observed i.e. 4.5, 1.2, 7.3 kg ha^{-1} respectively by sorghum in control treatment. Phosphorus uptake by sorghum was significantly higher in treatment received phosphorus (T_6) (21.5 kg ha^{-1}) as compared to the treatments without phosphorus (T_7) (15.1 kg ha^{-1}). Application of optimal dose of treatments showed significant increase in N, P and K uptake by sorghum over 50%, 75% RDF and control.

The treatment FYM 10 t ha^{-1} (T_{10}) only noticed significantly less total uptake of N, P and K as compared to 50% RDF (T_1) treatment. This revealed that the less nutrient supply through FYM leading to low uptake. The treatment 100% NPK + 37.5 kg sulphur (T_9) was recorded 28.7, 22 and 18.5 per cent higher nitrogen, phosphorus and potassium uptake over 100% NPK (S free) treatment (T_4). It could be attributed to the higher yield recorded by T_9 treatment by balanced fertilization which helped in more nutrient uptake (Table 1).

The application of 100% NPK in conjunction with 10 t FYM (T_8) recorded significantly highest uptake of S, Ca and Mg by sorghum (37.4, 103.7 and 65.6 kg ha^{-1} respectively). The treatment 100% NPK + 37.5 kg sulphur through gypsum (T_9) recorded 56.1 per cent higher total uptake of sulphur by grain and straw over 100% NPK (S free) treatment (T_4). This could be ascribed to be the availability of S in T_9 treatment.

The lowest uptake of secondary nutrient (0.8 kg ha^{-1} sulphur, 2.9 kg ha^{-1} calcium and 1.8 kg ha^{-1} magnesium) by sorghum plant was observed in control. The incorporation of 10 t ha^{-1} FYM only recorded significantly higher uptake of calcium and magnesium over control. Similar results were noticed by Jagadeeswari and Kumaraswamy (2000).

Macronutrient content in wheat grain

Scrutiny of the data (Table 4) indicates that the macro nutrient content in wheat grain was

Table 4. Long term effect of various treatments on macronutrient content in wheat grain under sorghum wheat cropping sequence

Treatments	Nutrient content (%)					
	N	P	K	S	Ca	Mg
T_1 – 50%NPK	2.253	0.313	0.317	0.145	0.140	0.041
T_2 - 100%NPK	2.434	0.387	0.348	0.189	0.180	0.048
T_3 - 150%NPK	2.456	0.446	0.476	0.201	0.188	0.055
T_4 - 100%NPK (S free)	2.345	0.32	0.441	0.186	0.141	0.046
T_5 - 100%NPK + 2.5 kg Zn ha^{-1}	2.387	0.396	0.395	0.207	0.142	0.042
T_6 - 100%NP	2.314	0.386	0.338	0.158	0.156	0.045
T_7 - 100%N	2.219	0.341	0.336	0.169	0.167	0.049
T_8 - 100%NPK +10 t FYM ha^{-1}	2.481	0.588	0.487	0.212	0.192	0.056
T_9 - 100%NPK + 37.5 kg S ha^{-1}	2.456	0.312	0.472	0.216	0.165	0.048
T_{10} - FYM only 10 t ha^{-1}	2.262	0.478	0.429	0.213	0.191	0.046
T_{11} - 75% NPK	2.423	0.326	0.319	0.156	0.154	0.045
T_{12} - Control	2.215	0.305	0.309	0.125	0.135	0.035
SE(m)±	0.003	0.005	0.011	0.011	0.004	0.001
CD at 5%	0.009	0.013	0.031	0.030	0.012	0.003

Table 5. Total uptake of macronutrients by wheat under long term fertilization in sorghum-wheat sequence

Treatments	Nutrient uptake (kg ha^{-1})					
	N	P	K	S	Ca	Mg
T_1 – 50%NPK	39.86	6.78	33.25	4.60	5.89	3.63
T_2 - 100%NPK	77.55	16.26	66.45	10.85	14.50	7.53
T_3 - 150%NPK	96.81	21.96	92.02	14.79	18.09	10.36
T_4 - 100%NPK (S free)	64.02	12.64	58.35	8.73	10.82	6.30
T_5 - 100%NPK + 2.5 kg Zn ha^{-1}	78.61	16.80	72.74	11.88	14.17	7.77
T_6 - 100%NP	39.50	8.59	37.85	5.10	6.52	3.75
T_7 - 100%N	27.69	5.80	27.29	3.68	4.80	2.77
T_8 - 100%NPK +10 t FYM ha^{-1}	104.53	29.02	96.23	19.10	19.45	11.09
T_9 - 100%NPK + 37.5 kg S ha^{-1}	74.75	13.10	64.29	12.68	13.00	6.80
T_{10} - FYM only 10 t ha^{-1}	8.65	2.52	10.96	1.34	1.77	0.95
T_{11} – 75% NPK	54.38	10.02	44.91	6.63	8.51	4.92
T_{12} – Control	1.48	0.27	1.43	0.45	0.24	0.14
SE(m)±	1.48	0.36	1.52	0.32	0.26	0.16
CD at 5%	4.09	1.00	4.20	0.88	0.73	0.45

significantly influenced by different treatments under study.

Close examination of the data indicated that significantly highest content in grain 2.481, 0.588 and 0.487 per cent of N, P and K respectively were recorded with the application of 100% NPK + 10 t FYM followed by 150% NPK treatment. Increasing trend of N, P and K concentration in wheat grain observed with increasing levels of fertilizers. The results are evidenced by the findings reported by Das *et al*., (2003).

Phosphorus content in grain was significantly higher in treatment that receiving phosphorus (T_6) (0.386%) than in treatments without phosphorus (T_7) (0.341%). Application of 100% NPK showed significant increase in N, P and K content in grain over control (Walia *et al.,* 1980).

Application of 10 t FYM ha^{-1} along with 100% NPK (T_8) recorded significantly highest Ca and Mg content (0.192 and 0.056%) in wheat grain whereas highest sulphur content (0.216%) was recorded in the treatment 100% NPK coupled with 37.5 kg S ha^{-1} (T_9) followed by 150% NPK treatment (0.201% sulphur, 0.188% calcium and 0.055% magnesium). Increasing trend of S, Ca and Mg concentration in wheat grain observed with increasing levels of fertilizers. Das *et al.,* (2003) also found similar type of results.

The treatment of 10 t ha^{-1} FYM only is found significantly superior over control in calcium and magnesium content in wheat grain. The calcium, magnesium and sulphur content in wheat grain significantly increased in 100% NPK + FYM 10 t ha^{-1} treatment over control. This might be due to the greater availability of these nutrients through chemical fertilizers as well as FYM.

Total uptake of macronutrients by wheat plant

Results in relation to uptake of primary and secondary nutrients by wheat are presented in Table 5. The data revealed that the grain and straw yield of wheat were highest (Table 1) in 100% NPK + FYM 10 t ha^{-1} consequently, the uptake of all nutrients were observed highest in this treatment followed by 150% NPK treatment. Similar results were recorded by Tyagi and Bhardwaj (1994). They revealed that the addition of FYM along with 100% NPK increased the uptake of nutrients.

Phosphorus uptake by wheat was significantly higher in treatment that receiving phosphorus (T_6) (8.59 kg ha^{-1}) as compared to without phosphorus (T_7) (5.80 kg ha^{-1}). The lowest uptake of primary nutrients (1.48 kg ha^{-1} nitrogen, 0.27 kg ha^{-1} phosphorus, 1.43 kg ha^{-1} potassium) by wheat was observed in control. Application of optimal dose of NPK showed significant increase in N, P and K uptake by wheat over control. The findings are in line with the results reported by Yaduvanshi (1988).

The uptake of S, Ca and Mg by wheat crop was significantly increased by the treatment, 100% NPK in conjunction with 10 t FYM (T_8) over 100% NPK alone and rise was to the extent of 76.0, 57.27 and 67 per cent S, Ca and Mg respectively. The treatment 100% NPK + 37.5 kg sulphur (T_9) was recorded 45.25 per cent more sulphur uptake by wheat over 100% NPK (S free) treatment (T_4). The lowest uptake of secondary nutrient (0.45 kg ha^{-1} sulphur, 0.24 kg ha^{-1} calcium and 0.14 kg ha^{-1} magnesium) by wheat crop was observed in control. FYM only treatment is significantly recorded more uptakes of secondary nutrients over control. Similar results were found by Nazirkar and Adsule (2004).

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