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Short Communication

Integrated nutrient management in lentil with organic manures, chemical fertilizers and biofertilizers

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Nutrient application is essential to improve growth and yield of lentil (*Lens culinaris* Medikus). Due to intensive cropping systems, soils are becoming deficient in macro as well as micro nutrients. The organic matter content in the soil is declining which also affects the soil microflora. Hence the logical alternative is to increase the usage of organic manures and biofertilizers. Lentil is known to respond to applications of nutrients (Singh *et al.* 2000), farmyard manure (FYM) (Singh *et al.* 2003) and *Rhizobium* inoculation (Singh *et al.* 2000). Nutrient requirement of the crop can be met by supplying nutrients through chemical fertilizers, organic manures such as FYM or vermicompost or through the use of biofertilizers such as *Rhizobium* and Phosphate Solubilizing Bacteria (PSB). However, the information on integrated use of organic manures, chemical fertilizers and biofertilizers on the growth, symbiotic parameters and yield of lentil are meagre.

A field experiment was conducted during *rabi* (winter) season 2008-09 at the Punjab Agricultural University, Ludhiana to study the effect of organic manures, chemical fertilizers and biofertilizers on symbiotic efficacy, growth and yield of lentil. The soil of the experimental field was loamy sand with pH 8.0 and testing low in organic carbon (0.30%) and available nitrogen (110 kg/ha) and medium in available phosphorus (15.2 kg/ha) and potash (295 kg/ha).

Ten treatments, given in Tables 1 and 2 were tested in a randomized block design with three replications. In the treatment of recommended dose of fertilizers (RDF) 20 kg N/ha and 40 kg P_2O_5/ha was applied through urea (46% N) and single superphosphate (16% P_2O_5), respectively. In *Rhizobium* + PSB treatments, seed was inoculated with *Rhizobium leguminosarum* and *Bacillus* sp. each @ 500 g/ha seed using minimum amount of water. Prior to sowing the inoculated seed was shade dried for about one hour. Chemical fertilizers and organic manures (FYM and vermicompost) were applied as per the treatments just before sowing. The cultivar 'LL 699' was sown on 22 November 2008 in rows 22.5 cm apart using a seed rate of 35 kg/ha. Weeds were managed manually by hand weeding at 30 days after sowing (DAS) and 60 DAS. No infestation of any insect pests or disease was observed and therefore no chemicals were sprayed.

Data on number and dry weight of nodules/plant were recorded 60 and 90 DAS by digging five plants from each plot. Number of nodules/plant were counted and then dried to get nodule weight/plant. Five plants were sampled 90 DAS for measuring shoot dry weight. Dry weight of the nodules and shoots were recorded by drying samples in an oven at 60^{o}C for 72 hours. Chlorophyll content in the leaves were measured at 90 DAS as per the method described by Witham *et al.* (1971). At maturity, data on plant height, pods/plant, seeds/pod, 100-seed weight, biological yield and grain yield were recorded. Harvest index was calculated by dividing economical yield by total biomass production. Net returns as well as B: C ratio were also worked out. All data were subjected to analysis of variance.

The results showed that all the treatments significantly enhanced the number and dry weight of nodules as compared to the control where no organic manure, chemical fertilizer or biofertilizer was applied (Table 1). The treatments which had received *Rhizobium* inoculation recorded significantly higher number and dry weight of nodules than those where no *Rhizobium* inoculation was done. *Rhizobium* inoculation is known to improve nodulation in lentil (Chowdhury *et al.* 1998). Furthermore**,** in these treatments, apart from *Rhizobium*, PSB was also used. PSB is known to solubilize the native phosphorus (El-Sayed 1999) and enhance its availability to the plants. This increased availability of the phosphorus might have helped in better nodulation. Improved nodulation was also observed in those treatments where *Rhizobium* was not applied but chemical fertilizers, FYM or vermicompost were applied alone or in combination. The organic manures are known to decrease P adsorption/fixation and enhance P availability. Thus resulting in better root growth and consequently exploitation of greater soil volume for nodulation. Similar trend was also observed in terms of nodule dry weight. Increased nodule biomass was recorded when combinations of chemical and organic fertilizers was used. More pronounced effects of *Rhizobium* and PSB in the presence of added fertilizers have been reported (El-Sayed 1999). Rao and Patra (2009) have also stated that recommended dose of fertilizers has no effect on microbial proliferation and performance, as also observed in the present study.

The number of nodules and their dry weight was higher at 90 DAS compared with 60 DAS, which could be due to improved plant growth (root as well as shoot) with age. The period of 60 DAS occurred on 22 January, 2009 when the crop was exposed to very low temperature under Punjab conditions and a month later (90 DAS) on 22 February as the temperature increased, the improvement in nodulation was also observed. So the better nodulation recorded at 90 DAS compared to 60 DAS could be due to improved plant growth with age as well as better environmental conditions in terms of warmer temperature.

Shoot dry weight and chlorophyll content increased with application of various organic manures, chemical fertilizers and biofertilizers, though the differences were non-significant on a small unit basis (per plant for shoot dry weight and per gram leaf weight for chlorophyll content). However, on whole crop area basis improvements in these parameters seem to be quite meaningful.

Pods/plant was significantly improved with the application of various nutrients through different sources either singly or in combination over the control (Table 2). Plant height, seeds/pod and 100-seed weight were not influenced significantly by different treatments. However, numerical increases over the control were observed in the case of plant height and 100-seed weight. Pods/plant and plant height of lentil are known to be improved with he use of *Rhizobium* inoculation + N + P_2O_5 (Chowdhury *et al*. 1998) and of *Rhizobium* inoculation + P_2O_5 (Singh *et al*. 2001).

The application of RDF increased the grain yield of lentil significantly (19.7%) over control treatment (Table 2). The application of FYM @ 5 t/ha or vermicompost @ 2 t/ha tended to increase the grain yield over control, however, the increase was not significant. Inoculation of seed with *Rhizobium* + PSB did not increase the grain yield significantly over control, which could possibly be due to the presence of effective native rhizobia in the soil where lentil crop had been grown during previous years as well. It has been reported that *Rhizobium* inoculation may not always have significant effect on grain yield (Bhatt and Chandra 2009). However, *Rhizobium* + PSB with inorganic as well as organic nutrient sources enhanced the grain yield. FYM @ 5 t/ha is known to increase the grain yield of lentil (Singh *et al.* 2003).

Integrated use of RDF, FYM or vermicompost and biofertilizers (*Rhizobium* + PSB) tended to increase the grain yield further over their sole applications, which could be due to the combined and synergistic effect. Furthermore, manures contain high amounts of organic matter which increases the moisture retention of the soil and improves dissolution of nutrients particularly phosphorus. High grain yields of lentil have been reported with the combined use of *Rhizobium* + phosphorus (Singh *et al.* 2001). Similar effects were observed in case of biological yield. Nutrient applications generally

Table 1. Effect of INM on nodule parameters, shoot weight and chlorophyll content in lentil

Treatment	Nodules/plant (no)		Nodule dry weight (mg/plant)		Shoot dry weight (g/plant)	Chlorophyll content (mg/g fresh weight of leaves)
	60 DAS	90 DAS	60 DAS	90 DAS	90 DAS	90 DAS
Control (no organic manure, chemical fertilizer or biofertilizer)	11.0	14.8	32.2	35.5	2.90	1.915
RDF (20 kg N + 40 kg P_2O_5/ha)	14.8	17.0	36.6	38.6	3.26	2.890
FYM 5 t/ha	13.6	16.2	33.9	37.3	3.05	2.321
Vermicompost 2 t/ha	15.9	16.8	36.8	37.8	3.13	2.418
RDF + FYM 5 t/ha	15.3	18.0	36.9	39.0	3.30	2.800
RDF + Vermicompost 2 t/ha	16.8	18.3	37.9	40.3	3.35	2.910
Rhizobium + PSB	19.0	24.0	39.8	45.5	3.06	2.465
RDF + *Rhizobium* + PSB	20.9	26.2	40.3	46.8	3.23	2.680
FYM 5 t/ha + *Rhizobium* + PSB	20.0	25.0	39.5	45.9	3.30	2.710
Vermicompost 2 t/ha + *Rhizobium* + PSB	22.8	25.6	41.6	47.6	3.21	2.790
CD (P=0.05)	1.7	2.0	2.5	3.7	NS	NS

Table 2. Effect of INM on plant growth, yield attributes and yield of lentil

Treatment	Plant height (cm)	Pods/ plant (no)	Seeds/ pod (no)	100-seed weight (g)	Grain yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Net returns (Rs/ha)	B:C ratio
Control (no organic manure, chemical fertilizer or biofertilizer)	32.9	44.0	1.5	2.40	947	2963	32.0	19310	3.12
RDF (20 kg N + 40 kg P_2O_5/ha)	38.9	54.6	1.5	2.50	1134	3175	35.7	24020	3.40
FYM 5 t/ha	33.1	51.7	1.4	2.43	1035	3128	33.1	21550	3.27
Vermicompost 2 t/ha	35.4	52.1	1.4	2.53	1005	2939	34.2	20550	3.14
RDF + FYM 5 t/ha	37.3	60.2	1.4	2.50	1181	3410	34.6	24930	3.37
RDF + Vermicompost 2 t/ha	39.1	51.9	1.5	2.50	1135	3292	34.5	23450	3.21
Rhizobium + PSB	36.2	47.0	1.4	2.50	987	2869	34.4	20410	3.22
RDF + *Rhizobium* + PSB	37.6	60.8	1.4	2.73	1270	3833	33.1	28000	3.77
FYM 5 t/ha + *Rhizobium* + PSB	35.3	55.1	1.4	2.66	1141	3668	31.1	24630	3.57
Vermicompost 2 t/ha + *Rhizobium* + PSB	38.9	52.3	1.5	2.63	1129	3363	33.6	24170	3.49
CD (P=0.05)	NS	4.9	NS	NS	172	542	NS	968	0.18

tended to improve the harvest index. Net returns as well as B: C ratio improved with the application of nutrients through various sources.

The results showed that the application of RDF, FYM 5t/ha or vermicompost 2t/ha produced similar seed yield of lentil. Therefore, depending upon the resources available with the farmers, sources of nutrient could be selected.

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