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Nutrient Management Productivity and its Balance in Soybean (*Glycine max* (L) Merrill) Wheat (*Triticum aestivum*) Cropping in Vindhyan Plateau of MP, India

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A B S T R A C T

A field experiment was conducted during rainy (kharif) season of 2017-18 at farmers field at Sehore, (M.P), to study the effect of 8 fertilizer levels (75% RDF, 75% RDF + FYM 5 t ha^{-1}, 100% RDF, 100% RDF + FYM 5 t ha^{-1}, 125% RDF, 125% RDF + FYM 5 t ha^{-1}, FYM 5 t ha^{-1}, Absolute control) on Yield, nodulation, NPK content, uptake and its balance in two soybean varieties JS 95-60 and JS 97-52 were evaluated in factorial randomized block design with 3 replications. The grain yield was significantly higher with application of 125% RDF + FYM 5 t ha^{-1} (1820 kg ha^{-1}), which was at par with 100% RDF + FYM 5 t ha^{-1} (1801 kg ha^{-1}). The variety JS 95-60 recorded significantly higher grain yield (2203 kg ha^{-1}) as compared to variety JS 97-52 (886 kg ha^{-1}). Number of root nodules per plant and dry weight of root nodules per plant are significantly higher with the application of 125% RDF + FYM 5 t ha^{-1} than other fertilizer treatments. Variety JS 97-52 was better in number and dry weight of root nodules per plant than JS 95-60. The NPK content and its uptake were significantly increased with to application of 125% RDF + FYM 5 t ha^{-1} followed by 100% RDF + FYM 5 t ha^{-1}. Variety JS 95-60 was also noticed significantly increased in respect of N, P and K content in straw, seed and their uptake. Application of different treatment combinations of fertilizer levels and varieties improved the available N in the soil. Phosphorus and potassium showed marginal gain in sum experimental plots.

Introduction

Soybean is one of the important legume crops of India which not only helps in maintaining soil fertility but it is also a rich source of protein and fats. Oil and protein rich soybean has now been recognized all over the world as a potential supplementary source of edible oil and nutrition. The oil of soybean contains 85% unsaturated fatty acid and is cholesterol free. Soybean seeds contain 43.2% protein, 19.5% fat, 20.9% carbohydrate and a good amount of other nutrients like calcium, phosphorus, iron and vitamins (Gopalan *et al.*, 1971). Soybean has 3% lecithin which is helpful for brain development. The appropriate combination of mineral fertilizers with organic manure can be feasible and visible to sustain agriculture as commercial and profitable ensuring high yield of crop without deterioration in quantity and quality of the produce and soil health. FYM (Farm yard Manure) is by far, the most popular and available for use as an organic source of plant nutrient with the farmers. The use of FYM is the tool to improve the physical, chemical and biological properties of the soil. Farmyard manure being the source of all essential elements, improves soil organic matter and humus part of soil. FYM also plays an important role inhabitation beneficial bacteria thus making the nutrients available to crop. Therefore the present study was undertaken to see the effect of applied inorganic fertilizer with FYM and without FYM on Yield, nodulation, NPK content, uptake and its balance in soybean varieties.

Materials and Methods

The field experiment was conducted during the rainy (*kharif*) season 2017-18 at farmers field of Sehore, Madhya Pradesh (23^0 12' N latitude, 77^0 05' E longitude and at 498.77 m above mean sea level). The experimental site is characterized by sub-tropical zone with extreme temperature during summer (45.60^0c) and very low temperature (as low as 5^0c). The average rainfall varies from 1000 to 1200 mm most of which is received during June-September. The soil was medium black clay loam having pH (7.3), electrical conductivity (EC) (0.12 dS m^{-1}), organic carbon (0.58), medium available N (245.25 kg ha^{-1}), medium available P (17.80 kg ha^{-1}), and high available K (425.24 kg ha^{-1}). The field trail consisting of 8 levels of fertilizer (75% RDF, 75% RDF + FYM 5 t ha^{-1}, 100% RDF, 100% RDF + FYM 5 t ha^{-1}, 125% RDF**,** 125% RDF +FYM 5 t ha^{-1}**,** FYM 5 t ha^{-1}**,** Absolute control) and 2 levels of soybean variety (JS 95-60 and JS 97-52) was a factorial experiment laid out in randomized block design with 3 replications. Fertilizer doses were calculated on the basis of recommended dose of nutrients 20 N+60 P_2O_5+20 K_2O+20 S, kg ha^{-1} through urea, single super phosphate and muriate of potash, respectively. The quantity of fertilizer was calculated for respective treatment separately and was drilled as per treatment at the time of sowing. Decomposed farm yard manure (FYM) @ 5 tones ha^{-1} were applied before sowing and well incorporated in the soil. The sowing was carried out on 5^{th} July 2010 maintaining row spacing of 45 cm with recommended seed rate of JS 95-60 and JS 97-52 was 75 kg ha^{-1} and 65 kg ha^{-1}, respectively was applied. Other agronomic management practices were followed as per the standard recommendation. The crop harvested at maturity and observation on Yield, straw yield and nodulation were recorded as per standard procedure. The soil samples collected after harvest of soybean crop were analysed for available N (Subbiah and Asija 1956), P (Olsen *et al.*, 1954) and K (Hanway and Heidel 1952). The grain and straw samples were digested with di acid mixture of HNO_3 and $HClO_4$ in 9:1ratio. Phosphorous was determined by vanadomolybdate yellow colour method (Jackson, 1973), K by flame photometer. Nitrogen in plants was determined by modified micro Kjeldahl method. The nutrient uptake was calculated by multiplying the nutrient content values with the yield data. The data were statistically analysed using standard procedures of ANOVA at 5% level of significance.

Results and Discussion

Number and weight of root nodules

Fertilizer levels increased the number and dry weight of root nodules per plant (Table 1). The maximum number and weight of root nodules per plant were recorded with the application of 125% RDF + FYM 5 t ha^{-1} which might be due to better root development and profuse nodulation on account of increase in the rhizobial activity in the rhizosphere under fertilizer levels especially due to increased P availability, which resulted in the formation of active and more number of root nodules. The results are in close agreement with the findings of Lone *et al.,* (2009) and Mohod *et al.,* (2010). The variety JS 97-52 was significantly superior in number of root nodules and dry weight of root nodules per plant than variety JS 95-60.

Grain and straw yields

Fertilizer levels were significantly influenced the grain yield of soybean (Table 1). Application of 125% RDF + FYM 5 t ha^{-1} was significantly higher in grain yield and it was at par with 100% RDF + FYM 5 t ha^{-1}. This might be due to balanced use of fertilizers in soil which increased their availability in soil. The increment in supply of essential elements through organic and in-organic sources, their availability, mobilization and influx into the plant tissues increased and thus improved growth and yield components and finally the seed yield of soybean. The results corroborated the findings of Singh Guriqbal (2009) and Shinde *et al.,* (2009). The variety JS 95-60 produced highest grain yield (2203 kg ha^{-1}) than variety JS 97-52 (886 kg ha^{-1}). It may be due to higher seeds per pod and better seed index. These favourable phenomenon in this variety resulted higher seed yield. Similar results were also observed by Thakur and Vyas (2005), and Khan *et al.,* (2005) were also reported variation in yield attributed with different varieties. Maximum straw yield was obtained in 125% RDF + FYM 5 t ha^{-1} (3127 kg ha^{-1}). It may be due to better growth attributes. Tiwari *et al.,* (1997) observed that the maximum straw yield of 5.94 tonnes was obtained with the application of 100 per cent NPK + 5 t ha^{-1} FYM. The variety JS 97-52 produced significantly higher straw yield (3576 kg ha^{-1}) compared to the variety JS 95-60. The highest straw yield may be due to the plant height and higher number of branches and dry weight per plant. This favourable morphological phenomenon in this variety resulted highest straw yield.

Nitrogen content (%)

The N –content in straw and seed was influenced by different fertilizer levels (Table 2). Application of 125% RDF + FYM 5 t ha^{-1} was recorded significantly higher N- content in straw (0.89%) and in seed (6.51%) and it was at par with 100% RDF + FYM 5 t ha^{-1}. It may be due to balanced and complete nutrition of plant through judicious combination of organics and in-organics. The beneficial effect of FYM must be due to its role in adequate nutrient supply, enhanced mobilization of nutrients, activation of beneficial soil microbes, biological activities (N-fixation) and improved physical condition of soil which provides the plant a good nutrient content to grow and develop. Effect of varieties on N- content in straw was not significant but N-content in seed was significant. The variety JS 95-60 was significantly superior in N- content in seed than variety JS 97-52. Total uptake of nitrogen by soybean (straw + seed) showed (Table 3) similar trend as it was seen and recorded in case of straw and seed contents. The increase in uptake of nitrogen could be the results of enhanced physiological processes within the plant system which resulted in the increased absorption of nitrogen by soybean plant and thereby, translocation of nitrogen. Supplementation of FYM with in-organic fertilizer improves the crop growth and thereby uptake of nitrogen. These results are in close conformity of the results observed by Chaturvedi and Chandel (2005) and Lone *et al.,* (2009).

Phosphorus content (%)

Application of 125% RDF + FYM 5 t ha^{-1} recorded the highest P-content in straw (0.133%) and in seed (0.87%) which were significantly superior than the other treatments (Table 2). This might be due to higher availability of plant nutrients with fertilization and continuous supply of nutrients through FYM, which resulted in increased nutrient content in the plant tissues and greater biomass production at higher fertilizer levels with FYM. It also may be synergistic effect between N and P. Similar findings in soybean crop was reported by Lone *et al.*, (2009). The variety JS 95-60 recorded significantly higher P-content in straw and seed as compared to variety JS 97-52. The total uptake was also improved significantly with different levels of fertilizer application and varieties (Table 3). The variety JS 95-60 recorded significantly higher total (straw + seed) P- uptake than JS 97-52. Application of 125% RDF + FYM 5 t ha^{-1} recorded the highest (20.58 kg ha^{-1}) total P-uptake (straw +seed) which was significantly superior than other treatments but was at par with 100% RDF + FYM 5 t ha^{-1}. The increase in uptake of phosphorus could be the results of enhanced physiological process within the plant system which resulted in the increased absorption of phosphorus by soybean plant and thereby, translocation of phosphorus which might have resulted in good yield of soybean. These results are in close conformity of the results observed by Chaturvedi and Chandel (2005) and Lone *et al.*, (2009).

Table.1 Effect of fertilizer levels and varieties on number and dry weight of root nodules, grain yield (kg ha^{-1}) and straw yield (kg ha^{-1})

Treatments	Number of root nodules per plant	Dry weight of root nodules per plant (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Fertilizer levels (F)				
75% RDF	44.94	111.38	1599	2955
75 % RDF + FYM 5 t ha^{-1}	49.61	124.85	1657	2980
100% RDF	46.61	117.83	1710	3044
100 % RDF + FYM 5 t ha^{-1}	51.44	130.86	1801	3081
125% RDF	50.17	126.98	1716	3069
125 % RDF + FYM 5 t ha^{-1}	56.50	144.01	1820	3127
FYM 5 t ha^{-1}	47.61	118.95	1054	2929
Control	40.94	100.78	997	2875
SEm ±	0.63	1.61	33.67	63.30
CD (P=0.05)	1.81	4.64	96.97	NS
Varieties (V)				
JS 95-60	47.03	118.75	2203	2439
JS 97-52	49.93	125.16	886	3576
SEm ±	0.31	0.80	16.84	31.65
CD (P=0.05)	0.90	2.32	48.49	91.58

Table.2 Effect of fertilizer levels and varieties on NPK-content (%) in straw and seed

Treatments	N-content (%) in straw	N-content (%) in seed	P-content (%) in straw	P-content (%) in seed	K-content (%) in straw	K-content (%) in seed
Fertilizer levels (F)						
75% RDF	0.80	6.35	0.100	0.74	1.17	2.44
75 % RDF + FYM 5 t ha^{-1}	0.84	6.40	0.106	0.79	1.27	2.52
100% RDF	0.82	6.40	0.105	0.76	1.25	2.50
100 % RDF + FYM 5 t ha^{-1}	0.86	6.46	0.122	0.84	1.37	2.61
125% RDF	0.85	6.44	0.115	0.81	1.35	2.59
125 % RDF + FYM 5 t ha^{-1}	0.89	6.51	0.133	0.87	1.47	2.69
FYM 5 t ha^{-1}	0.78	6.30	0.095	0.70	1.13	2.40
Control	0.76	6.05	0.085	0.65	1.07	2.30
SEm ±	0.01	0.028	0.004	0.007	0.01	0.022
CD (P=0.05)	0.02	0.079	0.011	0.02	0.03	0.063
Varieties (V)						
JS 95-60	0.83	6.44	0.114	0.86	1.38	2.66
JS 97-52	0.82	6.28	0.101	0.68	1.13	2.35
SEm ±	0.0033	0.014	0.0019	0.004	0.005	0.011
CD (P=0.05)	NS	0.040	0.0054	0.011	0.014	0.031

Table.3 Effect of fertilizer levels and varieties on NPK-uptake (kg ha^{-1}) in straw, seed and total (straw + seed)

Treatments	N-uptake (kg ha^{-1}) in straw	N-uptake (kg ha^{-1}) in seed	Total N-uptake (kg ha^{-1}) in straw + seed	P-uptake (kg ha^{-1}) in straw	P-uptake (kg ha^{-1}) in straw	Total P-uptake (kg ha^{-1}) in straw + seed	K-uptake (kg ha^{-1}) in straw	K-uptake (kg ha^{-1}) in straw	Total K-uptake (kg ha^{-1}) in straw + seed
Fertilizer levels (F)									
75% RDF	23.44	102.17	125.66	2.94	12.41	15.35	33.57	40.05	73.62
75 % RDF + FYM 5 t ha^{-1}	24.62	106.65	131.27	3.14	13.70	16.84	37.50	42.89	80.39
100% RDF	24.96	110.16	135.12	3.17	13.82	17.00	36.63	44.02	80.85
100 % RDF + FYM 5 t ha^{-1}	26.57	116.90	143.47	3.70	15.80	19.50	42.72	48.30	91.03
125% RDF	25.95	111.11	137.06	3.50	14.51	18.00	41.17	45.66	86.82
125 % RDF + FYM 5 t ha^{-1}	27.73	119.07	146.80	4.08	16.50	20.58	42.73	50.25	92.98
FYM 5 t ha^{-1}	22.85	66.53	89.38	2.75	7.73	10.49	32.42	25.90	58.32
Control	21.67	60.57	82.23	2.41	6.86	9.27	32.44	23.32	55.76
SEm ±	0.56	2.17	2.49	0.12	0.26	0.31	0.92	0.92	1.10
CD (P=0.05)	1.61	6.25	7.18	0.35	0.75	0.88	2.65	2.66	3.18
Varieties (V)									
JS 95-60	20.17	142.48	162.67	2.80	19.17	21.97	34.18	59.10	93.29
JS 97-52	29.27	55.81	85.08	3.63	6.16	9.78	40.61	21.00	61.60
SEm ±	0.28	1.08	1.24	0.06	0.13	0.15	0.46	0.46	0.55
CD (P=0.05)	0.80	3.13	3.59	0.18	0.38	0.44	1.32	1.33	1.59

Table.4 Balance of nitrogen in soil as influenced by fertilizer levels and varieties

Treatments	N-added through fertilizer (kg ha^{-1})	Total N	Crop removal N (kg ha^{-1})	Theoretical N balance (kg ha^{-1})	Actual N after harvesting (kg ha^{-1})	Loss / gain of available N (kg ha^{-1})	Loss/gain of N over initial (kg ha^{-1})
JS 95-60 + 75% RDF	15	260.25	171.21	89.04	250.37	161.33	5.12
JS 95-60 + 75 % RDF + FYM	40	285.25	173.98	111.27	253.91	142.64	8.66
JS 95-60 + 100% RDF	20	265.25	183.46	81.79	251.25	169.46	6.00
JS 95-60 + 100 % RDF + FYM	45	290.25	188.77	101.48	255.75	154.27	10.50
JS 95-60 + 125% RDF	25	270.25	177.83	92.42	253.60	161.18	8.35
JS 95-60 + 125 % RDF + FYM	50	295.25	186.70	108.55	257.27	148.72	12.02
JS 95-60 + FYM	25	270.25	114.31	155.94	252.30	98.36	7.05
JS 95-60 + Absolute Control	-	245.25	105.06	140.19	247.03	104.18	1.78
JS 97-52 + 75% RDF	15	260.25	80.11	180.14	256.02	75.88	10.77
JS 97-52 + 75 % RDF + FYM	40	285.25	88.55	196.7	260.25	63.55	15.00
JS 97-52 + 100% RDF	20	265.25	86.78	178.47	258.75	80.28	13.50
JS 97-52 + 100 % RDF + FYM	45	290.25	98.17	192.08	261.50	69.42	16.25
JS 97-52 + 125% RDF	25	270.25	96.29	173.96	259.30	85.34	14.05
JS 97-52 + 125 % RDF + FYM	50	295.25	106.91	188.34	265.45	77.11	20.20
JS 97-52 + FYM	25	270.25	64.44	205.81	260.00	54.19	14.75
JS 97-52 + Absolute Control	-	245.25	59.41	185.84	247.36	61.52	2.11

* Initial-N 245.25 kg ha^{-1}

Table.5 Balance of phosphorus in soil as influenced by fertilizer levels and varieties

Treatments	P-added through fertilizer (kg ha^{-1})	Total P	Crop removal P (kg ha^{-1})	Theoretical P balance (kg ha^{-1})	Actual P after harvesting (kg ha^{-1})	Loss / gain of available P (kg ha^{-1})	Loss/gain of P over initial (kg ha^{-1})
JS 95-60 + 75% RDF	45	62.8	21.88	40.92	13.97	-26.95	-3.83
JS 95-60 + 75 % RDF + FYM	55	72.8	23.55	49.25	14.23	-35.02	-3.57
JS 95-60 + 100% RDF	60	77.8	24.35	53.45	15.23	-38.22	-2.57
JS 95-60 + 100 % RDF + FYM	70	87.8	27.09	60.71	15.51	-45.20	-2.29
JS 95-60 + 125% RDF	75	92.8	24.56	68.24	16.00	-52.24	-1.80
JS 95-60 + 125 % RDF + FYM	85	102.8	27.73	75.07	16.87	-58.20	-0.93
JS 95-60 + FYM	10	27.8	14.05	13.75	16.61	-0.14	-4.19
JS 95-60 + Absolute Control	-	17.8	12.57	5.23	8.20	2.97	-9.60
JS 97-52 + 75% RDF	45	62.8	8.82	53.98	14.51	-39.47	-3.29
JS 97-52 + 75 % RDF + FYM	55	72.8	10.13	62.67	14.87	-47.80	-2.93
JS 97-52 + 100% RDF	60	77.8	9.65	68.15	15.94	-52.21	-1.86
JS 97-52 + 100 % RDF + FYM	70	87.8	11.99	75.89	16.18	-59.71	-1.62
JS 97-52 + 125% RDF	75	92.8	11.45	81.35	16.46	-64.89	-1.34
JS 97-52 + 125 % RDF + FYM	85	102.8	13.43	89.37	17.23	-72.14	-0.57
JS 97-52 + FYM	10	27.8	6.92	20.88	14.44	-6.44	-3.36
JS 97-52 + Absolute Control	-	17.8	5.97	11.83	9.50	-2.33	-8.30

* Initial-P 17.8 kg ha^{-1}

Table.6 Balance of potassium in soil as influenced by fertilizer levels and varieties

Treatments	K-added through fertilizer (kg ha^{-1})	Total K	Crop removal K (kg ha^{-1})	Theoretical K balance (kg ha^{-1})	Actual K after harvesting (kg ha^{-1})	Loss/gain of K over initial (kg ha^{-1})
JS 95-60 + 75% RDF	15	440.24	91.72	348.52	390.40	-34.84
JS 95-60 + 75 % RDF + FYM	40	465.24	96.87	368.37	399.57	-25.67
JS 95-60 + 100% RDF	20	445.24	101.26	343.98	392.10	-33.14
JS 95-60 + 100 % RDF + FYM	45	470.24	109.63	360.61	402.22	-23.02
JS 95-60 + 125% RDF	25	450.24	103.37	346.87	393.75	-31.49
JS 95-60 + 125 % RDF + FYM	50	475.24	110.31	364.93	405.56	-19.68
JS 95-60 + FYM	25	450.24	67.06	383.18	393.98	-31.26
JS 95-60 + Absolute Control	-	425.24	66.09	359.15	382.36	-42.88
JS 97-52 + 75% RDF	15	440.24	55.52	384.72	394.17	-31.07
JS 97-52 + 75 % RDF + FYM	40	465.24	63.90	401.34	403.87	-21.37
JS 97-52 + 100% RDF	20	445.24	60.05	385.19	396.87	-28.37
JS 97-52 + 100 % RDF + FYM	45	470.24	72.42	397.82	408.34	-16.90
JS 97-52 + 125% RDF	25	450.24	70.27	379.97	398.60	-26.64
JS 97-52 + 125 % RDF + FYM	50	475.24	75.65	399.59	410.58	-14.66
JS 97-52 + FYM	25	450.24	49.58	400.66	397.24	-28.00
JS 97-52 + Absolute Control	-	425.24	45.43	379.81	385.60	-39.64

***** Initial-K 425.24 kg ha^{-1}

Potassium content (%)

Application of 125% RDF + FYM 5 t ha^{-1} recorded significantly higher K-content in straw (1.47%) and in seed (2.69%) than other treatments (Table 2). The trend of such results could be ascribed due to the initial higher availability of potassium in the experimental soil, indicating the luxury consumption of potassium. The variety JS 95-60 recorded significantly higher K-content in straw and in seed as compared to variety JS 97-52. The total uptake was also improved significantly with different levels of fertilizers application and varieties (Table 3). The variety JS 95-60 recorded significantly higher total (straw + seed) K- uptake than variety JS 97-52. Application of 125% RDF + FYM 5 t ha^{-1} recorded the highest (92.98 kg ha^{-1}) total K-uptake (straw +seed) which was significantly superior to other treatments but was at par with 100% RDF + FYM 5 t ha^{-1}. It might be due to combined application of organics and in-organics which ultimately enhanced K absorption by plants. These results are in close conformity of the results observed by Chaturvedi and Chandel (2005) and Singh *et al.,* (2007).

Nitrogen, phosphorus and potassium balance in soil

The data on soil available N indicated in (Table 4) showed a positive balance of nitrogen in soil in almost all the plots as compared to initial level of available nitrogen (245.25 kg ha^{-1}). The actual nitrogen left in soil was ranged from 2.11 to 20.20 kg ha^{-1}. It was maximum (20.20 kg ha^{-1}) with combination of variety JS 97-52 + 125% RDF + FYM 5 t ha^{-1} and minimum was in variety JS 97-52+ no fertilizer. The increase in actual N left in the soil may be due to increased nodulation and thereby symbiotic N fixation, and application of organic matter (FYM) along with in-organic fertilizer. Singh *et al.,* (1998) reported that incorporation of FYM and inoculation of seed left a net balance of 40 kg N ha^{-1} for succeeding crop.

The net phosphorus balance in soil showed a negative trend in (Table 5) all most all the plots as influenced by different levels of fertilizer application and varieties. The reduction in net available phosphorus was lesser under variety JS 97-52 + 125% RDF + FYM 5 t ha^{-1}. The depletion of P might be due to more removable of P from furrow layers, poor availability and fixation of P. The results are in close agreement with the findings of Lal *et al.,* (1997).

The data on the net potassium balance in soil showed a negative trends in (Table 6) almost all the treatments, which may be due to more removable of K by soybean due to more complimentary uptake with N and P and less supplementation losses were observed when K was applied with 125% RDF + FYM 5 t ha^{-1}. These results are in close agreement with the findings of Lal *et al.,* (1997).

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