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Effect of Long-Term Manuring and Fertilization on Content and Uptake of Nutrients in Wheat under Sorghum-Wheat Cropping Sequence in Vertisol

Snehal D Wakchaure, S.D. Jadhao, B.A. Sonune, S.M. Bhoyar, V.K. Kharche, P.R. Kadu and Sindhu R. Rathod

Department of Soil Science, Dr. PDKV, Akola

Abstract:

A field study was conducted at the Research Farm of All India Coordinated Research Project on Long-Term Fertilizer Experiment (AICRP on LTFE), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, (Dr. PDKV) Akola, Maharashtra (India), on an ongoing long-term experiment initiated in 1988-89 under sorghum-wheat cropping sequence in Vertisol. The treatments comprised of different levels of recommended dose of fertilizers (RDF) *viz.,*50, 100, 150% and RDF in combination with farmyard manure (FYM), FYM alone (10 t ha^{-1}), RDF devoid of S, RDF along with S @ 37.5 kg ha^{-1} and Zn @ 2.5 kg ha^{-1}, NP, N alone and control. Results revealed that the conjoint use of optimal dose of 100% NPK along with FYM @ 5 t ha^{-1} resulted in the highest content of N (1.80 and 1.02% grain and straw), P (0.39 and 0.29% grain and straw), and K (1.48 and 0.67% in grain and straw), as well as the highest uptake of N (65.67 and 61.98 kg ha^{-1} in grain and straw), P (16.67 and 20.64 kg ha^{-1} in grain and straw) and K (23.68 and 85.29 kg ha^{-1} in grain and straw). Whereas the control had the lowest content of N (1.58 and 0.69% grain and straw), P (0.31 and 0.22% grain and straw), and K (1.30 and 0.45% in grain and straw) and uptake of N (7.72 and 7.59 kg ha^{-1} in grain and straw), P (2.43 and 2.43 kg ha^{-1} in grain and straw) and K (2.81 and 12.08 kg ha^{-1} in grain and straw).

Key Words: Nutrient Content, Nutrient Uptake, FYM, Wheat, Long-Term Fertilization

Introduction:

Sorghum-wheat is a significant cropping sequence that produces the main foodgrain crops of Peninsular Central India, particularly Maharashtra (Katkar *et al.* 2011). Wheat (*Triticum aestivum* L.) is India's second-most significant food grain crop after rice. Annual wheat production in Maharashtra is 2474 thousand tonnes. It also extends over 1057 thousand hectares (Annon, 2022).

Crop nutrient uptake is the principal factor that determines optimal fertilization practices. Therefore, it is of immense importance to apply fertilizers in an efficient way to improve the nutrient use efficiency. The nutrient uptake and transport within the plant system primarily depends upon the plant growth stages, soil fertility and amount of fertilizers applied. Chemical fertilizers are applied to the soil in order to supplement the nutrient supply and

increase crop yields. However, inadequate and imbalanced use of fertilizers adversely affects soil health and declines crop productivity (Kalhapure *et al.* 2014). The success of every cropping system relies on efficient utilization of resources, which includes the balanced use of manures and fertilizers. Conjoint use of organic manures and chemical fertilizers may prove a viable option for sustaining the productivity of cereal-based cropping sequence in view of the mere availability of macro as well as micronutrients due to intensive cultivation and heavy feeding habits of sorghum-wheat crop sequence (Mali *et al.* 2015). As cereal-cereal sequence is found to exhaust more nutrients an intervention in between may help in maintaining proper supply of nutrients. Application of organics to wheat crops is not in practice considering the difficulties in their decomposability and availability of nutrients. Integration of organic and inorganic sources of plant nutrients may help to supply adequate nutrients in an optimum proportion and also promising to quantify plant nutrition. FYM is an important and renewable organic source of nutrients. Large quantities of organic matter are available with farmers which can be utilized as complementary source to chemical fertilizers. (Kumari *et al.* 2017). Soil organic matter is a well-known reservoir of carbon as well as other nutrients in the soil, contains almost all the plant growth essential nutrients, therefore, is an important factor affecting the nutrient uptake by the crop (Wang *et al.* 2015).

Therefore, influence of organic manure and inorganic fertilization are very helpful tools in monitoring on nutrient uptake over a long period under sorghum-wheat cropping sequence.

Material and Methods:

Site description

A long-term field experiment under sorghum-wheat cropping sequence was initiated in 1988-89 on the research field of All India Coordinated Research Project on Long-Term Fertilizer Experiment (AICRP on LTFE), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experimental site (latitude of 22º 42' N and longitude 77º 02'E) at an elevation of 307.42 m above mean sea level (MSL) has a hot, semi-arid ecoregion. Most of the rainfall is received from the southwest monsoon. The soil at the test location is a family of *Typic Haplustert* Vertisols, which is montmorillonitic and hyperthermic (Ravankar et al., 1998). Its mineralogy is smectite clay with swell-shrink characteristics. The initial properties of soil at the start of the experiment during (*kharif*,1988) indicated that the soil is slightly alkaline in reaction (pH 8.1), medium in organic carbon (4.60 g kg^{-1}), moderately calcareous (5.7 %), low in available nitrogen (120 kg ha^{-1}), medium in available phosphorus (8.40 kg ha^{-1}), very high

in available potassium (358 kg ha^{-1}), sulphur was content just above the critical level (11.80 mg kg^{-1}) and marginal in DTPA- extractable Zn (0.62 mg kg^{-1}).

Experimental design, treatment details and crop management

The experiment is a part of a long-term experiment that was taken on the same site since 1988-89 without changing randomization, under the rainfed condition on the farm of (AICRP on LTFE), Dr. PDKV, Akola, Maharashtra (India) in Randomized Block Design (RBD) with twelve treatments replicated thrice (Table 1). Wheat (cultivar-AKW 4627) went into cultivation during second fortnight of November. Every year, organic manure (FYM) was applied one month before to sorghum sown. The recommended fertilizer rate for wheat crops was 120:60:60 kg N, P_2O_5, K_2O ha^{-1}. The remaining half of the N dose (60 kg ha^{-1}) was applied 21 days after sowing (DAS), together with the full doses of P_2O_5, K_2O, and half N at the time of sowing. Gypsum was applied as a source of sulphur in the T_9 treatment for both crops whereas $ZnSO_4$ was applied as a source zinc in the T_5 treatment. All other agronomic practices were performed as per standard packages of practice recommended by the university.

Table 1. Treatment details under long-term fertilizer experiment

Treatment	Treatment details	
	***Kharif* (Sorghum)**	***Rabi* (Wheat)**
T_1	50% NPK	50% NPK
T_2	100% NPK	100% NPK
T_3	150% NPK	150% NPK
T_4	100% NPK (S free)	100% NPK (S free)
T_5	100% NPK	100% NPK + Zn @2.5 kg ha^{-1}
T_6	100% NP	100% NP
T_7	100% N	100% N
T_8	100% NPK + FYM @ 5 t ha^{-1}	100 % NPK
T_9	100% NPK + S @ 37.5 kg ha^{-1}	100% NPK + S @ 37.5 kg ha^{-1}
T_{10}	FYM @ 10 t ha^{-1}	FYM @ 10 t ha^{-1}
T_{11}	75% NPK + 25 % N through FYM	75% NPK + 25 % N through FYM
T_{12}	Control (no manures and fertilizer)	Control (no manures and fertilizer)

Note: *T_5: treatment the Zn application on the basis of soil test value *T_8: treatment the dose of FYM from 10 t ha^{-1} was reduced to 5 ha^{-1}, *T_{10}: treatment the dose of FYM @ 10 t ha^{-1} was applied to sorghum and wheat crop *T_{11}: the application of 75 % NPK + 25 % N through FYM was started to apply from 2011-12.

Plant analysis and calculations of nutrient uptake

The plant samples were air-dried in shade and digested by using a di-acid and tri-acid mixture. Total N was analyzed by Micro-Kjeldahl method (Jackson, 1973), Total P by Vanadomolybdate yellow colour method (Jackson, 1973) and Total K by Flame photometry (Jackson, 1973). The uptake of major nutrients was worked out by multiplying total dry matter and nutrient concentration.

Statistical Analysis

The data were statistically analysed by the technique of analysis of variance (ANOVA) as suggested by Gomez and Gomez, (1984).

Results and Discussion

Nutrient content

The data obtained by the influence of long-term fertilization along with manure on nitrogen, phosphorus and potassium content in grain and straw were depicted in Table 2. The N content in grain varied from 1.58 to 1.80% whereas in straw it was ranged from 0.69 to 1.02%. In grain P content ranged from 0.31 to 0.41% and in straw varied from 0.22 to 0.29%. The K content in grain from 1.30 to 1.48% and in straw it was 0.45 to 0.67% respectively. From the perusal of the data, it was noted that the application of 100% NPK + FYM @ 5 t ha^{-1} resulted the higher NPK content in grain (1.80%N, 0.41% P and 1.48% K) and straw (1.02% N, 0.29% P and 0.67% K). The increase in N, P and K content might be due to effective and well-developed root system and increased availability of nutrients in the root zone and the plant system (Jat *et al.* 2007). Similarly, an integrated application of inorganics and FYM resulted in higher nutrient contents in plants, this might be due to the fact that inorganic fertilizer component provided nutrients during the early vegetative growth, while the organic component provided nutrients over a long period as it takes some time for the mineralization (Goutami and Rani, 2016). As per stated by Tolba *et al.* (2003) and Khater *et al.* (2004), who mentioned that FYM plays an important role for supplying plants by some required nutrients. Similar findings given by Malav *et al.* (2019); and Puli *et al.* (2012) noted that the application of optimal dose of NPK along with FYM showed the higher nutrient content.

Nutrient uptake

The data related to the uptake of nitrogen, phosphorus and potassium by wheat grain and straw as influenced by continuous application of fertilizers and manures are presented in Table 3. From the perusal of the data, it was noted that the nitrogen uptake by grain varied from 7.72 to 65.67 kg ha^{-1}, whereas by straw it was ranged from 7.59 to 61.98 kg ha^{-1} respectively. Significantly the highest uptake of nitrogen by grain (65.67 kg ha^{-1}) and straw

(61.98 kg ha^{-1}) was noted in the treatment receiving 100% NPK + FYM @ 5 t ha^{-1} (T_8) over the rest of the treatments and lowest was noted in control. Chesti *et al.* (2013) also reported higher uptake of N by wheat with the application of organic manures and attributed this to higher nutrient availability, improved metabolic functions in plants which might have resulted in higher nutrient uptake. In grain P uptake ranged from 2.43 to 16.67 kg ha^{-1} and in straw it was 2.43 to 20.67 kg ha^{-1}, respectively. The application of chemical fertilizer along with FYM (T_8) noted significantly highest uptake of phosphorus by grain (16.67 kg ha^{-1}) and straw (20.67 kg ha^{-1}) and control plot noted lowest P uptake. Higher P uptake with addition of FYM might be attributed to the solubilization of native P and release of P by mineralization of organic P (Sharma *et al.* 2016). The K uptake in grain ranged from 2.81 to 23.68 kg ha^{-1} and in straw it is varied from 12.08 to 85.29 kg ha^{-1}. Optimal dose of NPK and organic manure (T_8) significantly increased the K uptake by grain (23.68 kg ha^{-1}) and straw (85.29 kg ha^{-1}). The increased uptake of K may be ascribed to more availability of K from added fertilizers and manures. Application of manures along with chemical fertilizers recorded highest K uptake due to good proliferation of root system, resulting in better absorption of potassium (Kumari *et al.* 2017).

Results of this findings it has been revealed that the balanced application of chemical fertilizer along with FYM enhanced uptake of nitrogen, phosphorus and potassium by wheat may be because of the higher biomass production might be the most pertinent reason for the increased uptake of nutrients. The inorganic nitrogen not only provides an immediate source of N for plant growth but also enhances the mineralization of applied as well as native organic matter by meeting the N requirement of the decomposers (Goutami and Rani, 2016). As per Malav et al. (2019) stated that an increase in uptake of nutrients may be due to the increased in fertility levels attributed to the better availability of nutrients and their transport to the plant from the soil. The beneficial effect of application of higher amounts of organic manure through FYM is not only favoured the greater availability of throughout crop growth, fertilizer into different stages resulting in significant improvement in nutrient uptake. Similar findings given by Venugopal *et al.* (2017) noted that integrated nutrient application of NPK + FYM increased N and P uptake by sorghum grain and fodder. Sharma *et al.* (2010) also recorded higher N and P uptake by rice with application of 100% NPK + FYM as FYM was beneficial in enhancing the uptake of nutrients compared to no organic manure application. Thakur and Sawarkar (2009) in long term experiment in Vertisol noticed that the application of 100% NPK + FYM recorded significantly higher uptake of nutrients.

Conclusions

22 Thus, it can be concluded that the balanced application of optimal dose of NPK with organic manure had the suitable practice for wheat's crop nutrition which noted the highest NPK content as well as their uptake.

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Table 2. Effect of long-term manuring and fertilization on nutrient content of wheat

Treatments details		Nutrient content (%)					
		Grain			Straw		
		N	P	K	N	P	K
T_1	50 % NPK	1.62	0.32	1.33	0.75	0.26	0.49
T_2	100 % NPK	1.70	0.36	1.40	0.87	0.27	0.57
T_3	150 % NPK	1.78	0.39	1.47	0.99	0.29	0.65
T_4	100 % NPK (S free)	1.68	0.35	1.38	0.84	0.27	0.55
T_5	100 % NPK + Zn @ 2.5 kg ha^{-1}	1.72	0.37	1.42	0.90	0.28	0.59
T_6	100 % NP	1.66	0.34	1.36	0.81	0.27	0.53
T_7	100 % N	1.60	0.31	1.31	0.72	0.25	0.47
T_8	100% NPK + FYM @ 5 t ha^{-1}	1.80	0.39	1.48	1.02	0.29	0.67
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	1.74	0.41	1.43	0.93	0.28	0.61
T_{10}	FYM @ 10 t ha^{-1}	1.64	0.33	1.35	0.78	0.26	0.51
T_{11}	75% NPK + 25 % N through FYM	1.76	0.38	1.45	0.96	0.28	0.63
T_{12}	Control (no manures and fertilizer)	1.58	0.31	1.30	0.69	0.22	0.45
SE (m) ±		0.05	0.03	0.05	0.07	0.01	0.01
CD at 5%		0.14	0.08	0.14	0.22	0.026	0.02

Table 3. Effect of long-term manuring and fertilization on nutrient uptake by wheat

Treatments details		Nutrient uptake (kg ha^{-1})					
		Grain			Straw		
		N	P	K	N	P	K
T_1	50 % NPK	23.94	4.37	7.56	20.89	5.73	33.19
T_2	100 % NPK	46.29	9.62	15.44	40.32	11.38	60.49
T_3	150 % NPK	57.99	14.02	20.62	52.56	17.01	73.39
T_4	100 % NPK (S free)	41.56	8.32	13.64	37.16	10.12	56.79
T_5	100 % NPK + Zn @ 2.5 kg ha^{-1}	48.22	10.41	16.39	43.92	13.01	64.75
T_6	100 % NP	34.37	6.56	11.05	29.63	7.64	46.49
T_7	100 % N	11.84	2.78	3.58	9.07	3.57	15.11
T_8	100 % NPK + FYM @ 5 t ha^{-1}	65.67	16.67	23.68	61.98	20.64	85.29
T_9	100 % NPK + S @ 37.5 kg ha^{-1}	51.64	11.53	17.81	47.53	14.56	68.93
T_{10}	FYM @ 10 t ha^{-1}	27.97	4.67	8.65	24.43	5.52	39.64
T_{11}	75% NPK + 25 % N through FYM	53.14	12.26	18.62	51.68	16.21	73.25
T_{12}	Control	7.72	2.43	2.81	7.59	2.43	12.08
SE (m) ±		1.79	0.39	0.67	1.68	0.71	2.62
CD at 5%		5.25	1.16	2.02	4.93	2.07	7.69

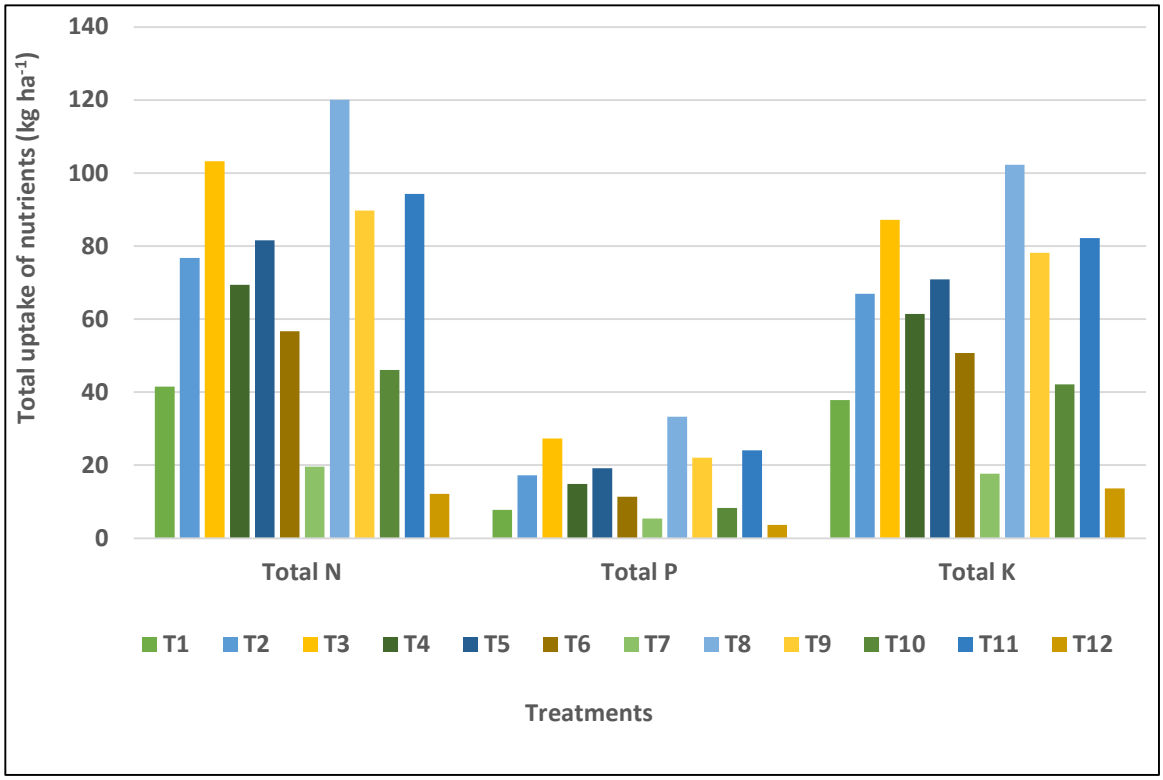

Fig 1. Effect of long-term manuring and fertilization on total uptake of nutrients by wheat in sorghum-wheat sequence