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Influence of INM on Performance of Soybean-Wheat based Cropping System under Central Narmada Agro-Climatic Zone of Madhya Pradesh

VINOD KUMAR[1] AND S K MISHRA[2*]

ABSTRACT

A field experiment was conducted to evaluate organic vis-à-vis inorganic fertilizers and soil sustainability in soybean-wheat cropping sequence for two consecutive years. Grain yield of both the crops, i.e., soybean (16.29 q/ha) and wheat (46.05 q/ha) was observed to be significantly superior by fertilizer application as per general recommended dose of respective crops. Integrated application of fertilizers i.e., inorganic fertilizers 50% and organic fertilizers 50% was found to be the next superior treatment to that of general recommended dose. Soil properties were improved by use of organic and inorganic fertilizers in combination. However, no significant change was observed in case of soil pH and electrical conductivity.

Keywords: Organic farming, Inorganic fertilizer, Soybean, Wheat, Cropping system, Soil sustainability

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INTRODUCTION

In India, the major cropping systems are maize-wheat, rice-wheat and soybean-wheat under irrigated and rainfed conditions (Jat *et al*., 2013). Soybean-wheat is the predominant cropping system in Madhya Pradesh (Yadav and Subba Rao, 2001). Soybean, *Glycine max* (L.) –wheat (*Triticum aestivum* L.) system has emerged as a predominant cropping system as a part of crop diversification as well as for maintaining the sustainability of the soils (Verma and Sharma, 2007). Soybean is a legume and wheat is a cereal, they together complimented each other in the cropping system. The farmers prefer soybean as a cash crop followed by wheat as a high-yielding food grain crop. Imbalance nutrition is one of the important constraints in the low productivity of these crops in north Indian plains (Singh and Singh, 2018). Sustaining production and productivity of any system is of paramount importance by improving the physical, chemical and biological properties of soil (Karunakaran and Behera, 2015). An application of organic material along with inorganic fertilizers into the soil leads to increase the productivity of the cropping system, enhance the fertilizer-use efficiency and sustain the soil health for longer period (Jat *et al*., 2013). Maintaining long-term soil productivity and conserving soil and water resources depends on the management of cropping system, which influences the magnitude of soil organic matter and soil erosion (Blanco and Lal, 2008). The productivity of cropping system depends largely on the judicious and balanced application of nutrients besides the amount of irrigation water available for the wheat crop. Now there is a growing awareness among the farmers to cultivate crops under organic farming system because of the escalating cost of chemical fertilizers, decrease soil fertility in respect of organic matter, secondary and micro nutrients, environmental and health concern due to pesticide usages and premium price for the organically produced crops (Ramesh *et al*., 2005). In peak periods of plant growth and pod formation, uptake may exceed 12.5, 1.2 and 10 kg/ ha/day for N, P and K, respectively. A good soybean crop producing 4 t/ha removes about 370 kg N, 40 kg P and 130 kg K/ha (Prasad, 2006) and for getting good yield of the crop, a continuous usage of inorganic fertilizer is raising in present scenario. This continuous use of inorganic fertilizer not only deleteriously affects the surrounding environment but also degrade the soil health by reducing the soil fauna and flora. Organic manure influences soil productivity through their effect on soil physical, chemical and biological properties. The management of manures within a crop rotation can have large effects on yields and crop quantity (Werner, 1997). Generation of information regarding the influence of organic and inorganic management practices and chemical or integrated management practices on the crop/cropping system productivity, soil fertility and economics is important to the farmers and community at large. Hence, the efforts have been made to increase the production potential of soybean and wheat crops by using different organic sources alone and in combination with inorganic fertilizers.

MATERIALS AND METHODS

The field experiment was conducted at JNKVV - Zonal Agricultural Research Station, Powarkheda, District–Narmadapuram (Madhya Pradesh) for two consecutive years. The soil of the experimental field was clay loam having pH (7.65), EC (0.48 ds / m) and OC (5.9g / kg), available nitrogen (262 Kg / ha), phosphorus (4.5 Kg / ha) and potash (300 Kg / ha). The experiment was laid out with 8 treatments and no replications. The treatments were : T_1 - 50% recommended NPK+ 50% N as FYM + inorganic sources of micro nutrients as per soil test , T_2 - Different organic sources each equivalent to 1/3 of recommended N (FYM- vermicompost + non edible

[1] Scientist (Agronomy), AICRP on Integrated Farming System, JNKVV – Zonal Agricultural Research Station, Powarkheda, Narmadapuram, Madhya Pradesh, India
[2] Scientist, JNKVV – Dryland Horticulture Research & Training Centre, Garhakota, Sagar, Madhya Pradesh, India
*Corresponding Author E-mail: mishradhrtc@gmail.com

neem oil cake), T_3 - T_2+ inter cropping of trap crop (location specific in each season), T_4 - T_2+ agronomic practices for weed and pest control (no chemical, pesticides and herbicides), T_5 - 50% N as FYM + biofertilizer (*Azotobacter*) for N+ rock phosphate to substitute the P requirements of crops + phosphate solubilizing bacterial culture (PSB), T_6 - T_2 +bio fertilizer containing N (*Azotobacter*) and P (PSB) carriers, T_7 - 100% NPK +secondary and micronutrients based on soil test . The gross size of the strip for each treatment was 68 x 7.5 m and net strip size was 66 x 6 m. The recommended dose of nitrogen, phosphorus and potassium was 20:60:20 kg/ha and 120:60:40 kg/ha, respectively for soybean and wheat crops. The source of organic material used viz. FYM containing N – 05%, P – 0.2% and K – 0.5% , vermi-compost N – 1.5% and Neem cake N – 5.2% in both the crops soybean –wheat. The soybean variety JS 95-60 was sown with row spacing 45 cm and seed rate 75 kg/ha. In wheat, variety HI 8498 was sown with row spacing 22.5 cm and seed rate 100 kg/ha. The nitrogen content in organic sources was determined in each year and the amount of these materials required for substituting a specified amount of nitrogen as per treatment was calculated. Organic sources were applied before sowing of respective crop. Nitrogen, phosphorus and potassium were applied through urea, single super phosphate and muriate of potash for both crops. Five post sowing irrigations were given to wheat crop and no irrigation was applied to soybean. The average grain yield and productivity of both soybean and wheat of the soybean - wheat cropping sequence were calculated by taking average of two consecutive years. The soil health parameters viz. pH and EC, available nutrients viz. nitrogen, phosphorus and potassium were determined after harvest of each crop. Glass electrode pH meter and conductivity meter were used to determine the pH and EC, respectively. Available nitrogen, phosphorus and potassium were determined by as per standard procedures.

RESULTS AND DISCUSSION

Soybean

Perusal of the data (Table 1) revealed that the maximum value of plant height (58.7 cm) was recorded with 100% NPK +secondary and micronutrients (T_7). This treatment was significantly superior over rest of the treatments but statistically at par with 50% recommended NPK+ 50% N as FYM + inorganic sources of micro nutrient (T_1) and 1/3 of recommended N (FYM- vermicompost + neem oil cake (T_2) in respect of plant height. Higher values of pods / plant (54.4), pods weight / plant (22.6 g), seed yield / plant (14.55 g) and 100 seeds weight (13.72 g) were also recorded with the application of 100% NPK +secondary and micronutrients (T_7) over other treatments. The highest grain yield (16.29 q/ha) was obtained from the treatment (T_7) 100 % NPK + secondary and micronutrients based on soil test. Regarding organic treatment combinations, 50% recommended NPK+ 50% N as FYM + inorganic sources of micro nutrients as per soil test (T_1) had found to be higher yielding (14.51 q/ha) combination than other organic treatments. Use of organic sources (FYM) might have helped to release the nutrients and make it readily available to plant as and when required by it so as to produce higher grain yield. Increase in yield by application of FYM along with bio fertilizers was also reported by Singh *et al.* (2007), Shivakumar and Ahlawat (2008). The next highest yield 13.73 q/ha and 12.43 q/ha was recorded from treatment

Table 1: Effect of integrated nutrient management on growth and yield attributes of soybean JS 95-60 (Mean of two years)

Treatment Details	Plant height (cm)	Pods/ plant	Pods weight/plant	Seed yield /plant (g)	100 seed weight (g)	Seed Yield qt./ha)
T_1 : 50% recommended NPK+ 50% N as FYM + inorganic sources of micro nutrients as per soil test	57.6	49.23	21.6	14.10	13.21	14.51
T_2: 1/3 of recommended N (FYM- vermicompost + neem oil cake)	56.2	46.24	20.2	13.85	13.01	13.73
T_3: T_2+ inter cropping of trap crop (location specific in each season).	51.4	41.73	19.3	13.30	12.07	12.31
T_4: T_2+ agronomic practices for weed and pest control (no chemical, pesticides and herbicides)	52.6	42.10	19.7	13.42	12.15	12.43
T_5: 50% N as FYM + biofertilizer (*Azotobacter*) for N+ rock phosphate to substitute the P requirements of crops + phosphate solublising bacteria (PSB) culture	48.1	40.14	18.1	12.84	11.81	11.89
T_6: T_2 +bio fertilizer containing N (*Azotobacter*) and P (PSB) carriers	49.8	41.71	18.8	13.20	11.92	12.06
T_7: 100% NPK +secondary and micronutrients based on soil test	58.7	54.4	22.6	14.55	13.72	16.29
T_8: T_2 + Green leaf manuring during summer	52.1	42.07	19.5	13.38	12.10	12.42
SEm±	**7.45**		**0.83**	**0.39**	**0.39**	**0.53**
CD 5%	**3.19**		**1.83**	**0.85**	**0.85**	**1.07**

(T_2) 1/3 of recommended N (FYM + vermicompost + neem oil cake) and treatment (T_4) - T_2+ agronomic practices for weed and pest control (no chemical, pesticides and herbicides), respectively. The lowest grain yield (11.89 q/ha) was recorded from the treatment (T_5) 50% N as FYM + biofertilizer *(Azotobacter)* for N+ rock phosphate to substitute the P requirements of crops + phosphate solublising bacteria (PSB) culture.

Wheat

Perusal of the data (Table 2) revealed that the highest plant height (96.40 cm) was recorded with 100% NPK +secondary and micronutrients (T_7) which was significantly superior over other treatments. Application of 100 % NPK + secondary and micronutrients produced maximum tillers/m^2 (126.80). Maximum length of spike (10.30 cm) and grain / spike (51.60) was recorded in treatment T_7. Fertilizer application as per recommended dose (120:60:40) (T_7) has produced significantly higher grain yield (46.05 q/ ha) and straw yield (71.85 q/ha) with harvest index of 38.36%. Under organic-inorganic combination, higher grain yield (38.66 q/ha) and straw yield (59.29 q/ha) was produced by application of 50% recommended NPK+ 50% N as FYM + inorganic sources of micro nutrients as per soil test (T_1). Use of FYM might have released the nutrients for wheat crop as in case of soybean. The increase in yield was mainly due to the application of organic source (FYM) which improved the fertility status resulting in to better utilization of nutrients by wheat crops. Similar results were also reported by Sushila and Giri (2000) and Gosavi *et al.* (2009). The increase in grain yield by 59.7 % and straw yield by 70.4 % along with yield attributing characters of wheat due to nutrient management by combination of organic and inorganic sources was also observed by Ram and Mir (2006) and Kharub and Chander (2008).

Table 2: Effect of integrated nutrient management on growth and yield attributes of wheat HI 8498 (Mean of two years)

Treatments Details	Plant height (cm)	No. of tillers/m²	Length of spike	Grain/spike	Grain yield (q/ha)	Straw yield q/ha)	Harvest Index %(HI)
T_1 : 50% recommended NPK+ 50% N as FYM + inorganic sources of micro nutrients as per soil test	92.30	122.41	10.14	47.40	38.66	59.29	39.46
T_2: 1/3 of recommended N (FYM - vermicompost + neem oil cake)	88.10	109.21	8.97	39.73	27.95	45.52	38.04
T_3: T_2+ inter cropping of trap crop (location specific in each season).	89.14	112.10	9.18	41.22	28.44	46.61	37.89
T_4: T_2+ agronomic practices for weed and pest control (no chemical, pesticides and herbicides)	90.35	112.35	9.23	41.34	28.48	46.89	37.78
T_5: 50% N as FYM + biofertilizer *(Azotobacter)* for N+ rock phosphate to substitute the P requirements of crops + phosphate solublising bacteria (PSB) culture	87.24	106.23	8.67	38.95	27.29	44.10	38.22
T_6: T_2 +bio fertilizer containing N (*Azotobacter*) and P (PSB) carriers	87.96	108.94	8.78	39.45	27.80	44.84	38.27
T_7: 100% NPK +secondary and micronutrients based on soil test	96.4	126.80	10.30	51.60	46.05	71.85	39.05
T_8: T_2 + Green leaf manuring during summer	87.45	108.56	8.71	39.42	27.67	44.46	38.36
SEm±	**0.39**	**1.43**	**0.44**	**2.29**	**1.39**	**0.97**	**1.27**
CD 5%	**1.10**	**2.90**	**1.28**	**6.70**	**2.80**	**2.83**	**NS**

Soil Nutrient Status

There was no remarkable change in soil properties viz. pH and EC were not much deviated from the whole value different treatments while other soil properties viz. OC and P content were improved under all the treatments significantly. The maximum available nitrogen (263.57 kg/ha), P (9.85 kg/ha) and K (307.42 kg/ha) was recorded under treatment of T_2 +bio fertilizer containing N (*Azotobacter*) and P (PSB) carriers (T_6). The uptake of major nutrient NPK increased significantly in all the treatments (Table 3). The maximum NPK uptake was recorded in treatment T_7 (100% NPK +secondary and micronutrients based on soil test).

CONCLUSION

1. 50% recommended NPK through fertilizer + 50% N through FYM to both crops (soybean – wheat) stable yield and total productivity of the system. A significant improvement in soil properties also takes place.
2. Sustainable agriculture is possible only when integrated nutrient management system is adopted by the farmers. It holds more promise for small and marginal farmers who cannot afford full package of fertilizer application through inorganic source.

Future concern

1. Low-cost production technologies for organic production system will be developed and standardized to ensure competitive price of organic produce to the grower in domestic and international markets.
2. Nutrient release pattern of different organic source in combination and alone, developing relationship between the crop N demand and supplies, screening of crop/vegetable varieties and to develop and assess

Table 3: Soil data (Mean of two years)

Treatments	pH	EC ds/m	OC g/ha	Available kg/ha			Total uptake kg/ha		
				N	P	K	N	P	K
T_1	7.66	0.56	6.82	200.71	9.75	307.42	204.42	46.23	254.57
T_2	7.57	0.55	7.07	262.57	9.75	303.71	148.85	38.9	206.57
T_3	7.61	0.55	6.84	258.0	9.74	306.85	155.85	41.86	204.85
T_4	7.60	0.54	6.91	253.28	9.74	299.14	156.0	39.39	232.28
T_5	7.59	0.58	7.15	255.85	9.78	303.42	123.14	38.77	167.28
T_6	7.58	0.59	7.04	263.57	9.85	312.14	145.14	35.20	211.0
T_7	7.32	0.58	6.72	254.42	9.72	299.0	204.85	38.98	279.42
T_8	7.61	0.56	6.94	257.85	9.82	303.0	141.0	36.68	193.28
Initial	7.65	0.48	5.9	262.00	9.50	300.0			
SEm±	**0.12**	**0.00**	**0.05**	**2.02**	**0.15**	**3.39**	**3.50**	**0.83**	**4.57**
CD 5%	**0.24**	**0.01**	**0.12**	**4.07**	**0.30**	**6.84**	**7.06**	**1.68**	**9.28**
CV	**3.10**	**2.37**	**1.60**	**1.45**	**2.93**	**2.08**	**4.12**	**3.96**	**3.91**

organic based cropping system.

3. Assessment of reported beneficial effect of organic farming with respect to crop quality.
4. Development of bio-intensive diversified complementary cropping system to utilize limited land and water in more efficient manner to small and marginal farmers.

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