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Physiological parameters, nodulation and yield in soybean(*Glycine max* L.) as influenced by organic manures and fertility levels

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Abstract

A field experiment was conducted during the *kharif* 2010 at the Experimental Farm of Department of Seed Science and Technology, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The experiment aimed to study the effect of organic manures and fertility levels on growth, physiological parameters, nodulation and yield of soybean seed. The field experiment consisted of twelve treatment combinations of four organic manures and three fertility levels. The results indicated that application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} and recommended dose of fertilizers (100% RDF) resulted in highest dry matter accumulation (297.45 gm^{-2} and 313.30 gm^{-2}, respectively), leaf area index (5.67 and 5.77, respectively), maximum nodules number and weight at both flowering and pod formation stage. The combined application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} and 100% RDF resulted in significantly highest crop growth rate and leaf area duration. The use of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} resulted in significantly highest seed (1815 kg ha^{-1}) and straw yield (3253 kg ha^{-1}) as compared to alone application of vermicompost @ 2.5 t ha^{-1} and FYM @ 5 t ha^{-1}. 100 % RDF resulted in significantly highest seed (1585 kg ha^{-1}) and straw yield (3138 kg ha^{-1}) as compared to 50 % RDF and control treatment.

Key words: FYM, vermicompost, fertility levels, crop growth rate, leaf area duration, nodules, seed yield.

Introduction

Soybean (*Glycine max* L.) is a member of Leguminosae family, and is an important oilseed crop of India with high protein (40-42%) and oil (20-22%) content. Despite of significant achievement in production technologies, productivity of soybean is very low. Deficiency of essential nutrients is major reason for low productivity. Chemical fertilizers play an important role to meet nutrient requirement of the crop but their continuous use on lands may have deleterious effects on physical, chemical and biological properties of soil, which in turn reflects on yield (Sarkar *et al*., 1997). Incorporating organic and inorganic fertilizers to soil provides multiple benefits for improving the chemical and physical status of the soil (Basso and Ritchie, 2005), hence higher yield. So, there is a need to work out nutrient management strategy to increase the production level and reduce the usage of chemical fertilizers and in turn increase the usage of organic manures which are known to improve physico-chemical properties of soil and also supply the nutrients in available form to the plants. Therefore, present study was planned to find out the

effect of organic manures and fertility levels on growth, physiological parameters, nodulation and seed yield of soybean.

Materials and Methods

The field experiment was carried out during the rainy season (*kharif*) of 2010 at the Experimental Farm of Department of Seed Science and Technology, CSK HPKV, Palampur situated at 32°6 N latitude and 76°3 E longitude with an elevation of 1290.8 m above mean sea level. The experiment was conducted on silty clay loam soil having pH 5.5, organic carbon (0.78%), available nitrogen (333 kg ha^{-1}), available phosphorus (23 kg ha^{-1}) and available potash (250 kg ha^{-1}). The treatment consisted of 4 levels of organic manures (control, FYM @ 5 t ha^{-1}, vermicompost @ 2.5 t ha^{-1} and FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1}) and 3 fertility levels (control, 50% recommended dose of fertilizer and 100% recommended dose of fertilizer). The experiment was laid out in factorial randomized block design with three replications. FYM, vermicompost as well as required quantity of N, P_2O_5 and K_2O in the form of urea, single super phosphate and muriate of potash, respectively were applied as per the treatments at the time of sowing. Soybean variety Himso 1588 was sown on 15th June 2010 at an inter row spacing of 45 cm. Randomly five plants per plot were selected in the net plot area and tagged for recording growth and yield parameters. The Leaf area index was calculated by the linear equation suggested by Wiersma and Bailey (1975), as reproduced below:

Leaf area = 0.411 + 2.008 LW (terminal leaflet)

$$LAI = \frac{\text{Leaf area plant}^{-1}}{\text{Land area covered by plant}}$$

Physiological growth parameters *viz;* crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and leaf area duration (LAD) were calculated by the methods as suggested by Watson (1952). The formulae are given below:

$$\text{Crop growth rate (CGR) (g m}^{-2}\text{day}^{-1}) = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

$$\text{Relative growth rate (RGR) (g g}^{-1}\text{day}^{-1}) = \frac{(l_n W_2 - l_n W_1)}{(t_2 - t_1)}$$

$$\text{Net assimilation rate (NAR) (g cm}^{-2}\text{ day}^{-1}) = \frac{(W_2 - W_1)(l_n L_2 - l_n L_1)}{(t_2 - t_1)(L_2 - L_1)}$$

Where,

W_1 and W_2 are dry weight at time t_1 and t_2.

$$\text{Leaf area duration (LAD) (m}^2\text{ days)} = \frac{(L_1 + L_2)}{2} X (t_2 - t_1) + \text{------} \frac{(L_{n-1} + L_n)}{2} X (t_n - t_{n-1})$$

Where,

L_1 and L_2 are leaf area at time t_1 and t_2.

L_n and L_{n-1} are leaf area at time t_n and t_{n-1}.

After harvest, seed yield ha^{-1} and straw yield ha^{-1} were computed.

Results and Discussion

Growth parameters

Organic manures either alone or in combination significantly influenced the dry matter accumulation at all the stages of crop growth. The dry matter accumulation was significantly highest with the combined application of FYM applied @ 2.5t ha^{-1} + vermicompost @ 1.25t ha^{-1} at all the stages of crop growth compared to all other treatments. Increase in dry matter accumulation was slow up to 60 days after sowing and it increased at a faster rate from 60 days to 90 days after sowing indicating grand growth phase of the crop. In general, in association with soil microorganisms, organic manures are known to help in synthesis of certain phytohormones and vitamins which promote the growth and development of crops. From the data presented in Table 1 and due to favourable conditions during the crop growth period and slow release of nutrients associated with

vermicompost might have resulted in higher concentration of nutrients in plant cells resulting in higher dry matter accumulation. Moreover, better nutrition of crop plants due to FYM application might have increased the photosynthesis rate which was reflected in significant increase in the dry matter accumulation at different stages of crop growth. Similar were the findings by Desai *et al.* (1999).

The dry matter accumulation was significantly influenced by fertilizer levels. The dry matter accumulation increased significantly and consistently with the increase in fertilizer levels from 0 to 100 per cent recommended dose of fertilizer at all crop growth stages. The highest dry matter accumulation was recorded with 100 per cent RDF at all crop growth stages followed by 50 per cent RDF. Significantly lowest dry matter yield was observed in control plots. At early growth stages, root and leaf development was less, therefore, dry matter accumulation was also observed less. But, during grand growth period these organs (leaf and roots) were active and resulted in higher dry matter production. The leaves of the plant are normally its main organs of photosynthesis. So higher leaf area index coupled with vigorous vegetative growth at higher fertility levels might be responsible for higher dry matter production of soybean. Khutate *et al.* (2005) also recorded maximum dry matter per plant with the application of 100 per cent NPK. Similar results were also reported by Singh *et al.* (2007).

The data indicated a significant effect of organic manures application on leaf area index (LAI) of soybean at different stages of crop growth (Table 1). Application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} resulted in significantly higher leaf area index compared to alone application of FYM @ 5t ha^{-1} and vermicompost @ 2.5 t ha^{-1}. The minimum LAI was recorded in control plots. LAI is a resultant of

Table 1. Effect of organic manures and fertility levels on dry matter accumulation and leaf area index of soybean at 90 DAS

Treatment	Dry matter accumulation (g m^{-2})	Leaf area index
Organic manures		
Control (M_0)	238.64	4.52
FYM @ 5 t ha^{-1} (M_1)	260.95	5.08
Vermicompost @ 2.5 t ha^{-1} (M_2)	276.61	5.26
FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} (M_3)	297.45	5.67
SEm±	5.81	0.13
CD (P=0.05)	17.25	0.38
Fertility levels		
Control (F_0)	222.89	4.47
50 % RDF (F_1)	269.06	5.16
100 % RDF (F_2)	313.30	5.77
SEm±	5.03	0.11
CD (P=0.05)	14.94	0.33

leafy growth of the plant. In the present study, better nutrition of the plants due to FYM and vermicompost application might have resulted in improvement in leaf size, which might have led to significant improvement in LAI with different levels of FYM and vermicompost. Such results are in confirmation with the findings of (Govindan and Thirumurugan, 2005) who also reported higher LAI with the application of vermicompost and FYM respectively.

LAI was also influenced significantly by increasing levels of fertilizer levels from 0 to 100 per cent RDF. Application of 50 per cent RDF recorded higher leaf area index than no fertilizer application and application of 100 per cent RDF resulted in significantly highest LAI. An ideal fertilizer schedule increased the LAI for efficient use of solar radiation. Leaf area index increased owing to more activities of meristematic tissues of the plant producing more number of trifoliates, which ultimately increased photosynthetic surface area and thereby leaf area index of the plant. It is well known fact that concurrent increase in plant height tends to increase the number of functional leaves per plant, which in turn increase leaf area index. Application of 100 per cent NPK recorded maximum leaf area index as also reported by Khutate *et al.* (2005).

Number, fresh and dry weight of nodules

At flowering, application of organic manures alone or in combination produced significantly higher number of nodules at flowering as well as pod formation stage of soybean. Significantly, maximum number of nodules were noticed with the application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} at flowering and pod formation stage (Table 2). However, M_3 behaved statistically similar to M_2 at pod formation stage. The minimum number of nodules per plant were recorded where no organic material was used at both stages of observation. The fresh weight of nodules was also recorded significantly higher with the combined application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} at flowering whereas M_3 remaining at par with M_2 produced significantly higher fresh weight of nodules. Though the difference between M_2 and M_1 was not significant. Lowest fresh weight was recorded in control plots. The dry weight of nodules was also differed significantly with the application of organic manures and the highest was recorded with M_3 remaining at par with M_2 followed by M_1 and control plots. The M_0 was rated as inferior most in this regard. The higher dry matter accumulation leading to more photosynthates, translocated towards roots. The roots colonization with FYM also enhanced nodules number due to the favourable rhizosphere environment created by the addition of organic manures in addition to adequate supply of essential plant nutrients and it might be the factor responsible for higher root dry weight.

Different fertility levels influenced the number of nodules, fresh and their dry weight at flowering and pod formation stage of soybean significantly. The number of nodules, fresh weight and dry weight increased consistently and significantly with increase in fertility levels from 0 to 100 per cent NPK application and significantly highest nodule number, fresh weight and dry weight was recorded with application of 100 per cent RDF. However, F_2 remaining at par with F_1 produced significantly similar dry weight but more than control plots. Because of the better nutrition the environment around the crop roots improved hence, helped in increased number, fresh weight and dry weight of root nodules.

Physiological growth parameters

Crop growth rate

Organic manures significantly influenced crop growth rate at all the stages of observations except at harvest. The combined application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} resulted in significantly highest crop growth rate. Further comparison of the data shows that M_2 and M_1 remaining at par with each other at 60-90 days interval produced significantly higher crop growth rate compared to control plots (Table 3). The control

Table 2. Effect of organic manures and fertility levels on the number, fresh and dry weight of nodules per plant of soybean at different stages of growth

Treatment	Stage of crop					
	Flowering			Pod formation		
	Number of nodules	Nodule fresh weight (g)	Nodule dry weight (g)	Number of nodules	Nodule fresh weight (g)	Nodule dry weight (g)
Organic manures						
Control (M_0)	35.79	0.74	0.29	55.31	1.36	0.53
FYM @ 5 t ha^{-1} (M_1)	41.72	0.93	0.37	62.50	1.46	0.62
Vermicompost@ 2.5 t ha^{-1} (M_2)	45.36	1.11	0.42	64.94	1.53	0.67
FYM @ 2.5 t ha^{-1} + vermicompost@ 1.25 t ha^{-1} (M_3)	48.53	1.25	0.46	68.76	1.64	0.71
SEm±	0.98	0.03	0.01	1.44	0.07	0.02
CD (P=0.05)	2.87	0.07	0.04	4.23	0.21	0.06
Fertility levels						
Control (F_0)	36.72	0.79	0.29	52.48	1.30	0.49
50% RDF (F_1)	43.79	1.02	0.39	64.52	1.53	0.68
100% RDF (F_2)	48.03	1.21	0.48	71.63	1.67	0.73
SEm±	0.85	0.02	0.01	1.25	0.06	0.02
CD (P=0.05)	2.49	0.06	0.03	3.66	0.18	0.05

treatment recorded significantly lowest crop growth rate at all growth stages of soybean. This was possibly due to accelerated photosynthetic activity of the plants which also contributed towards stronger reproductive phase resulting more dry matter production. Malkotia (2006) reported significantly higher crop growth rate with the application of 10 t ha^{-1} FYM as compared to no FYM application.

Application of fertilizer @ 100 per cent RDF recorded significantly highest crop growth rate followed by 50 per cent RDF at all the stages of observation whereas the crop growth rate was recorded lowest in control plots. At harvest stage, CGR was not influenced to a significant level by the application of different levels of fertilizers. In the present study, increase in fertilizer level from control to 100 per cent RDF is expected to increase the respective nutrient content in the plants, thereby resulting in increased photosynthetic area and this might have led to higher dry matter accumulation at all the dates of observations which ultimately reflected in increase in crop growth rate. RDF alone

Table 3. Effect of organic manures and fertility levels on physiological growth parameters of soybean

Treatment	CGR ($gm^{-2}day^{-1}$)		RGR ($g\ g^{-1}\ day^{-1}$)		NAR ($g\ cm^{-2}day^{-1}$)	LAD (m^2 days)	
	60-90 DAS	90 DAS-At harvest	60-90 DAS	90 DAS-At harvest	60-90 DAS	60-90 DAS	90 DAS-At harvest
Organic manures							
Control (M_0)	6.06	4.43	0.049	0.014	0.89	61.90	43.69
FYM @ 5 t ha^{-1} (M_1)	6.48	4.55	0.046	0.013	1.07	66.73	49.15
Vermicompost @ 2.5 t ha^{-1} (M_2)	6.76	4.53	0.044	0.013	1.09	68.53	50.89
FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} (M_3)	7.26	4.43	0.044	0.013	1.04	75.50	54.81
SEm±	0.23	0.25	0.001	0.001	0.09	1.71	1.27
CD (P=0.05)	0.39	NS	NS	NS	NS	5.01	3.71
Fertility levels							
Control (F_0)	5.65	4.61	0.048	0.015	0.92	60.12	43.21
50 % RDF (F_1)	6.64	4.93	0.045	0.013	1.08	67.69	49.87
100 % RDF (F_2)	7.63	4.36	0.044	0.012	1.08	76.69	55.83
SEm±	0.14	0.21	0.001	0.001	0.07	1.48	1.09
CD (P=0.05)	0.34	NS	NS	NS	NS	4.43	3.22

recorded significantly higher values for growth parameters. It could be attributed to the quick and readily availability of major nutrients like N, P and K to plants at earlier stages of plant growth. Non-significant effect at harvest may be due to diversion of photosynthates towards reproductive phase for formation of pods and seeds etc. Similar findings were reported by Kumar and Gangawar (1985).

Relative growth rate and Net assimilation rate

The results revealed that organic manures as well as different fertility levels under study did not influence the RGR and NAR of soybean significantly at all stages of crop growth. Different levels of organic manures and fertility levels did not influence the net assimilation rate at all the stages of observations to a significant level (Table 3).

Leaf area duration

The results revealed that leaf area duration increased consistently at all the crop growth stages of observations with different levels of organic manures. Application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} together resulted in significantly highest leaf area duration at all the stages of growth of soybean compared to all other treatments whereas application of vermicompost @ 2.5 t ha^{-1} was found statistically at par with FYM @ 5 t ha^{-1} produced higher LAD than control plots which resulted in lowest leaf area duration at all growth stages. Leaf area duration (LAD) expresses the magnitude and persistence of leaf area or leafiness during the period of crop growth which is directly responsible for higher LAD with the application of FYM @ 2.5 t ha^{-1} + vermicompost @1.25 t ha^{-1} compared to no manure application. Significantly highest LAD was recorded with the application of 100 per cent RDF compared to lower levels of fertilizer application and significantly minimum leaf area duration was observed in plots where no chemical fertilizer was applied at all the stages of observations.

Seed yield and straw yield

The data presented in Table 4 reveal that organic manures significantly influenced the seed yield and straw yield. Application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} resulted in significantly highest seed and straw yield followed by vermicompost @ 2.5 t ha^{-1} and FYM @ 5 t ha^{-1} alone. The later two treatments were found statistically similar to each other in straw yield. Significantly lowest seed and straw yield were observed in control plots. There was an increase of 769 kg grain due to its application over control. The increase in the seed yield was to the extent of 42.6 per cent. It is also evident from the data table that all other treatment differed significantly with each other. However, control treatment proved significantly inferior among all the treatments. This might be attributed to rapid mineralization of N and steady supply of N from FYM and vermicompost, which might have met the N requirement of crop at critical stages. Further farmyard manure acts as nutrient reservoir and upon decomposition produces organic acids, thereby absorbed ions are released slowly during entire growth period leading to higher seed yield and yield components (Maheshbabu *et al.,* 2008). There was consistent and significant increase in seed and straw yield with increase in fertilizer level from 0 to 100 per cent RDF. Application of 100% RDF resulted in significantly highest seed and straw yield followed by 50 per cent RDF. Increase in seed yield due to 100 per cent RDF and 50 per cent RDF was 23.66 per cent and 16.39 per cent over control treatment. These results could be very well attributed due to better growth and development of soybean plants, better LAI and significant improvement in all the yield contributing characters of crops which ultimately improved the

Table 4. Effect of organic manures and fertility levels on seed and straw yield of soybean

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Organic manures		
Control (M_0)	1038	2218
FYM @ 5 t ha^{-1} (M_1)	1244	2759
Vermicompost @ 2.5 t ha^{-1} (M_2)	1492	3077
FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} (M_3)	1807	3253
SEm±	24.91	64.85
CD (P=0.05)	73	190
Fertility levels		
Control (F_0)	1194	2453
50 % RDF (F_1)	1428	2890
100 % RDF (F_2)	1564	3138
SEm±	21.84	56.31
CD (P=0.05)	64	165

seed yield to significant level. Similar were the findings by Sawarkar *et al.* (2010). Although major fraction of photosynthates assimilated during grain filling stage are translocated to the storage organs, but due to higher dry matter accumulation (Table 1), physiological growth parameters and leaf area on account of better nutrient supply owing to fertilizer application might have helped in increasing the straw yield.

Conclusion

It can be concluded from the present study that application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1.25 t ha^{-1} and recommended dose of fertilizers (100% RDF) improved growth, nodules number and weight, physiological parameters and seed yield of soybean.

References

Basso B and Ritchie JT 2005. Impact of compost, manure and inorganic fertilizer on nitrate leaching and yield for a 6-year maize-alfalfa rotation in Michigan. Agric. Ecosystem Env. **108** (4): 309-41.

Desai VR, Sabale RN and Raundal PV 1999. Integrated nitrogen management in wheat-coriander cropping system. J. Maharashtra Agric. Univ. **24** (3): 273-75.

Govindan K and Thirumurugan V 2005. Synergistic association of Rhizobium with phosphate – solubilizing bacteria under different sources of nutrient supply on productivity and soil fertility in soybean (*Glycine max*). Indian J. Agron. **50** (3): 214-17.

Khutate NG, Mendhe SN, Dongarkar KP, Gudadhe and Gavande VH 2005. Effect of nutrient management treatments on growth and yield of soybean. J. Soil Crops **15** (2): 411-14.

Kumar A and Gangawar KS 1985. Analysis of growth, development and yield of Indian rapeseed (*Brassica compestris* var. toria) in relation to nitrogen and plant density. Indian J. Agron. **33** (2): 134-42.

Maheshbabu HM, Hunje R, Biradar Patil NK and Babalad HB 2008. Effect of organic manures on plant growth, seed yield and quality of soybean. Karnataka J. Agric. Sci. **21**: 219-21.

Malkotia V 2006. Integrated nutrient management in grain Amaranth (*Amaranthus hypochondriacus*) varieties. M Sc Thesis, CSK HPKV, Palampur, Himachal Pradesh (Unpublished).

Sarkar RK, Karmakar S and Chakraborty A 1997. Response of summer green gram (*Phaseolus radiatus*) to nitrogen, phosphorus application and bacterial inoculation. Indian J. Agron. **38:** 578-81.

Sawarkar SD, Thakur R and Khamparia RS 2010. Impact of long term continuous use of inorganic and organic nutrients on micronutrients uptake by soybean in vertisol. J. Soil Crops **20** (2): 207-10.

Singh SR, Najar GR and Singh U 2007. Productivity and nutrient uptake of soybean (*Glycine max*) as influenced by bio-inoculants and farmyard manure under rainfed conditions. Indian J. Agron. **52** (4): 325-29.

Watson DJ 1952. The physiological basis of variations in yield. Adv. Agron. **4**: 101-45.

Weirsma JV and Bailey TB 1975. Estimation of leaflet trifoliate and total leaf area of soybean. Agron. J. **67**: 26-30.