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Research Article

# Effect of Vermicompost and Rhizobium Inoculation on Growth and Yield of Lentil Genotypes under Rainfed Region

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## ABSTRACT

Vermicompost (VC) and Rhizobium inoculation (RI) can be used to improve the growth and productivity of lentil. This study aimed to assess the impact of both organic and inorganic fertilizers on the productivity and growth of genotypes of lentils grown under rainfed environments. For this, a field experiment was conducted at the experimental field area of the Barani Agricultural Research Institute (BARI), Chakwal, in 2024–2025 under rainfed conditions. The investigation was carried out on a sandy loam textured soil with a pH of 7.8, extractable K (126 mg kg-1), extractable P (2.5 mg kg-1), and low organic matter (0.31%). The RCBD factorial (randomized complete block design) was used in this study, which included three replications and seven treatments in a 1.2 m * 5 m plot. Urea, single super phosphate, and murate of potash were the sources of N, P, and K, respectively. On October 25, 2024, the crop was planted, and on April 4, 2025, it was harvested. The mean values were compared using the Least Significant Difference (LSD) test at a 5% probability level after the collected data was statistically analyzed using the analysis of variance technique (ANOVA). When the treatments were compared, it was found that all of the genotypes of lentil (G1=21CL307, G2=21CL309, and G3= Chakwal Masoor, a check variety) performed better in T6 (Rhizobium + VC + 100% RDF), as evidenced by improved germination percentages (98, 97, 98), plant height (48.66 cm, 47.33 cm, 45 cm), number of pods/plant (116.33, 118, 108.33), number of seeds/pod (2.66, 2.7, 2), 1000-grain weight (37g, 36.66g, 36.66g), and grain yield (359.5 kg $ha^{-1}$, 364 kg $ha^{-1}$, 354.33 kg $ha^{-1}$). The control group, which did not receive any fertilizer treatments, had the lowest outcomes. Every other treatment outperformed the control treatment statistically. According to this study, applying fertilizer such as rhizobium + VC + 100% RDF is advised to improve the growth and yield of lentil genotypes grown under rainfed conditions.

**Keywords:** Rhizobium; Vermicompost; Lentil, Growth and yield; Rainfed Agriculture; Sandy Loam Soil.

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## INTRODUCTION

The fifth most important legume in the world is lentil (*Lens culinaris* L.), which is

grown in around 50% of the world's countries. Worldwide, 5.73 million tonnes of lentils are produced on more than 4.8 million hectares of land (Sardar et al., 2025). Protein, carbs, various vitamins, minerals, and macro- and micronutrient components are all included in lentil grains (Alexander at al., 2024). Being a leguminous crop, it uses atmospheric nitrogen to partially meet its nitrogen needs, which is why it plays a significant role in crop rotations across the nation. Because lentils are a less-maintained crop that is typically cultivated in poor soils with rain and no fertilizer or manures, its output level is typically low. Several nutrient deficits have emerged in many crops, including lentils, as a result of the regular loss of soil nutrient supplies. This is due to the fact that increased production levels result in higher and faster rates of soil nutrient exhaustion. (Singh and Singh, 2014).

It is crucial to use balanced fertilization, which includes applying chemical fertilizers, organic fertilizers, and biofertilizers like VC and rhizobium, to increase the crop's output. The preservation of soil's biological and physical properties, as well as its capacity to act as a buffer, depends heavily on organic molecules. Vermicompost is a good source of organic manure with a relatively higher amount of plant nutrients than standard organic manures (Khan and Chauhan, 2023). Under the fine-textured Vertisols, the highest production was achieved by combining the usage of organic sources with N, P, and K (Behara and Pandey, 2006). Rhizobium inoculation (Uddin, 2022), farmyard manure (Singh et al., 2015), and fertilizer inputs all had an impact on lentil.

Growing fertilizer need of the country and increasing fertilizer prices have emphasized on the use of bio-fertilizers in agriculture. The research work with bio-fertilizer in combination with VC and NPK is lacking. Keeping this in view, current study was designed to carry out to find the best combination of organic and inorganic nutrition sources and biofertilizers for enhancing productivity, profitability and soil health in lentil under clay loam soil in rainfed agriculture.

## MATERIALS AND METHODS

### Experimental Setup

The study was conducted from October 25, 2024, to April 4, 2025, at the Barani Agricultural Research Institute (BARI), Chakwal (32°55'33"N, 72 °43'30"E). The sandy loam soil at the experimental site had a pH of 7.8. Both the nitrogen percentage and organic matter content were low (0.31% and 3 mg $kg^{-1}$). Phosphorus availability was likewise poor (2.5 mg $kg^{-1}$). The amount of potash in the soil was medium, at 126 mg $kg^{-1}$. Seven treatment were applied and their detailed in Table 1, Rhizobium inoculants were collected from Land Resources Research Institute, NARC Islamabad.

Table 1: Treatments details

| Treatment | Description | Details of Application |
|---|---|---|
| $T_1$ | Control | No fertilizer, biofertilizer, or organic amendment applied |
| $T_2$ | RDF | 100% Recommended Dose of Fertilizers applied as per crop requirement |
| $T_3$ | Rhizobium | Seed inoculation with *Rhizobium* @ 500 g $acre^{-1}$ |
| $T_4$ | VC | Vermicompost applied @ 4 t $ha^{-1}$ |
| $T_5$ | Rhizobium + VC | Seed inoculation with *Rhizobium* @ 500 g $acre^{-1}$ + Vermicompost @ 4 t $ha^{-1}$ |
| $T_6$ | Rhizobium + VC + 100% RDF | *Rhizobium* @ 500 g $acre^{-1}$ + Vermicompost @ 4 t $ha^{-1}$ + 100% RDF |
| $T_7$ | Rhizobium + VC + 50% RDF | *Rhizobium* @ 500 g $acre^{-1}$ + Vermicompost @ 4 t $ha^{-1}$ + 50% RDF |

### Agronomic practices

Ploughing and leveling was done in the experimental field, and row to row distance was kept as 20 cm. Hand drilling was done for sowing and seed rate was @ 150 seeds/row. In all experimental plots, weeding, harrowing, and fertilizer application were ensured uniformly.

### Data collection

For data collection, three plants were selected from each plot. At maturity stage, plants were measured for height, number of pods per plant, number of seeds per pod, and germination percentage. To determine the weight of the thousand seeds, samples of 1000 randomly submerged seeds from each plot were weighed using a digital scale. The grain yield (Kg $ha^{-1}$) of the experimental cultivars in each plot was also recorded, and the results from all the

measured parameters were statistically examined.

**Statistical Analysis**

Analysis of variance table was performed for each parameters and treatments were compared using least significant difference (LSD) test at 5% level of significance using Statistix 8.1 software.

## RESULTS

**Effect of treatments on growth and yield parameters of lentil genotypes**

The percentage of lentil genotypes (G1, G2, and G3) that germinated under various treatments (T1-T7) varied considerably (Table 2). Advanced treatments typically enhanced germination across all genotypes, with T6 showing the highest values (98% for G1 and G3, 97% for G2). T1 had the lowest germination rate (85%–89%). Plant height increased gradually from T1 to T6, following a similar pattern to the germination %. The smallest plants were found under T1 (20.66 cm for G1, 22.66 cm for G2, and 21.33 cm for G3), whilst the tallest plants were found under T6 (48.66 cm for G1 and G2, 45.00 cm for G3). This could be due to plant nutrients being held in organic sources such as vermicompost, which may have improved the soil's physicochemical and biological properties, resulting in increased crop output. However, soils that are simply fertilized with artificial fertilizers do not have all of these benefits (Singh and Singh, 2014). Our results are comparable to those of Chauhan and Khan (2023). Argaw and Mnalku (2017) reported that vermicompost and Rhizobium inoculation show significant positive effect on growth and yield of Faba Bean.

Across all genotypes, the number of pods per plant gradually rose from T1 to T6 (Table 2). The lowest values were found under T1 (53.67–58.33), while the highest values were found under T6 (116.33 for G1, 118.00 for G2, and 108.33 for G3). Treatments also increased the number of seeds per pod, reaching a high at T6 with 2.66 for G1, 2.70 for G2, and 2.00 for G3. Under T1, the lowest values were found (1.03–1.16).

Under advanced treatments, grain weight significantly increased, peaking in T6 (37.00 g for G1, 36.66 g for both G2 and G3). The lowest grain weight was obtained by T1 (14.67–17.33 g). With the highest yields in T6 (359.3 kg $ha^{-1}$ for G1, 364.0 kg $ha^{-1}$ for G2, and 354.33 kg $ha^{-1}$ for G3), grain yield trends closely mirrored the yield components. T1 had the lowest yields (139.0–177.0 kg $ha^{-1}$). Although it was still much greater than previous treatments, T7 displayed a minor decrease in comparison to T6. This could be because plant nutrients are held in organic sources such as vermicompost, which may have improved the soil's physicochemical and biological properties, resulting in increased crop yield. However, soils that are simply fed with inorganic fertilizer do not have all of these benefits (Singh and Singh, 2014). Our results are comparable to those of Chauhan and Khan (2023). Similarly, beneficial effect of vermicompost and rhizobial inoculation on some soil characteristics, growth and yield of mung bean were also found by Alkobaisy et al. 2021.

**Correlation analysis**

The correlation analysis of all three types of lentils (V1, V2, and V3) established that the grain yield is positively and significantly correlated with plant height, number of pods per plant, number of seeds per pod, and 1,000-grain weight with the latter showing correlation in V3 (r = 0.991) (Table 3). This indicates that plants that grew tall formed a strong canopy to improve light absorption (Meena et al., 2023), and the synergy between vermicompost and Rhizobium amplified nitrogen fixation and phosphorus levels and, as a result, decreased the number of pods that aborted and the overall sink capacity (Rehman et al., 2024). Moreover, the presence of strong association with the weight of 1000 grains signifies the importance of organic amendments in offering vital micronutrients in starch production and retention of a stay-green characteristic in the grain-filling phase (Singh et al., 2022). In contrast, the germination percentage and yield have a rather weak correlation (0.15 to 0.29), which suggests that although initial stand establishment is also required, ultimate productivity depends on physiological performance during the stage of reproductive production more than initial population density does (Basit et al., 2021).

**Effect on soil fertility**

Post-harvest soil analysis was done and it was observed that soil fertility improved where organic sources fertilizers were applied (Table 4). Application of VC @ 4t $ha^{-1}$ and microbial inoculant along with RF significantly increased OM, available nitrogen, phosphorus and potash in soil over control. However, soil fertility improvement was observed in all treatments where organic and inorganic sources were applied except control. This improvement in soil health might be a factor that increase lentil yield. Arsalan et al. (2020) also found improvement in soil fertility when FYM applied along with chemical fertilizers in wheat. Similarly, enhancement in soil fertility due to combined effect of FYM and chemical fertilizer were also evident in the study by Sharma and Sharma, 2023.

Table 2: Growth and yield attributes of lentil genotypes as affected by various treatments.

| | Treatments | Germination % | Plant Height (cm) | No. Pods/plant | No. of Seeds/pod | 1000 Grain wt (g) | Grain Yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| V1 | T1=Control | 97 | 20.66 | 57.67 | 1.03 | 15.67 | 177 |
| | T2=RDF | 89 | 29.66 | 81 | 1.4 | 25 | 212.67 |
| | T3= Rhizobium (@500g/acre) | 93 | 33.33 | 96.67 | 1.6 | 28.33 | 251 |
| | T4= VC (@ 4 t/ha) | 92 | 38.33 | 98.33 | 1.66 | 32.33 | 291 |
| | T5= Rhizobium + VC | 93 | 40.33 | 101.33 | 1.83 | 32.33 | 321.33 |
| | T6=Rhizobium + VC + 100% RDF | 95 | 48.66 | 116.33 | 2.66 | 37 | 359.3 |
| | T7= Rhizobium + VC + 50% RDF | 98 | 44 | 105 | 1.66 | 32 | 337.3 |
| V2 | T1=Control | 97 | 22.66 | 58.33 | 1.16 | 14.67 | 139 |
| | T2=RDF | 89 | 30.66 | 72 | 1.53 | 26.33 | 261.33 |
| | T3= Rhizobium (@500g/acre) | 92 | 33.66 | 95 | 1.6 | 30 | 267.67 |
| | T4= VC (@ 4 t/ha) | 91 | 38 | 97.67 | 1.73 | 31 | 291.67 |
| | T5= Rhizobium + VC | 93 | 41 | 101.67 | 1.7 | 34 | 308.67 |
| | T6=Rhizobium + VC + 100% RDF | 96 | 48.66 | 118 | 2.7 | 36.66 | 364 |
| | T7= Rhizobium + VC + 50% RDF | 98 | 44.33 | 105.33 | 1.73 | 33 | 348.33 |
| V3 | T1=Control | 97 | 21.33 | 53.67 | 1.06 | 17.33 | 149.33 |
| | T2=RDF | 89 | 23.33 | 70 | 1.26 | 24.33 | 236.33 |
| | T3= Rhizobium (@500g/acre) | 93 | 29.66 | 82.33 | 1.50 | 26.66 | 240.33 |
| | T4= VC (@ 4 t/ha) | 95 | 29 | 96.33 | 1.56 | 29.66 | 273 |
| | T5= Rhizobium + VC | 93 | 29.33 | 92 | 1.63 | 32.66 | 309 |
| | T6=Rhizobium + VC + 100% RDF | 93 | 45 | 108.33 | 2 | 36.66 | 354.33 |
| | T7= Rhizobium + VC + 50% RDF | 94 | 44.33 | 100 | 1.66 | 30.66 | 303.33 |
| | CV | 2.78 | 4 | 3.96 | 9.81 | 4.56 | 5.08 |
| | LSD (0.05) | 1.56 | 2.32 | 5.94 | 2.26 | 2.17 | 23.09 |
| | T×V (*p* value) | 0.0224 | 0.0000 | 0.0688 | 0.0324 | 0.0381 | 0.0014 |

## CONCLUSIONS AND RECOMMENDATIONS

The present study evaluated the effect of integrated nutrient management involving Rhizobium inoculation, vermicompost, and recommended doses of inorganic fertilizers on the growth and yield of lentil genotypes under rainfed conditions at Barani Agricultural Research Institute, Chakwal during 2024–2025. The results indicated that the combined application of Rhizobium + vermicompost + 100% recommended dose of fertilizers (RDF) significantly improved germination percentage, plant height, number of pods per plant, seeds per pod, 1000-grain weight, and grain yield compared with the control and other treatments. Among the tested genotypes, 21CL307 and 21CL309 performed comparatively better than the check variety Chakwal Masoor under integrated nutrient management. The findings demonstrate that the synergistic use of organic, biological, and inorganic nutrient sources enhances nutrient availability and improves lentil productivity in rainfed environments characterized by low soil fertility.

Based on the results of this study, the integrated application of Rhizobium inoculation, vermicompost, and 100% recommended dose of fertilizers is recommended to enhance lentil growth and yield under rainfed conditions. The promising genotypes 21CL307 and 21CL309 may be further evaluated in multi-location trials for wider adaptability and potential varietal development. The adoption of integrated nutrient management practices should be promoted to improve soil fertility, sustain lentil productivity, and reduce dependence on chemical fertilizers in rainfed farming systems.

. Table 3: Correlation analysis of lentil growth and yield traits.

| Variety | Parameters | R value |
|---|---|---|
| | Germination % vs. Grain Yield | 0.293668 |
| | Plant height vs. Grain Yield | 0.986254 |
| **G1** | No. pods/plant vs. Grain Yield | 0.94199 |
| | No. of Seeds/pod vs. Grain Yield | 0.845718 |
| | 1000 Grain Wt vs. Grain Yield | 0.938852 |
| | Germination % vs. Grain Yield | 0.157982 |
| | Plant height vs. Grain Yield | 0.968389 |
| **G2** | No. pods/plant vs. Grain Yield | 0.933227 |
| | No. of Seeds/pod vs. Grain Yield | 0.795301 |
| | 1000 Grain Wt vs. Grain Yield | 0.970123 |
| | Germination % vs. Grain Yield | 0.229875 |
| | Plant height vs. Grain Yield | 0.813239 |
| **G3** | No. pods/plant vs. Grain Yield | 0.953551 |
| | No. of Seeds/pod vs. Grain Yield | 0.95915 |
| | 1000 Grain Wt vs. Grain Yield | 0.991723 |

Table 4: Post-harvest analysis.

| Treatments | Post-harvest analysis | | | |
|---|---|---|---|---|
| | OM (%) | N (mg $kg^{-1}$) | Av. P (mg $kg^{-1}$) | K (mg $kg^{-1}$) |
| T1= Control | 0.28 | 3.5 | 4.2 | 95 |
| T2= RDF | 0.32 | 5.2 | 7.11 | 117.67 |
| T3= Rhizobium (@500g/acre) | 0.35 | 6 | 6.11 | 101.00 |
| T4= VC= @ 4 t/ha | 0.44 | 8.2 | 8.14 | 120.00 |
| T5= Rhizobium + VC | 0.46 | 10 | 8.48 | 109.67 |
| T6= Rhizobium + VC + 100% RDF | 0.58 | 13 | 9.4 | 128.67 |
| T7= Rhizobium + VC + 50% RDF | 0.42 | 10 | 8.48 | 117.33 |
| CV | 12.61 | 6.59 | 4.83 | 3.25 |
| LSD $_{(0.05)}$ | 0.918 | 0.9314 | 0.1098 | 4.5047 |

## AUTHOR CONTRIBUTIONS

AL, MA & MK planned and performed the experiments, SY, RU, MB, FB, MA interpreted the results, editing and grammar check, AL made the write-up, and RL, AA, SS, MY, AA, AA and SS statistically analyzed the data, made illustrations and editing

## COMPETING OF INTEREST

The authors declare no competing interests.

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