International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(2): 497-500

Received: 16-01-2019
Accepted: 18-02-2019

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Effect of integrated nutrient management on productivity, nutrient uptake, soil properties and economics of soybean-wheat cropping system in western Maharashtra

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Abstract
This study was conducted at IFS, MPKV, Rahuri in Western Maharashtra. The soybean grain equivalent yield in respect of the system in T_5 was significantly superior over the rest of the treatments except T_6. Amongst different sources of organics, substitution of 50% N through FYM recorded significantly higher system productivity (5458 kg ha^{-1}) in terms of soybean grain equivalent yield. The total nitrogen uptake (210 kg ha^{-1}), total phosphorous uptake (35kg ha^{-1}), total potassium uptake (90 kg ha^{-1}) of soybean was recorded significantly highest in the treatment T_5 (100% recommended NPK dose through fertilizers) which was at par with T_6. The highest gross monetary returns, net returns with B**:** C ratio was recorded in the treatment involving use of 100% RDF in both the seasons which was closely followed by treatment T_6 (50%N through FYM + 50 % RDF followed by 75 % RDF during *Rabi*).

Keywords: Soybean, wheat, integrated nutrient management, cropping system

Introduction
Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner. The aim of Integrated Nutrient Management (INM) is to integrate the use of natural and man-made soil nutrients to increase crop productivity and preserve soil productivity for future generations. Fertility of soil is very important for obtaining optimum production of crops.

Organic matter induces life into the soil and sustains biological life. In order to attain sustained production of crops, recycling of organic matter in the soil should become a regular feature of modern agriculture, the almost complete reliance on the use of chemical fertilizer, ignoring bio organic material has in the course of time brought in focus a number of problem such as, wide spread deficiencies of nutrients and decline in productivity of crops and increasing environmental pollution.

The long-term use of inorganic fertilizers without organic supplements damages the soil physical, chemical and biological properties and causes environmental pollution. Organic manures act not only as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in soil, influence structure, nutrients get turnover and many other changes related to physical, chemical and biological parameters of the soil (Albiach *et al.,* 2000) [1]. Use of organic manures alone or in combination of chemical fertilizers will help to improve physic-chemical properties of the soils, Organic manures provide a good substrate for the growth of microorganisms and maintain a favorable nutritional balance and soil physical properties. One such strategy to maintain soil fertility for sustainable production of soybean is through judicious use of fertilizers (Bobade *et al*., 1998) [2] coupled with organic resources to achieve sustainability in production, the use of organic manures alone is not sufficient (Prasad, 1996) [4]. It has also been brought out that the use of organic manures in integration with fertilizers meets the need of micronutrients of soybean (Joshi *et al.,* 2000) [3]. Therefore, keeping this in view an investigation entitled "Effect of Integrated Nutrient Management on Productivity, Nutrient uptake, Soil properties and Economics of Soybean-Wheat Cropping System in Western Maharashtra".

Methodology

An experiment was conducted at IFSRP, MPKV, Rahuri to study the Integrated Nutrient Management in Soybean-Wheat Cropping System during 2017-18 with four replications. Twelve treatments with randomized block design was used for this study. The experimental and treatment details are given below.

Trématent détails

Treatment	*Kharif*	*Rabi*
T_1	Control	Control
T_2	50% RDF	50% RDF
T_3	50% RDF	100% RDF
T_4	75% RDF	75% RDF
T_5	100% RDF	100% RDF
T_6	50%N (FYM) + 50% RDF	75% RDF
T_7	25%N (FYM) + 75% RDF	50% RDF
T_8	50%N (WCS) + 50% RDF	75% RDF
T_9	25%N (WCS) + 75% RDF	50% RDF
T_{10}	50%N (GM) + 50% RDF	75% RDF
T_{11}	25%N (GM) + 75% RDF	50% RDF
T_{12}	Farmer's practice urea @ 50 kg ha^{-1}	Farmer's practice urea @ 50 kg ha^{-1}

Results

Yield and system productivity: It is revealed that, application of NPK, either through inorganic fertilizers or in combination with organic manures/crop residue/green manure, significantly increased the yields of soybean, wheat and soybean grain equivalent yield over control. Grain and fodder/straw yield of soybean and wheat increased significantly with the increase in NPK levels from 50 to 100% (Table 1). The maximum grain yield of soybean and wheat and that of the system in terms of soybean grain equivalent yield was recorded under T_5 (100% RDF in *kharif* and *Rabi*) which was at par with T_6 (50%N through FYM + 50 % RDF followed by 75 % RDF during *Rabi*)

The soybean grain equivalent yield in respect of the system in T_5 was significantly superior over the rest of the treatments except T_6. Amongst different sources of organics, substitution of 50% N through FYM recorded significantly higher system productivity (5458 kg ha^{-1}) in terms of soybean grain equivalent yield. Substitution of 50% N through any of the organic sources, recorded significantly higher soybean grain equivalent yield as compared to 25% N substitution rate. The omission of chemical fertilizers and organic manures continuously for the last 32 years resulted in low yield of both the crops due to continuous mining of nutrients. The integrated use of chemical fertilizers with organics *viz.,* FYM, green manure and wheat cut straw might have added huge quantity of organic matter in soil that resulted in higher grain yields. This could be ascribed to the contribution from annual use of organics that improved physico-chemical properties of soil and increased availability of plant nutrients.

Table 1: Grain, fodder/straw yield of soybean, wheat and grain equivalence of soybean

Treatment	Soybean (kg ha^{-1})		Wheat (kg ha^{-1})		Soybean equivalent yield (kg ha $^{-1}$)	SYI
	Grain	Fodder	Grain	Straw		
T_1	1624	1985	664	856	1996	0.16
T_2	2346	2919	2695	3465	3855	0.30
T_3	2606	3078	3369	4007	4492	0.46
T_4	2687	3133	3270	4068	4518	0.48
T_5	3353	4354	4187	5173	5698	0.69
T_6	3213	4051	4009	4956	5458	0.65
T_7	2944	3704	3033	4007	4643	0.44
T_8	2507	3252	3084	3880	4234	0.48
T_9	2469	3117	2846	3598	4062	0.44
T_{10}	2625	3371	3268	4122	4456	0.56
T_{11}	2511	3320	3023	3761	4204	0.51
T_{12}	1908	2457	1843	2251	2940	0.21
Mean	2566	3229	2941	3678	4213	-
S. Em±	192.64	168.24	223.71	205.59	168.67	-
C.D at 5%	554.26	484.06	643.66	591.52	485.29	-
CV %	15.01	10.42	15.21	11.17	8.01	-

Total nutrient uptake: The data in respect of nutrient uptake are presented in Table 2 and 3. The nutrient uptake study revealed that, the total nitrogen uptake (210 kg ha^{-1}), total phosphorous uptake (35kg ha^{-1}), total potassium uptake (90 kg ha^{-1}) of soybean was recorded significantly in the treatment T_5 (100% recommended NPK dose through fertilizers) which was at par with T_6. While in case of wheat, total nitrogen uptake (90 kg ha^{-1}), total phosphorous uptake (21 kg ha^{-1}), total potassium uptake (71 kg ha^{-1}) of wheat was recorded significantly in the treatment T_5 (100%recommended NPK dose through fertilizers) which was at par with T_6.

Soil fertility status: The data of soil fertility were studied and are presented in Table 2, 3.The data on soil fertility revealed that, soil reaction and electrical conductivity were non-significant. Organic carbon content was slightly increased in the treatments where organic sources were used and decreased where there was no use of organic sources. In *kharif*, it was higher in the treatment T_6 (0.73 %), available nitrogen content (217 kg ha^{-1})in the treatment T_6, P (24 kg ha^{-1}) and K (697 kg ha^{-1}) in the treatment T_6 after harvest of *kharif* soybean. In *Rabi*, the treatment T_6 recorded the highest residual available soil N, P and K (225, 25 and 679 kg ha^{-1}), respectively.

Table 2: Effect of integrated nutrient management on soil fertility and total nutrient uptake of *kharif* soybean

Treatment	pH (1:2.5)	E.C. (dSm^{-1})	O. C. (%)	Avalable nutriments (kg ha^{-1})			Nutrient uptake (kg ha^{-1})		
				N	P	K	N	P	K
T_1	8.22	0.23	0.53	166	10	542	87	14	37
T_2	8.20	0.20	0.63	180	17	656	146	24	60
T_3	8.22	0.30	0.65	185	20	639	161	25	64
T_4	8.18	0.23	0.61	198	20	650	166	27	67
T_5	8.21	0.23	0.68	209	21	665	210	35	90
T_6	8.11	0.21	0.73	217	24	697	202	33	86
T_7	8.15	0.21	0.69	199	21	646	186	31	78
T_8	8.14	0.22	0.79	205	22	646	157	22	68
T_9	8.13	0.21	0.67	208	19	647	155	22	64
T_{10}	8.12	0.22	0.66	214	23	636	165	24	67
T_{11}	8.13	0.21	0.63	211	22	649	158	24	65
T_{12}	8.18	0.20	0.57	209	13	589	118	16	47
S.Em ±	0.03	0.029	0.010	6.27	0.42	6.45	10.05	1.24	2.43
C.D at 5%	NS	NS	0.030	18.03	1.20	18.54	28.91	3.58	7.00
Initial	8.16	0.23	0.63	175	17	632	--	--	--

Table 3: Effect of integrated nutrient management on soil fertility and total nutrient uptake of *Rabi* wheat

Treatment	pH (1:2.5)	E.C. (dSm^{-1})	O.C. (%)	Avalable nutriments NPK ----------kg ha^{-1}--------			Nutrient uptake NPK --------kg ha^{-1} --------		
T_1	8.24	0.22	0.52	170	9	537	12	3	10
T_2	8.19	0.20	0.63	187	17	651	89	13	43
T_3	8.21	0.21	0.64	191	20	635	70	15	53
T_4	8.19	0.23	0.61	203	21	642	70	15	54
T_5	8.21	0.23	0.67	214	22	670	90	21	71
T_6	8.14	0.22	0.72	225	25	679	86	19	67
T_7	8.16	0.21	0.68	204	22	638	67	15	53
T_8	8.13	0.22	0.65	211	22	640	66	15	50
T_9	8.14	0.22	0.66	214	20	642	60	13	46
T_{10}	8.13	0.23	0.65	220	24	631	69	14	52
T_{11}	8.18	0.23	0.67	217	21	644	64	14	48
T_{12}	8.17	0.20	0.60	190	11	585	38	9	29
S. E m±	0.028	0.009	0.01	6.04	0.51	6.66	3.40	0.90	2.13
C.D at 5%	NS	NS	0.03	17.37	1.46	19.15	9.78	2.61	6.14
Initial	8.16	0.23	0.63	175	17	632	--	--	--

Economics*:* Economics of soybean-wheat crop sequence under integrated nutrient supply system was computed on the prevailing market prices are presented in Table 4. The highest gross monetary returns, net returns with B**:** C ratio was recorded in the treatment involving use of 100% RDF in both the seasons which was closely followed by treatment T_6 (50%N through FYM + 50 % RDF followed by 75 % RDF during *Rabi*).

Table 4: Economics of different INM treatments on soybean –wheat sequence

Treatment	Gross monetary returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio
T_1	56898	57189	-291	0.99
T_2	110093	67311	42781	1.64
T_3	128008	71603	56404	1.79
T_4	128798	71569	57229	1.80
T_5	162754	76989	85764	2.11
T_6	155808	78815	76993	1.98
T_7	132648	73455	59193	1.81
T_8	120982	70155	50827	1.72
T_9	116002	69392	46610	1.67
T_{10}	127291	70889	56402	1.80
T_{11}	120144	69878	50266	1.72
T_{12}	83942	61367	22575	1.37
Mean	120281	69884	50396	1.70
S. Em±	4625.46	-	4625.46	-
C.D at 5%	13308.56	-	13308.56	-
CV %	7.69	-	18.35	-

Conclusion

In soybean– wheat sequence, the maximum productivity was obtained under treatment involving application of 100% RDF in *kharif* and *rabi* which was at par with 50%N through FYM + 50 % RDF followed by 75 % RDF during rabi. Gross and net returns as well as B**:** C ratio was noted maximum in the same treatments. Continuous application of organic manure in conjunction with inorganic fertilizers maintained/the improved organic carbon and available nitrogen in the soil.

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