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Effect of Inorganic and Organic Sources of Nutrients on Growth, Root Nodulation and Physiological Parameters of Soybean (*Glycine max* L. Merrill.)

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Abstract

A field experiment conducted during 2006-2007 in randomized block design with ten treatments and three replications. The growth parameters viz. plant height, number of trifoliate per plant and plant dry matter were found to be significantly enhanced with the application of 50 kg N + 1.0 t neem cake/ha compared to rest of the treatment at various stages of growth except number of trifoliate per plant at 30 DAS. Recommended dose (N P : K :: 20:60:40) of fertilizer along with inoculation produced significantly more number and dry weight of nodules per plant over control and rest of the treatments at 30 and 45 DAS, whereas it was at par with 50 kg N + 1.0 t neem cake/ha at 60 DAS. Various doses of inorganic and organic nutrients significantly affected the physiological growth parameters viz. LAI, RGR, CGR, NAR and LAR at different stages of study. Maximum LAI, RGR, CGR, NAR and LAR was obtained with the application of 50 kg N + 1.0 t neem cake/ha at 30 and 60 DAS, whereas, at 45 DAS highest value was recorded with 50 kg N + 5 t FYM per hectare which was at par with 50 kg N + 1 t neem cake/ha and significantly greater than rest of the treatments.

Key words : Soybean, Sources of nutrients, Growth, Root nodulation, Physiological parameters.

Soybean (*Glycine max* L. Merrill.) is an important source of fat and protein for the large large population of the world. It utilizes atmospheric nitrogen by its symbiotic relationship with *Bradyrhizobium japonicum* to meet a major part of its nutritional requirement under normal conditions. There is a limit to which symbiosis would be able to meet the nitrogen needs of soybean under inoculated conditions. Evidences indicated that the nitrogen fixation is inversely related to the amount of combined nitrogen either under high fertilization or available from the native pool in the soils. It was, therefore, thought necessary to study the contribution of nutrients from different sources (organic/inorganic/combination). In order to evaluate the ultimate effect of different sources of nutrients on the yield performance of soybean, it would also be of great interest to see their effect on various growth parameters and nodulation of soybean. Keeping these points in view the response of soybean to varying rates of inorganic and organic nutrients was studied to know the effect of organic and inorganic fertilizers on growth, nodulation and physiological parameters of soybean.

Methods

The experimental trials were conducted at the Agricultural Research Farm of Amar Singh (PG) College, Lakhaoti, Bulandshahr (UP). The soil of the experimental site was low in organic carbon (0.49), available nitrogen (162.0 kg/ha), available phosphorus (10.0 kg/ha) and potassium (208.0 kg/ha) and sandy loam in texture having pH 7.5. The water table during the crop season was at 3.5 m depth. Soybean variety PK-262 having 120—125 days maturity was inoculated by *Bradyrhizobium japonicum* and sown in the experimental field. Experiment was conducted in randomized block design with ten treatments and three replications. The treatments were as follows : Control i.e. without any application of manures and fertilizers but seed was inoculated with *Bradyrhizobium japonicum*, 25 kg N per ha applied through urea, 50 kg N per ha applied through urea, 5 tonne FYM per ha, 1 tonne neem cake per ha, 25 kg N applied through

Table 1. Effect of inorganic and organic sources of nutrients on growth of soybean.

Treatments	Plant height (cm) on DAS			Number of trifoliates/ plant on DAS			Dry matter accumulation (g)/ plant on DAS			
	30	45	60	30	45	60	30	45	60	At harvest
T_1 Control (inoculated)	25.10	46.23	60.33	9.33	10.93	18.10	3.03	11.53	13.53	27.91
T_2 25 kg N/ha	28.73	49.90	63.47	9.13	11.47	19.50	3.15	13.00	14.30	30.91
T_3 50 kg N/ha	29.63	61.80	66.33	9.80	14.23	23.37	3.77	18.20	19.00	35.36
T_4 5 t FYM/ha	26.67	52.13	62.47	10.03	13.43	21.37	3.22	16.93	18.23	34.69
T_5 1 t Neem cake/ha	28.07	59.80	65.03	8.77	13.57	22.57	3.20	17.27	19.47	36.98
T_6 25 kg N+1 t neem cake/ha	30.46	60.23	69.33	9.33	17.10	28.57	3.64	20.03	22.13	39.13
T_7 50 kg N+1 t neem cake/ha	33.87	64.90	73.90	8.93	17.80	34.90	4.20	25.63	26.30	47.69
T_8 25 kg N+5 t FTM/ha	29.00	60.00	67.13	8.57	16.67	25.13	3.92	19.60	20.67	38.14
T_9 50 kg N+5 t FYM/ha	30.67	62.33	71.23	9.57	17.10	30.90	4.10	23.23	23.97	42.69
T_{10} Rec. NPK (20:60:40)	28.47	58.33	65.57	9.67	13.10	20.60	3.08	15.13	15.97	32.58
SE ±	1.32	1.99	1.84	0.71	0.87	1.77	0.09	0.75	0.83	1.99
CD at 5%	3.99	6.08	5.64	NS	2.58	5.21	0.29	2.28	2.51	6.21

+ 1 tonne neem cake per ha, 50 kg N applied through + 1 tonne neem cake per ha, 25 kg N applied through + 5 tonne FYM per ha, 50 kg N applied through + 5 tonne FYM per ha and recommended doses of NPK : 20 kg N + 60 kg P_2O_5 + 40 kg K_2O per hectare applied through urea, diammonium phosphate and muriate of potash. The net plot size was 5.0 × 2.4 meter square. Basal application of fertilizers, manures and neem cake as per the treatment was done. The plant height, number of leaves or trifoliate per plant and dry matter accumulation in different plant parts have been observed 30, 45 and 60 days after sowing (DAS) from the five randomly selected plants in each plot and averaged. Dry matter accumulation per plant was recorded at harvesting stage also. The leaf area was calculated by measuring the leaf length (L) from base to tip and its maximum breadth (B) and then length and breadth were multiplied with correction factor. Later the leaf area was calculated as :

$$\text{Leaf area} = L \times B \times \text{Correction factor}$$

Then leaf area index was calculated by following formula :

$$\text{Leaf area index} = \frac{\text{Leaf area}}{\text{Leaf area}}$$

The nodulation studies were made at 30, 45 and 60 days after sowing on the plants harvested for dry matter studies. Roots of the sample plants used for recording pre-harvest observations were digged along with soil mass of surrounding area and washed in running tap water to remove soil particles adhered to it. Nodules were separated from the roots and then blot dried with the help of filter paper. After counting the number of nodules of each plot, these were weighed and kept for drying in forced air oven at 70 ± 1 C for 48 hours. Then dry weight was recorded.

Results and Discussion

Effect of Inorganic and Organic Sources of Nutrients on Growth

The plant height was significantly increased at all the stages of growth due to application of inorganic nitrogen combined with organic sources of nutrients. Maximum plant height (33.87 cm. 64.90 cm and 73.90 cm) was recorded with the treatment 50 kg N + 1 t neem cake per hectare at 30, 45 and 60 days after sowing, respectively. Lowest plant height was observed in control (inoculated) at all the stages of growth. The results were conformity with the several workers (1). Increase in plant height was attributed to internodes elongation. At all the growth stages, 50 kg N + 1 t neem cake per hectare gave maximum plant height due to the continuous supply of nutrients received by the plants from organic sources. Number of trifoliate per plant of soybean was not significantly affected by different treatments at 30 DAS while they

Table 2. Effect of inorganic and organic sources of nutrients on nodulation of soybean.

Treatments	Number of nodules/plant on DAS			Fresh weight of nodules (g)/ plant on DAS			Dry weight of nodules (g)/ plant on DAS		
	30	45	60	30	45	60	30	45	60
T_1 Control (Inoculated)	6.33	21.13	64.23	0.050	0.170	0.556	0.015	0.131	0.268
T_2 25 kg N/ha	8.80	21.77	68.57	0.062	0.204	0.891	0.025	0.154	0.402
T_3 50 kg N/ha	4.57	26.57	40.80	0.025	0.674	0.323	0.007	0.040	0.121
T_4 5 t FYM/ha	10.13	36.27	81.43	0.079	0.290	1.038	0.040	0.265	0.542
T_5 1 t Neem cake/ha	7.70	23.90	65.67	0.061	0.201	0.795	0.021	0.155	0.368
T_6 25 kg N+1 t neem cake/ha	10.23	26.90	70.43	0.065	0.236	0.902	0.030	0.184	0.428
T_7 50 kg N+1 t neem cake/ha	4.57	18.03	45.13	0.039	0.133	0.365	0.009	0.082	0.133
T_8 25 kg N+5 t FYM/ha	12.13	31.80	81.00	0.069	0.245	0.914	0.035	0.249	0.439
T_9 50 kg N+5 t FYM/ha	4.60	19.90	51.33	0.044	0.145	0.434	0.011	0.093	0.139
T_{10} Rec. NPK (20:60:40)	15.13	45.10	83.90	0.097	0.320	1.156	0.049	0.288	0.585
SE ±	0.51	1.38	2.32	0.0036	0.009	0.059	0.0019	0.0069	0.017
CD at 5%	1.54	4.05	6.97	0.0124	0.029	0.179	0.0051	0.0201	0.051

were found significantly affected at 45 and 60 DAS. The maximum (10.03) and minimum (8.57) number of trifoliate per plant was found with the treatments 5 t FYM per hectare and 25 kg N + 5 t FYM per hectare, respectively at 30 days after sowing. But at the 45 and 60 DAS, application of 50 kg N+1 t neem cake per hectare gave maximum number of trifoliate (17.80 and 34.90) per plant of soybean. The effect of different inorganic and organic sources of nutrients on dry matter accumulation of soybean plant was found significant at all the growth stages. The maximum value (4.20 g, 25.63 g, 26.30 g and 47.69 g) of dry matter accumulation per plant was recorded with 50 kg N + 1 t neem cake per hectare at 30 DAS, 45 DAS, 60 DAS and at the time of harvesting, respectively. The lowest value of dry matter accumulation per plant was found in control at all the growth stages of study. This was possibly because supply of N with other nutrients through organic sources particularly neem cake was responsible for better vegetative growth of plant up to reproductive stage. Soybean with increasing rates of nitrogen and FYM resulted in increased dry matter production (2).

Effect of Inorganic and Organic Sources of Nutrients on Nodulation

The effect of various treatments of inorganic and organic sources of nutrients on number of nodules, fresh weight and dry weight of nodules was found

Table 3. Effect of inorganic and organic sources of nutrients on physiological parameters of soybean.

Treatments	Leaf area index on DAS			Crop growth rate (g/d) on stage		Relative growth rate (g/g/d) on stage	
	30	45	60	I	II	I	II
T_1 Control (Inoculated)	2.26	4.13	5.12	0.528	0.134	0.0889	0.0117
T_2 25 kg N/ha	2.45	4.56	5.58	0.617	0.088	0.0951	0.0065
T_3 50 kg N/ha	2.84	4.78	5.86	0.923	0.054	0.1061	0.0031
T_4 5 t FYM/ha	2.44	4.42	5.38	0.875	0.088	0.1122	0.0052
T_5 1 t Neem cake/ha	2.29	4.40	5.31	0.899	0.147	0.1139	0.0087
T_6 25 kg N+1 t neem cake/ha	2.72	4.70	5.66	1.054	0.141	0.1151	0.0072
T_7 50 kg N+1 t neem cake/ha	3.04	4.91	6.03	1.399	0.045	0.1219	0.0022
T_8 25 kg N+5 t FYM/ha	2.73	4.53	5.56	1.006	0.072	0.1077	0.0044
T_9 50 kg N+5 t FYM/ha	2.99	4.94	5.92	1.237	0.050	0.1169	0.0023
T_{10} Rec. NPK (20:60:40)	2.53	4.55	5.54	0.764	0.057	0.1071	0.0038
SE ±	0.09	0.11	0.10	0.048	0.091	0.0042	0.0054
CD at 5%	0.29	0.32	0.31	0.149	NS	0.0118	NS

Table 3. Continued.

Treatments	Net assimilation rate (g/cm²/d) on stage I	II	Leaf area ratio (cm²/g) on stage I	II	Relative leaf growth rate (cm²/cm²/d on stage I	II
T_1 Control (Inoculated)	0.000569	0.000097	156.63	117.84	0.0412	0.0143
T_2 25 kg N/ha	0.000610	0.000059	155.52	117.28	0.0422	0.0134
T_3 50 kg N/ha	0.000830	0.000035	126.65	88.06	0.0352	0.0134
T_4 5 t FYM/ha	0.000879	0.000059	126.57	86.14	0.0402	0.0131
T_5 1 t Neem cake/ha	0.000931	0.000103	121.18	81.48	0.0442	0.0125
T_6 25 kg N+1 t neem cake/ha	0.000973	0.000052	117.63	75.17	0.0362	0.0124
T_7 50 kg N+1 t neem cake/ha	0.001193	0.000027	101.35	63.88	0.0322	0.0137
T_8 25 kg N+5 t FYM/ha	0.000946	0.000050	113.58	77.18	0.0342	0.0136
T_9 50 kg N+5 t FYM/ha	0.001068	0.000030	108.52	70.14	0.0342	0.0121
T_{10} Rec. NPK (2:60:40)	0.000745	0.000035	142.91	101.12	0.0402	0.0132
SE ±	0.00004	0.00006	5.46	3.31	0.0040	0.024
CD at 5%	0.00013	NS	16.23	10.23	NS	NS

significant at all the growth stages. Maximum number of nodules, fresh and dry weight of nodules per plant was found with recommended doses of NPK (20:60:40). This was possibly due to availability of all the essential primary macro nutrients to the roots during nodulation and nodule growth. Phosphorus and potassium were also responsible for better nodule development with each other while nitrogen was responsible for dry matter accumulation in roots. The number of nodules on the tap root increased up to 75 kg N per hectare applied in soybean (3). The inoculation and application of phosphorus increased number of nodules, fresh and dry weight of nodules in soybean per plant in soybean (4).

Effect of Inorganic and Organic Sources of Nutrients on Physiological Parameters

Maximum leaf area index (LAI) was found with the treatment having 50 kg N + 1 t neem cake per hectare at 30 and 60 days after sowing and with 50 kg N + 5 t FYM per hectare at 45 days after sowing. The leaf area index per plant increased probably due to more activities of meristematic tissues of the plant producing more number of trifoliate, correlated with increase in total photosynthetic surface and increased leaf area index of the plant during the vegetative phase, thus, contributed towards the higher production of branches and also increased the dry matter accumulation at different growth stages. The application of fertilizer, singly or in combination increased LAI and photosynthetic efficiency of soybean (5). Different inorganic and organic sources of nutrients had significant effect on other growth parameters like CGR, NAR from 30 to 45 DAS. LAR was significantly affected due to different inorganic and organic sources of nutrients at both stages 30 to 45 DAS and 45 to 60 DAS. Perusal of data would reveal that maximum value of LAI, crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) was recorded in the treatment having 50 kg N + 1 t neem cake per hectare. Analysis of above data indicated that combined use of inorganic and organic sources of nutrients with higher doses of N have better effect on physiological parameters. The increase in values of different physiological parameters during the crop growth period not only resulted in higher dry matter production but due to more accumulation of photosynthates. The increase in CGR, RGR, NAR and RLGR (relative leaf growth rate) also reported by the scientists in oilseeds at higher nitrogen rates (6).

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