CAREER POINT INTERNATIONAL JOURNAL OF RESEARCH

Career Point International Journal of Research(CPIJR)
©2022 CPIJR | Volume 2 | Issue 3 | ISSN : 2583-1895
June-2024 | DOI: https://doi.org/10.5281/zenodo.13666827

Evaluating the Effects of Organic and Inorganic Fertilizers on Lentil (Lens culinaris) Growth and Nodulation

Ghanendra Nagar [1], Rohitashv Nagar[2], Deepak Nagar[3], Narendra Kumar Bhinda[4], P. C. Choudhary[5]

School of Agricultural Sciences, Career Point University, Kota

[1]M.Sc. Agronomy Student, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: dn7732s@gmail.com
[2,3,4,5] Assistant Professor, Department of Agronomy, School of Agricultural Sciences, Career Point University, Kota, Rajasthan, India Email: rohitashv.nagar@cpur.edu.in

Abstracts:

The present investigation was conducted at Agronomy research farm, School of Agriculture, Career point University Alniya Kota, during *rabi* seasons of 2023-24. The field experiment was laid out with 14 treatment combinations comprising of one varietal treatments (Kota Masoor-1) with Randomized Block Design and three replications. Various nutrient management treatments had significant impact on growth parameters of lentil *viz.*, plant height, number of branches per plant, at all crop growth stages. The aforesaid characters were significantly superior under the treatment NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha over rest of the treatments. Although, application of NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha, 50% NPKS + FYM @ 5 t/ha and 50% NPKS + Vermicompost @ 2 t/ha was found comparable with former treatment in respect of all growth characters. The minimum values of all these parameters were recorded in the control. Various nutrient management treatments had significant impact on the number of root nodules per plant and increased significantly higher in all the fertility treatments over control in both the observations recorded at 30 and 60 days after sowing stages. The maximum root nodules per plant and maximum dry weight of root nodules 6.88 and 10.12, 4.15 and 8.95 were recorded with the application of NPKS(20:17:20:20kg/ha)+ R*hizobium* culture + PSB at both the stages of crop growth respectively.

Key words: Lentil, Rhizobium, Vermicompost, Nutrients

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I Introduction:

Lentil (Lens culinaris) is a highly valued leguminous crop, known for its rich protein content and significant contribution to human diets across the world. Besides its nutritional benefits, lentil plays a crucial role in sustainable agriculture due to its ability to fix atmospheric nitrogen through a symbiotic relationship with rhizobium bacteria, a process called nodulation. Optimizing both the growth and nodulation of lentils is essential for improving crop yield and soil health, making it a vital area of study.

Effective nutrient management is key to enhancing the growth and nodulation of lentils. Organic nutrient sources, such as compost, manure, and green manure, contribute to soil health by improving its structure, increasing organic matter content, and promoting microbial activity. These improvements in soil quality can lead to better root development and enhanced nodulation, resulting in a more robust crop. On the other hand, inorganic nutrient sources, primarily synthetic fertilizers, offer immediate nutrient availability, which can accelerate plant growth and increase yields. However, the long-term effects of these fertilizers on soil health and microbial populations can vary significantly from those of organic sources.

The interaction between organic and inorganic fertilizers in influencing the growth and nodulation of lentils presents a compelling area of research. While organic sources support sustainable agricultural practices by improving long-term soil fertility, inorganic fertilizers can provide the necessary nutrients during critical growth periods. Understanding how these different nutrient sources affect lentil growth and nodulation can help in developing integrated nutrient management strategies that optimize both crop production and environmental sustainability.

This study aims to investigate the effects of organic and inorganic nutrient sources on the growth and nodulation of lentil. By evaluating various combinations of organic and inorganic treatments, the research seeks to determine the most effective strategies for enhancing lentil productivity. The outcomes of this study will offer valuable insights for farmers, agronomists, and policymakers, guiding them in implementing balanced and sustainable fertilization practices for lentil cultivation.

II Literature Review:

Pulses are a staple food around the world, playing a key role in many traditional cuisines. In India, it is an important group of food crops that can play a vital role to address national food and nutritional security and also tackle environmental challenges. From the nutritional point of view, pulses have been an important source of plant-based protein which are usually lacking in animal-based proteins. Pulses contribute about 10 per cent of the daily protein intake and 5 per cent of energy intake and hence are of particular importance for food security in low income countries. Pulses contain 22–34.6 per cent protein on dry-seed basis, which is almost 2-3 times higher as in cereals. In addition, pulses are important to fulfill the nutritional needs of the human body and importantly health-conscious consumers as pulses are free from gluten, sodium and cholesterol. The positive impact of pulses on soil health is very well known, in particular their ability to naturally fix atmospheric nitrogen, which fertilizes the soil for both intercropped crops and crops to be cultivated subsequently. This in turn lowers the need to use chemical nitrogenous fertilizers. Reducing the production and application of these fertilizers in agriculture decreases GHG emissions and thus, plummeting their degrading / threatening impacts on environment, ecology and sustainability overall. Pulses can enhance the aggregation and structure of the soil, which can improve the water retaining capacity of soil and consequently water-use efficiency of crops as well. Globally, in 2017, pulses accounted for 85.40 million hectares of global crop area producing 87.40 million tonnes of grain with an average productivity of 1023 kg ha-1. However, still the production of pulses is not keeping pace with a minimum requirement of 60 g of protein per day. India is the world"s largest grower, producer and consumer of pulses accounting 34 per cent of total acreage, 26 per cent of the total production and about 30 per cent (23-24 million tonnes) of the total consumption in the world. In India, the area under pulses was >29 million ha with the total production of 25.23 million tonnes at a productivity of 841 kg ha-1 during 2021-22 (MoA & FW, 2022). The integrated nutrient management (INM) has assumed greater significance in the recent past. Work on INK as a whole is very less. Besides, the prohibitive cost of chemical fertilizers often compels to use organic and bio-fertilizers. Therefore, INM involving inorganic, biological and organic sources has potential to improve soil fertility on sustainable basis, since it supplies almost all the nutrients besides increasing nutrient use efficiency and improving physio-chemical properties of soil. The application bio-fertilizer mixed with FYM saved 50 % recommended dose of chemical fertilizer. (Rajkhowa et al., 2003, Rajput and Pandy 2004 and Rajput and Kushwah, 2005). Growing fertilizer need of the country and increasing fertilizer prices have emphasized on the use of bio-fertilizer in Indian agriculture.

III Methodology:

Materials and Methods Location Kota district is located at 25.18° N to 75.83° E Latitude in South Eastern Rajasthan. It covers an area of 221.36 km^2. Agro-climatically, the district falls in Zone V, known as Humid South Eastern Plain. The average rainfall in the region is 660.6. mm. Maximum temperature range in the summer is 40 to 48°C and minimum 1.0- 2.6°C during winter. Main Rainy season crops of the district are maize, soybean and pulses. While in winter, wheat, mustard, coriander and garlic are main crops.

Experimental Details The experiment was carried out with the following standard procedure regarding treatments, replications and experimental design etc. were used to achieve the objectives. Further details are as follows

T1	: Control (no fertilizers)
T2	:NPK+S (20:17:20:20) kg/ha
T3	: 50% NPK + S
T4	: FYM @ 5t/ha
T5	:Vermicompost @ 2 t/ha
T6	:NPK+S (20:17:20:20 kg/ha) + FYM @5 t/ha
T7	:NPK+S (20:17:20:20kg/ha)+Vermicompost @2t/ha
T8	: 50% NPK+S+ FYM@ 5 t/ha
T9	:50% NPK+S+Vermicompost @ 2t/ha
T10	: Rhizobium culture + PSB.
T11	:NPK+S (20:17:20:20 kg/ha)+(Rhizobiumculture+PSB)
T12	: 50% NPK+S + (Rhizobium culture + PSB)
T13	:FYM @ 5t/ha+(*Rhizobium*culture+PSB)
T14	:Vermicompost @ 2t/ha.+(*Rhizobium*culture+PSB)

Measurement of the growth parameters

The plant population was recorded at 30 days after sowing and at maturity of the crop. The number of plant were counted in one-meter row length from randomly selected three rows in each plot and there average were calculated. The plant height was measured in cm at 30, 45, 60 days after sowing and at maturity from the soil surface to the main apical bud up to last foliate. Five plant s selected randomly from each plot and their average height were measured in cm with the help of measuring scale. The total number of branches per plant were counted at 30, 60, 90 days after sowing and at maturity along with main shoot of randomly selected five tagged plants and the mean was calculated. The numbers of root nodules of five randomly selected plants were counted in each plot after uprooting the plant with the help of Ganti at 30 and 60 days after sowing using second rear rows. The roots were carefully washed with water and healthy root nodules. Dry weight of root nodules were recorded from five randomly selected plants in each plot at 30 and 60 DAS. Healthy and effective root nodules kept in thermostatically controlled oven at 800C for 20 hours to obtain constant dry weight and finally their weight was recorded in mg.

IV Results and Discussion

Plant population:

The statistical analysis of data pertaining to plant population per meter row length at 30 days stage as well as at maturity has been summarized, where it is reviewed that the experimental variable did not affect plant population significantly. The study of Table-1 revealed that the plant population was uniform for all practical purpose under various nutrient management treatments. At 30 DAS, it ranged from 11.96/m row length in absolute control treatment to 12.20/m row length in T_6 (NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha) treatment. It is apparent from these plant counts that the sowing was done properly and uniformly using healthy and viable seeds of Kota Masoor 1 (RKL 607-1) variety to give rise to the better seed germination and emergence. Secondly, plant count at maturity stage indicated that there was no any adverse influence of weather conditions such as maximum and minimum temperature, relative humidity and rainfall on crop. At maturity stage, plant population ranged from 11.66 to 11.86/m row length.

The plant population is the most important character, which directly influenced the crop yield. Uniform plant density is an important pre requisite for obtaining higher precision when it is not a variable factor as treatment. The data in Table-1 indicated that the plant population remained almost uniform in all the treatments without giving any definite trend. It is obviously reflected that sowing of experimental crop was done properly and uniformly in each treatment using healthy and viable seed of lentil variety Kota Masoor-1 (RKL 607-1) for better germination. Thus, the crop stand remained almost uniform in all the integrated nutrient management treatments. There was no harmful effect of the treatment applied to the same furrow in which seed were hand drilled.

Plant height

Data regarding effect of organic, inorganic and bio-fertilizers on plant height of lentil at various growth stages have been summarized in Table- 2. Plant height was recorded from 30 days after sowing (DAS) to maturity. An examination of data embodied in Table-2 revealed that plant height was, in general, enhanced by multi-fold with the advancement of plant growth till maturity stage under all treatments. The different treatments of nutrient management significantly influenced the plant height at all growth stages. The data (Table-2) revealed that treatment NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha attained significantly more height (10.36, 15.15, 23.43 and 33.91 cm) among all treatments at 30, 60, 90 DAS and maturity, respectively. However, it was found at par with NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha at all crop growth stages; 50% NPKS + FYM @ 5 t/ha, 50% NPKS + Vermicompost @ 2 t/ha and NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB at 30, 60 DAS and maturity; FYM @ 5 t/ha + *Rhizobium* culture + PSB at 30 DAS and maturity; and with 50% NPKS + *Rhizobium* culture + PSB at maturity. Minimum plant height was recorded in control closely followed by 50% NPKS, *Rhizobium* culture + PSB, Vermicompost @ 2 t/ha, Vermicompost @ 2 t/ha + *Rhizobium* culture + PSB, FYM @ 5 t/ha, NPKS (20:17:20:20 kg/ha) and 50% NPKS + *Rhizobium* culture + PSB.

Number of branches per plant:

The number of branches per plant was recorded at different growth intervals and the mean data have been presented in Table 3. The formation of branches was, in general, fast up to maturity, which resulted in more than four-fold rise in the branches per plant. Analysis of variance (Appendix III) indicated that different treatments of nutrients management exerted significant influence upon this growth character at all stages of observation. Application of 100% of the recommended dose of NPKS (20:17:20:20 kg/ha) in combination with 5 t FYM/ha (T6) brought about maximum branches range from 2.03 at 30 DAS to 5.15 per plant at maturity. This treatment proved significantly superior to rest of the treatments except the treatment NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha, 50% NPKS + FYM @ 5 t/ha, 50% NPKS + Vermicompost @ 2 t/ha,NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB and FYM @ 5 t/ha + *Rhizobium* culture + PSB at all crop growth stages. The minimum number of branches i.e. 1.00, 1.33 and 3.47 per plant was recorded in control at 30, 60, 90 DAS and maturity, respectively.

The morphological parameters *viz.*, plant height and number of branches per plant recorded periodically, have exhibited many interesting architectural variations due to dual inoculation of *Rhizobium* culture and PSB under the application of NPKS at 100 and 50% rates with or without FYM and vermicompost incorporation. Both these parameters, in general, increased by multi-fold in all the treatments with the successive growth and development stages. At maturity stage, plant height ranged from 30.71 to 33.91 cm and branches 3.82 to 5.15 per plant under the various treatments.

The morphological parameters, plant height and number of branches per plant were significantly influenced by nutrient management treatments at all crop growth stages. Application of NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha (T_6) resulted in significantly tallest plants and highest branches per plant over rest of the treatments. However, this treatment was found at par with NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha, 50% NPKS + FYM @ 5 t/ha, 50% NPKS + Vermicompost @ 2 t/ha and NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB. The increase in plant growth was attributed to the increase availability of nutrients with application of inorganic fertilizer, continuous supply of nutrients due to the action of biofertilizers and release of nutrients from organic fertilizer. NPK plays pivotal role in several physiological and biochemical processes, viz., root development, photosynthesis, energy transfer reaction and symbiotic biological N-fixation process. Sulphur influences the formation of protein and chlorophyll, is a constituent of plant‘s structural material and increases root development. FYM and vermicompost improved the physical property of soil and activities of *Rhizobium* culture, which fixed the atmospheric nitrogen as well as soil nitrogen made available to the plant and PSB, which made available phosphorus from insoluble to soluble form. Beneficial effect of FYM, vermicompost and biofertilizer singly or jointly along with NPKS on growth characters of lentil have also been reported by Pathak *et. al.* (2003), Singh *et al.* (2003), Hossain and Suman (2005), Singh *et al.* (2007), Zeidan (2007), Singh *et al.* (2008) and Kumar *et al.* (2009).

Number of root nodules per plant:

The data in Table 4 revealed that the number of root nodules was augmented steadily with the increase of plant growth till 60 days stage. Application of NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB (T11) brought about maximum number of root nodules i.e. 6.88 at 30 DAS and 10.62 per plant at 60 days stage. This treatment (T11) found to be significantly superior to most of the treatments except 50% NPKS + *Rhizobium* culture + PSB at both stages of observation.

Dry weight of root nodules per plant:

The dry weight of root-nodules exhibited the same result trend as observed in case of root-nodule numbers per plant because both were interrelated to each other (Table-5 The applied treatments exerted their significant influence upon this parameter at both the stages of plant growth. Application of hundred percent dose of NPKS (20:17:20:20 kg/ha) along with *Rhizobium* culture + PSB (T11) gave the maximum dry weight of root nodules i.e. 4.15 mg/plant at 30 days stage and 8.95 mg/plant at 60 days stage of plant growth. It was closely followed by Vermicompost @ 2t/ha + *Rhizobium* culture+PSB and 50% NPK+ S + *Rhizobium* culture+PSB at 30 DAS and 60 DAS. Absolute control treatment resulted in the lower dry weight of root-nodules. Lentil, being a legume, fixes atmospheric nitrogen and improves the soil fertility. Integrated nutrient management in legumes is of great importance as it encourages the root nodulation, growth and productivity per unit is in addition to soil health on the sustainable basis.

Root-nodulation study indicated that the combined application of NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB, resulted to increase maximum number of root-nodules per plant as well as their dry weight of root nodules per plant at 30 and 60 days stages. This was at par with 50% NPKS + *Rhizobium* culture + PSB in case of number of root nodules and their dry weight per plant and with FYM @ 5 t/ha + *Rhizobium* culture + PSB, Vermicompost @ 2 t/ha + *Rhizobium* culture + PSB, *Rhizobium* culture + PSB, NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha and NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha in case of dry weight of root nodules per plant only. Biological nitrogen fixation by the symbiotic bacteria (*Rhizobium sp*.) in root-nodules of legume plants, lentil is one of them, is quantitatively one of the most important ways in which atmospheric nitrogen enters the biosphere. Biosphere is that parts of the earth's envelope in which living organisms exist in their natural state. The combination of organic and inorganic sources of nutrients in treatments like NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB, 50% NPKS + *Rhizobium* culture + PSB, FYM @ 5 t/ha + *Rhizobium* culture + PSB, Vermicompost @ 2 t/ha + *Rhizobium* culture + PSB, *Rhizobium* culture + PSB, and NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha encouraged the formation of increased number and dry weight of root nodules per plant up to the significant level. This may be because of the increase number of nitrogen fixing bacteria in

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©2022 CPIJR | Volume 2 | Issue 3 | ISSN : 2583-1895
June-2024 | DOI: https://doi.org/10.5281/zenodo.13666827

the rhizosphere (root-zone) and the sufficient supply of nutrients to plant for development of root nodules. These results corroborate with those of many workers, viz., Jain *et al* (1995), Singh and Kumar (1996), Chandra and Pareek (2002), Sharma and Sharma (2004), Balyan and Singh (2005), Hossain and Suman (2005), Karmakar *et al.* (2006), Khanna *et al.* (2006) and Kumar and Chandra (2008).

Table 1. Yield attributes as influenced by fertility sources and wheat varieties

Treatments	Days taken to 50% flowering	Days taken to maturity	No. of ear heads (m^1)	Length of ear (cm)	No. of spikelets (ear^{-1})	No. of grain (ear^{-1})	Yield	
Fertility sources							Grain	Straw
F_1	80.0	117.00	114.40	7.58	27.13	51.67	29.77	37.56
F_2	79.60	115.30	94.0	6.28	18.13	39.67	26.84	33.02
F_3	82.90	118.60	129.20	9.51	37.67	56.63	35.74	46.84
SEm±	**1.86**	**2.13**	**1.585**	**0.136**	**1.085**	**1.240**	**0.60**	**0.79**
CD (P=0.05)	**3.13**	**4.63**	**4.589**	**0.395**	**3.144**	**3.590**	**1.75**	**2.30**
Varieties								
V_1	74.34	113.60	114.67	8.03	28.67	51.22	31.62	40.38
V_2	78.00	118.30	110.33	7.56	26.89	48.83	29.57	37.30
V_3	78.30	120.10	112.67	7.79	28.00	50.00	30.71	38.58
V_4	75.00	114.26	108.33	7.37	25.00	46.67	29.25	36.77
V_5	80.60	122.00	116.67	8.20	29.67	51.89	32.77	42.67
SEm±	**2.06**	**2.34**	**2.046**	**1.176**	**1.401**	**1.600**	**0.77**	**1.03**
CD (P=0.05)	**3.46**	**4.78**	**5.925**	**0.510**	**NS**	**NS**	**2.25**	**2.98**

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June-2024 | DOI: https://doi.org/10.5281/zenodo.13666827

Table 2 Effect of tillage and nitrogen management practices on yield and economics of wheat

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Net return (ha.)	B:C ratio
Tillage practices					
Zero tillage	2935	4660	7595	41929	1.94
Minimum tillage	3520	5525	9045	53857	1.83
FIRB	3907	5995	9902	57275	1.91
Conventional tillage	4220	6380	10600	60595	1.95
SEm±	**101.7**	**143.3**	**245**	**1121.7**	**0.09**
CD (P=0.05)	**305**	**430**	**735.1**	**3365**	**0.27**
Nitrogen management practices					
Control	2920	4630	7568	50160	1.63
RND (120:80:55 kg/ha NPK)	4185	6326	10511	60715	1.93
SPAD (80:60:50 kg/ha NPK)	3480	5465	8945	53834	1.81
Targeted yield 5t/ha (150:80:65 kg/ha)	3890	5975	9865	57630	1.89
SEm±	**99.3**	**138.7**	**237.9**	**1091.7**	**0.08**
CD (P=0.05)	**298**	**416**	**713.9**	**3275**	**0.24**

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Table 3: Effect of nutrient management on number of branches of lentil at different growth stages

Treat.	Combination	Number of branches at			
		30 DAS	60 DAS	90 DAS	Maturity
T_1	Control (No fertilizers)	1.23	1.62	3.78	3.82
T_2	NPK+S (20:17:20:20kg/ha)	1.66	2.42	4.44	4.48
T_3	50% NPK+S	1.3	1.92	3.98	4.02
T_4	FYM @ 5t/ha	1.56	2.16	4.38	4.42
T_5	Vermicompost @ 2t/ha	1.63	2.36	4.04	4.08
T_6	NPK+S (20:17:20:20kg/ha)+ FYM @ 5t/ha	2.03	3.36	5.11	5.15
T_7	NPK+S(20:17:20:20kg/ha)+Vermicompost @ 2t/ha	2	3.22	5.04	5.08
T_8	50%NPK + S + FYM @5t/ha	1.93	2.92	4.84	4.88
T_9	50%NPK + S+Vermicompost @2t/ha	1.96	2.98	4.71	4.75
T_{10}	*Rhizobium* culture+PSB	1.5	1.96	4.01	4.05
T_{11}	NPKS(20:17:20:20kg/ha)+ R*hizobium* culture + PSB	1.9	2.89	4.64	4.68
T_{12}	50% NPK+ S + *Rhizobium* culture+PSB	1.7	2.62	4.48	4.52
T_{13}	FYM@5t/ha + *Rhizobium* culture+PSB	1.73	2.89	4.58	4.62
T_{14}	Vermicompost @ 2t/ha + *Rhizobium* culture+PSB	1.6	2.22	4.24	4.28
	S.E.m±	**0.12**	**0.22**	**0.24**	**0.26**
	C.D.(at 5%)	**0.33**	**0.63**	**0.72**	**0.69**

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June-2024 | DOI: https://doi.org/10.5281/zenodo.13666827

Table 4. Effect of nutrient management on number of root nodules /plant of lentil at different growth stages.

Treatment	Combination	Number of root nodules/plant at	
		30 DAS	**60 DAS**
T_1	Control (No fertilizers)	3.68	4.62
T_2	NPK+S (20:17:20:20kg/ha)	4.35	6.02
T_3	50% NPK+S	4.02	5.82
T_4	FYM @ 5t/ha	3.88	5.42
T_5	Vermicompost @ 2t/ha	3.75	5.02
T_6	NPK+S (20:17:20:20kg/ha)+ FYM @ 5t/ha	4.82	9.02
T_7	NPK+S(20:17:20:20kg/ha)+Vermicompost @ 2t/ha	4.62	8.55
T_8	50%NPK + S + FYM @5t/ha	4.42	7.28
T_9	50%NPK + S+Vermicompost @2t/ha	4.38	7.15
T_{10}	*Rhizobium* culture+PSB	5.35	9.08
T_{11}	NPKS(20:17:20:20kg/ha)+ R*hizobium* culture + PSB	6.88	10.62
T_{12}	50% NPK+ S + *Rhizobium* culture+PSB	5.82	9.88
T_{13}	FYM@5t/ha + *Rhizobium* culture+PSB	5.75	9.22
T_{14}	Vermicompost @ 2t/ha + *Rhizobium* culture+PSB	5.68	9.08
	S.E.m±	**0.29**	**0.37**
	C.D. (at 5%)	**0.68**	**0.86**

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Table No.5: Effect of nutrient management on dry weight of root nodules /plant (mg) of lentil at 30 and 60 days after sowing.

Treatment	Combination	Dry weight of root nodules /plant (mg)	
		30 DAS	**60 DAS**
T_1	Control (No fertilizers)	2.22	4.07
T_2	NPK+S (20:17:20:20kg/ha)	2.88	6.93
T_3	50% NPK+S	2.82	6.75
T_4	FYM @ 5t/ha	2.55	5.96
T_5	Vermicompost @ 2t/ha	2.28	4.8
T_6	NPK+S (20:17:20:20kg/ha)+ FYM @ 5t/ha	3.48	6.95
T_7	NPK+S(20:17:20:20kg/ha)+Vermicompost @ 2t/ha	2.95	7.81
T_8	50%NPK + S + FYM @5t/ha	3.28	7.85
T_9	50%NPK + S+Vermicompost @2t/ha	3.85	7.8
T_{10}	*Rhizobium* culture+PSB	3.08	7.56
T_{11}	NPKS(20:17:20:20kg/ha)+ R*hizobium* culture + PSB	4.15	8.95
T_{12}	50% NPK+ S + *Rhizobium* culture+PSB	3.89	7.05
T_{13}	FYM@5t/ha + *Rhizobium* culture+PSB	3.55	7.04
T_{14}	Vermicompost @ 2t/ha + *Rhizobium* culture+PSB	3.95	7.95
	S.E.m±	**0.29**	**0.37**
	C.D.(at 5%)	**0.68**	**0.86**

V Conclusion:

The study conducted at the Agronomy Research Farm, School of Agriculture, Career Point University Alniya Kota, during the rabi season of 2023-24, demonstrated the significant impact of various nutrient management treatments on the growth parameters of lentil (Kota Masoor-1). The findings indicated that the combined application of NPKS (20:17:20:20 kg/ha) with FYM @ 5 t/ha notably enhanced plant height, number of branches per plant, and overall growth at all crop stages compared to other treatments. Additionally, treatments incorporating vermicompost and

Career Point International Journal of Research(CPIJR)
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June-2024 | DOI: https://doi.org/10.5281/zenodo.13666827

Rhizobium culture, alongside NPKS and FYM, showed comparable results, highlighting their potential as effective nutrient management strategies. The experiment revealed that the application of NPKS (20:17:20:20 kg/ha) + Rhizobium culture + PSB produced the maximum number and dry weight of root nodules per plant, signifying improved root health and nutrient uptake. The study underlined the importance of integrated nutrient management (INM) in enhancing soil fertility, crop growth, and sustainable agricultural practices. The results support the notion that combining inorganic, organic, and biological fertilizers can optimize nutrient availability, improve plant physiological and biochemical processes, and ultimately increase lentil productivity.

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