Title
Integrated nutrient managment for sustainable production of sorghum-wheat crop sequeence

Author
Bhale, Vilas Madhukar, Dr.

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Introduction

Sorghum-(*Sorghum bicolor*) – Wheat (*Triticum aestivum L*. emend.fiori.and paol) is the most important crop sequence of India occupying 60-70% of the total cultivated area in Maharashtra. Wide adoption of this system is mainly due to staple food to human being and fodder to cattles. But continuous adoption of this sequence led to reduce soil fertility which ultimately resulted in declining the efficiency and productivity of the systems. More over sorghum-wheat crop sequence is an exhaustive cropping sequence which deplete soil nitrogen and other nutrient extensively. So to maintain soil fertility in this sequence, integrated nutrient management is the only option. Presently fertilizer application is based on the nutrient requirement of individual crop and the carryover effect of the organic manures or fertilizer or crop residues applied to preceding crop are generally ignored. Fertilizer application through inorganic source even in balanced amount does not sustain soil fertility and productively under continuous cropping on same site. Integrated Nutrient Management involving conjuctive use of organic, inorganic, crop residues, *leucaena* loppings may improve soil productivity and also develop sustainable system productivity. Keeping this in view, study was initiated to identify the sustainable integrated nutrient supply system for sorghum-wheat crop sequence in the Vidarbha region of Maharashtra , India.

Material and Methods

The field experiment is continue on fixed site since 1984-85 at Cropping Systems Research Unit, Dr.PDKV, Akola (Maharashtra, India). The soil was clayey with pH 7.4, EC 0.20, dsm^{-1}, organic C 4.4 gms/kg of soil, and available N, P and K were 209,11 and 350 kg/ha^{-1} respectively at the initiation of the experiment (1984-85). Twelve treatments which includes various combination of inorganic fertilizer and organic nutrients source viz., FYM, Crop residues (Wheat straw), and Leucaena loppings was replicated four times in Randomized block design. The details are given in Table 2. The soil samples were collected at the end of cycles, as well as harvesting of sorghum and wheat crop. The economic analysis were computed as per prevailing market prices of individual years. Stability indices were computed for the sequence of integration on the basis of grain equivalent yield in each treatments in crop sequence

Results and Discussion

Sorghum yield (tons ha^{-1})

The data pooled over 24 years (Table 1) indicated that higher productivity (3.23 t ha^{-1}) was noticed with application of 100% RDF through inorganic fertilizer indicating that if balanced and recommended dose of fertilizer through inorganic source was applied, the productivity is remains consistent. Further it was noticed that 50% nitrogen can be substituted through FYM (3.21 t ha^{-1}) and *leucaena* loppings (3.05 t ha^{-1}) which were comparable to 100% RDF. There is a scope to substitute 25% and 50% Nitrogen though organic sources viz FYM, Wheat straw and *leucaena* loppings thus saving of 60 kg inorganic N fertilizer. Similar trend of treatment behavior was observed with fodder yield.

Drastic reduction in grain yield with no fertilizer application was noticed (0.52 t ha^{-1}). The grain yield at these treatment during 1984-85 was 891 kg ha^{-1} which was reduced to 497 kg ha^{-1} during 2008-09 indicating almost 50% reduction in yield of sorghum. Significant reduction in yield due to 50% reduced RDF was noticed during all the years of study including pooled results of 24 years. Stability in yield was noticed when these reduced dose was substituted through organic source either FYM or Leucaena lopping or Wheat straw

Residual effect on Wheat yield (tons ha^{-1})

In pooled results over 24 years (Table 1) higher productivity of wheat was recorded with 50% substitution of Nitrogen through FYM (2.61 tons ha^{-1}) which was comparable with 100% RDF and 50% substitute through *Leucaena* loppings. There is no scope to reduce the recommended dose of fertilizer to 25% or 50% as reduction in wheat yield was observed. However, equivalent yield was obtained if reduced fertilizer dose is integrated with organic sources either FYM, wheat straw or *Leucaena* loppings. Move or less similar trend was noticed with straw yield.

System Productivity (tons ha^{-1})

Pooled data indicated that system productivity in terms of sorghum equivalent yield (SEY) was maximum (7.1 tons ha^{-1}) with 50% RDF + 50% N through FYM followed by 100% RDF to wheat crop (T4) which was comparable to 50% RDF substitution through *leucaena* loppings and significantly superior to rest of inorganic

fertilizer application including integration with organic sources. Significant reduction in system productivity was noticed when 50% RDF was substituted through wheat straw compared to 100% RDF. Lowest SEY was noticed with control followed by farmer practice. This clearly indicated that integration of fertilizer to the extent of 25 or 50% through either FYM or *leucaena* lopping is beneficial to harvest equivalent yield of sorghum-wheat system. This results are in confirmation with Jamwal (2005) who obtained positive result of FYM in wheat – maize cropping sequence.

Table 1 : Yield and Sorghum equivalent yield, sustainable yield, NMR and B:C ratio as influenced by different treatments.(Pooled mean of 24 years)

Tr.	Yield of Sorghum (t/ha)		Yield of Wheat (t/ha)		Sorghum Equivalent yield (SEY t/ha)	Sustainable yield index (SYI)	NMR Rs/ha	B:C ratio
	Grain	Fodder	Grain	Straw				
T1	0.52	3.17	0.39	0.75	1.12	-0.21	-3693	0.79
T2	2.35	7.49	1.67	2.84	4.88	0.30	29420	2.39
T3	2.49	8.15	2.22	3.70	5.84	0.38	37038	2.64
T4	2.75	8.72	2.12	3.68	5.96	0.43	38758	2.72
T5	3.23	9.77	2.51	4.00	7.01	0.57	47209	2.95
T6	3.21	9.86	2.61	4.17	7.14	0.57	48698	3.05
T7	3.09	9.60	2.33	3.82	6.61	0.52	44453	2.91
T8	2.75	9.02	2.37	3.81	6.34	0.45	41313	2.76
T9	2.82	9.05	2.16	3.61	6.08	0.45	39855	2.75
T10	3.05	9.33	2.48	4.08	6.79	0.53	45812	2.99
T11	3.01	9.39	2.32	3.75	6.51	0.50	43524	2.89
T12	2.13	7.42	1.35	2.19	4.17	0.22	24150	2.19
SE ±	0.08	0.20	0.07	0.10	0.43	-	3890	-
CD 5%	0.22	0.57	0.20	0.30	-	-	-	-

Treatment details given in Table - 2

Sustainability :-

Substitution of 50% N through FYM produced higher sustainable yield index (T6) which was comparable to 100% RDF to both the crops. Sustainable yield index was ranged between 0.30 to 0.43 with inorganic sources of fertilizer and maximum with 100% RDF (0.57). However, in integration of nutrient through organic source, the SYI was ranged between 0.45 to 0.52 and maximum with 50% integration of nutrient through FYM (0.57). This clearly indicated that for sustainable productivity of sorghum-wheat crop sequence, the best option is to adopt integration to organic sources either FYM or *Leucaena* loppings. Negative SYI (-0.21) was recorded with zero fertilizer application followed by lowest (0.22) with farmer practice.

Economic Analysis

Data pooled over 24 years indicated that application of 50% RDF through inorganic fertilizer + 50% N through FYM recorded, highest net monetary returns (48,698 Rs ha^{-1}). This was mainly because of higher productivity of system. This was followed by 100% RDF to the system through inorganic fertilizer. The maximum B:C ratio (3.05) was noticed with 50% RDF + 50% N through FYM followed by 50% RDF + 50% N through *leucaena* loppings. Lowest C:B ratio (0.79) was noticed with zero fertilizer application (Table 1) .

Nutrient balance and soil properties

At the end of 24 years of experimentation (Table 2) it was observed that the organic carbon was built-up and reached to maximum 6.4 g/kg of soil with *leucaena* loppings followed by FYM integration. These findings are in agreement with the observation of Yadav *et al* (2008). Integration of inorganic fertilizer with organic sources has increased organic C content compare to only inorganic sources of nutrients. The nutrient balance on soil after 24 years of experimentation indicated remarkable balance of N, P, K in integrated nutrient management. The initial value of 209 kg N was reduced to 146 kg at zero fertilizer application. At 100% RDF the nitrogen balance was 338 kg/ha and at 50% RDF + 50% N through FYM, the nitrogen available was highest (407 kg/ha). There was 198 kg/ha gain in nitrogen due to integration of 50% N substitution through FYM. There was 34 kg/ha gain in phosphorus with integration of 50% RDF + N through FYM.

Table 2 :- Effect of integrated nutrient management on chemical properties of soil at the end of 24 years.

Tr.No	Treatment details		pH	EC dsm^{-1}	O.C.g/kg	Nutrient balance		
	Kharif (Sorghum)	*Rabi* (Wheat)				N	P	K
T1	Control	Control	7.48	0.12	2.00	-63	-3	-176
T2	50% RDF	50% RDF	7.49	0.13	3.95	+27	+13	-68
T3	50% RDF	100% RDF	7.51	0.15	4.05	+53	+15	-42
T4	75% RDF	75% RDF	7.53	0.17	4.20	+60	+16	-18
T5	100% RDF	100% RDF	7.57	0.19	4.35	+129	+17	-9
T6	50% RDF + 50% N FYM	100% RDF	7.56	0.18	5.75	+198	+34	+91
T7	50% RDF + 25% N FYM	75% RDF	7.55	0.17	5.65	+140	+32	+33
T8	50% RDF + 50% N WS	100% RDF	7.54	0.19	5.55	+147	+23	+28
T9	50% RDF + 25% N WS	75% RDF	7.56	0.19	5.45	+116	+19	+12
T10	50% RDF + 50% N LL	100% RDF	7.55	0.16	6.35	+178	+30	+31
T11	75% RDF + 25% N LL	75% RDF	7.54	0.15	6.15	+154	+26	+15
T12	Farmer's practice (50:25:00 NPK)	Farmer's practice (40:25:12.5 NPK)	7.51	0.14	2.95	+19	+13	+128
Initial			7.4	0.2	4.4	209	11	350

RDF:- recommended dose of fertilizer Sorghum as well as Wheat 120:60:60 kg NPK kg ha^{-1}.
FYM- Farm yard manure, WS- Wheat straw, LL- Leucaena loppings, N - Nitrogen

This treatment (T6) also recorded highest gain in K. The negative gain was noticed in inorganic fertilizer and at 100% RDF, the gain in K was -9 kg/ha. In general there was negative balance of K in all the inorganic fertilizer sources. However where these was integrated with organic fertilizer, the gain in K was positive. This clearly indicated that soil integration of inorganic fertilizer with organic sources are essential to sustain soil fertility and productivity for sustainable production of sorghum-wheat crop sequence. Improvement in EC, pH was noticed with integration of inorganic fertilizer with organic source of nutrient.

Conclusion

Based on 24 yrs data, it can be concluded that integration of nutrients 50% RDF through inorganic source and 50% N substitution through FYM or *leucaena loppings* to sorghum followed by 100% RDF to wheat is beneficial for increased the productivity and sustainability of sorghum-Wheat crop sequence.

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