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Effect of Vermicompost Types along with Rhizobium Inoculation Impact on Nodulation Potential, Growth and Yielding Attributes of Lentil

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Vermicompost is a humified, stabilized and finely alienated peat like mass by activity of earthworms in a form that is eagerly available for plants. Due to its porous nature , high water storage capacity, having hormones such as substance and plant growth regulators such as auxins, cytokinins, absicisic acid and also high levels of macro and micro nutrients, vermicompost fertilizer can play an important role in plant growth and development and also in reducing harmful effects of various harmful stresses on plants. In regard of this, special focus of this study was to prepare different types of vermicomposts using earthworm specie Eisenia fetida and to access the effect of these various types of vermicompost on lentil growth and yield. Field experiment was laid out in Randomized complete block design (RCBD) using 06 treatments having 03 replications conducted at University Research Farm Koont, Chakwal Road, Rawalpindi. Analysis of variance (ANOVA) was used to detect difference among means of all treatments at 5% significance level by using Fisher's protected Least Significant Differences (LSD) Test. Statistical results revealed that vermicompost application @ 5 tonns/ha significantly affected growth and yield of lentil and maximum growth was attained with cow dung derived vermicompost+rhizobium followed by wheat straw, vegetable waste and minimum with leaf litter derived vermicompost. Cow dung vermicompost was found to be efficient for all growth and yield parameters.

Keywords: Eisenia Fetida; Lentil Growth; Least Significant Differences; Organic Waste; Rhizobium Inoculation; Vermicompost Types; Yield.

Vermicomposting is one of the invigoration technique of organic farming that is considered to be cheap for farmers because of its low cost and is safe, hygienic and effective for disposal of solid wastes[1]. Engrossment of earthworm (*Eisenia fetida*) for decomposition of organic waste is found to be effective because loss of nitrogen from organic wastes is reduced while using worms as a source of organic composting[2]. This technique helps in economically feasible and

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efficient reprocessing of organic residues, animal excreta and wastes of industries. Numerous species (*Eisenia fetida, Perionyx exacatus, Eisenia Andrei, Perionyx sansibaricus* and *Eudrilus eugeniae*) have found to be essential contenders for decomposing solid organic wastes[3].

Vermicompost is important for amending soil properties and contains simple absorbable nutrients vital for plant growth. It is stable organic matter; it loosens soil and enhances aeration when added to the soil[4,5]. It is magnificently divided peat like mass with more porosity, admirable soil conditioner that can surge growth and yield of crops, increase no. of seeds, leaves, shoots, length and tillers in rice, maize, soybean, groundnut, sorghum (6) and vegetables like tomatoes, cucumber, spinach and peppers[7]. The application of vermicompost extracts in a solution process known as compost tea prevents from plant diseases[8] and has found for improvement in health, nutritional quality and crop yields[9].

Beside other legumes, lentil (*Lens culinaris* Medik) is one of the most ancient leguminous crop. Subsequently, after soybean 35-38%, lentil constitutes more protein percentage, 24% in comparison with other pulses. Due to the ability of Biological Nitrogen Fixation (BNF), lentil not only serves as human nutrition but helps to improve the nutritional value and maintain soil fertility. Lentil seed substantiates best supplement to cereals, being high in carbohydrate/ protein contents[10].

The most important characteristics of lentil crop is symbiotically their distinctive ability for nitrogen fixation and in serving as a source of nitrogen in natural as well as in agricultural ecosystem. With the help of plant growth promoting *rhizobacteria*, pulses are symbiotically peculiar in fixing nitrogen and ultimately increase nitrogen in soil by reducing atmospheric nitrogen into ammonia and eventually enhancing soil fertility[11].

The minimum typical yield of lentil crop may be due to lack of agronomic management, less use of fertilizers on marginal lands, insufficiency of high yielding crops and also due to insufficient native symbionts of rhizobia in soil of host specific lentil cultivars. However, numerous researches revealed that vermicompost application @ 5 tonns/ ha significantly increase crop growth and yields, reduce environmental pollution and enhance soil health and productivity[12]. Therefore, the current study was consequently carried out to evaluate vermicompost types along with rhizobium inoculation effect on nodulation potential, growth and lentil yielding attributes.

MATERIALS AND METHODS

Preparation of Vermicompost Types

Young *Eisenia fetida* were selected from stock culture held in vermicomposting shelter at Farm Station No# 04 in village Mandrota, district Attock. Four different types of raw materials were used for the study, these include cow dung, vegetable waste, wheat straw and leaf litter. Twelve perforated plastic containers having carrying capacity of 05 kg of organic raw material, 04 treatments having 03 replications each, were used for the experiment. After 15-20 days pre-decomposed raw materials (3 kg) was filled separately in each plastic container as method described by[13]. In order to remove heat and volatile gases different raw materials were turned over daily for initial 15 days. After pre decomposition of wastes around, 100 young *Eisenia fetida* worms were slowly released in each container. For favorable activity of worms, 40-50% moisture was maintained by daily sprinkling of water. After 50-60 days near harvesting, the color of raw material changed to dark brown or black. At the end of experiment activity of earthworms were removed by sieving. Afterwards, vermicompost types were air dried and placed in plastic bags for storage.

Experimental Site and Layout

After preparation and characterization of vermicompost, field experiment was conducted in University Research Farm Koont, Chakwal Road, Rawalpindi to evaluate the effect of vermicompost types on lentil growth. The experiment was laid out in Randomized Complete Block Design (RCBD). There were total 06 treatments with 03 replications each as soil application: (T_0=control, T_1=rhizobium, T_2=cowdung, T_3=vegetable waste, T_4=wheat straw and T_5= leaf litter derived vermicomposts) and for obtaining better results vermicompost tea was applied as foliar application separately using different raw materials at branching and flowering stage. The net plot size of each treatment was 9 m^2 having 3 m × 3m dimensions. Gross plot size was 288 m^2. Seeds were inoculated with Rhizobium

inoculum before sowing. Sowing was done on 22nd October, 2019. Thinning was done after the emergence of plants depending upon the number of plants emerged. Weeding was done at regular basis manually by hand. All other agronomic practices were kept constant.

Seed Treatment with Inoculum

For treatment of seeds with inoculum slurry, 350 g of inoculums, 10 g sugar and 50 ml of water was mixed in a 100 ml beaker. 500 g seeds of variety (Markaz-09) were soaked in the mixture. Afterwards treated seeds were left an hour for air drying. Under controlled conditions treated lentil seeds were sown in plots, bacteria isolated from lentil root nodules.

Preparation of Vermicompost Tea

For vermicompost tea preparation, non-aerated method was used. For that purpose, 1 part of vermicompost was mixed with 6 parts of distilled water (volume per volume). To avoid settling of residues, everyday mixture was stirred for 10 minutes for duration of seven to ten days. After that, by using 4 layers of muslin cloth, extracts were filtered[14]. For better results vermicompost tea was foliary applied separately for four types of vermicomposts made at 2 intervals, first at branching stage and second before flowering initiation.

RESULTS AND DISCUSSION

Leaf Chlorophyll content was measured at vegetative stage. Statistical analysis of data indicated that chlorophyll content of lentil was significantly affected by vermicompost types along with rhizobium inoculation as compare to control. Maximum chlorophyll content was recorded with application of cow dung derived vermicompost (66.96±0.82) kg/ha^{-1} which was statistically at par with wheat straw derived vermicompost (61.29±4.65). Whereas, minimum chlorophyll content was observed in control (32.20±0.78) which was different with rest of the treatments.

Generally, treatments with vermicompost+rhizobium had greater chlorophyll content as compared to rhizobium or control , this might be due to more concentration of nitrogen in leaves due to ability of vermicompost tea to adsorb mineral nitrogen which is later taken up by plants. These results are similar with[15] who revealed enriched vermicompost animal manure to be best for increasing cholorophyll content of leaves. These results are also supported with findings of[16] who reported that application of vermicompost tea enhanced cholorophyll and nutrient contents of lentil leaves.

Shoot Height at Maturity (cm)

Shoot Height was measured at maturity. Maximum shoot height was attained with application of cow dung derived vermicompost (43.82±0.64), followed by remaining vermicompost types were statistically still higher than control. Whereas, minimum shoot height was attained in control (19.81±1.16). Minimum plant height in control treatment might be due to zero application of vermicompost and rhizobial strains in control treatment. Increased plant height with enriched vermicompost$_+$rhizobium resulted from better nodulation, better nitrogen uptake and increased soil fertility[17,18] Maximum height resulted due to seed inoculation of rhizobial strains and balanced supply of nutrients that stimulate biological activities. Similar results have been revealed by[19].

Root Length at Maturity (cm)

Root length was also measured at maturity. Maximum root length was recorded in cow dung derived vermicompost (19.52±0.17), followed by remaining vermicompost types that were also statistically higher than control. Whereas, minimum root length was observed in control (5.25±0.04) which was different with rest of the treatments.[20] reported similar results that root lengths increased by treatment with fertilizers, inoculums and organic manures.[21] studied effect of vermicompost on soil fertility and crop productivity, they revealed that vermicompost improved physical conditions of soil by microbial activities which enhance aeration and ultimately improved root length and nutrient availability for increasing plant growth.

Number of Branches Plant^{-1}

No of branches plant^{-1} were counted at maturity. Highest number of branches plant^{-1} were recorded in cow dung derived vermicompost (23.53±1.64), followed by wheat straw, vegetable waste while least with leaf litter derived vermicomposts as compare to rhizobium and control. Whereas, lowest number of branches plant^{-1} were observed in control (5.70±0.10). This could

be due to reason that no vermicompost+*rhizobial* strains were applied to control seeds, which resulted in minimum number of branches plant^{-123} which also recorded promotive effect of rhizobial strains and phosphorous on number of branches plant^{-1}. Increase in branches number might be due to cumulative effect of vermicompost balanced nutrition including phosphorous[24].

Fig. 1. Organic wastes used for Vermicompost preparation

Fig. 3. Effect of Vermicompost types on Nodulation of Lentil

Number of Pods Plant^{-1} at Flowering

Maximum number of pods are formed with application of cow dung derived vermicompost (98.40±2.04) followed by wheat straw derived vermicompost (84.07±3.81), while minimum number of pods were formed with control treatment (34.73±0.22).[25] also reported similar results for application of vermicompost to (Markaz-09) variety. Variations among fruiting of different vermicompost types might be due to nutritional

Fig. 2. Experimental layout of lentil research area (Koont Farm Rawalpindi)

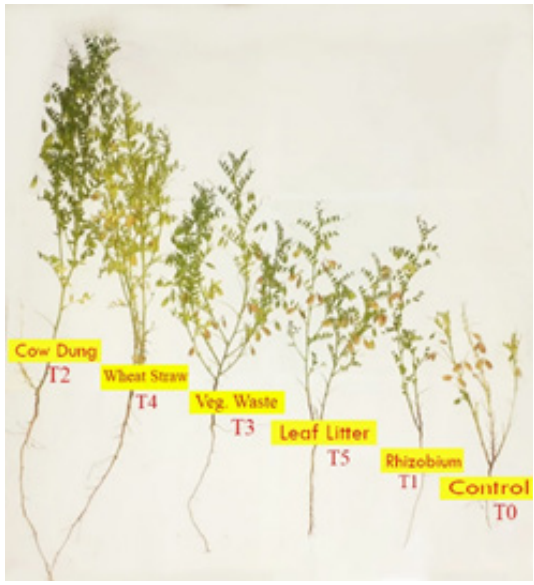

Fig. 4. Effect of vermicompost types on Growth of lentil

Table 1. Effect of vermicompost types on growth and yield attributes of lentil

Treatments (Vermicompost derived products)	1.Chlorophyll (SPAD)	2.ShootHeight (cm)	3.Root Length (cm)	4.Branches No	5.Pods No
Control	32.20±0.78 d	19.81±1.16 f	5.25±0.04 f	5.70±0.10 f	34.73±0.22 f
Rhizobium	40.27±0.33 c	26.43±0.37 e	9.89±0.32 e	8.33±0.32 e	46.37±0.17 e
Cow Dung	66.96±0.82 a	43.82±0.64 a	19.52±0.17 a	23.53±1.64 a	98.40±2.04 a
Vegetable Waste	53.54±0.49 b	34.88±0.15 c	15.63±0.17 c	15.17±0.43 c	71.27±4.38 c
Wheat Straw	61.29±4.65 a	39.40±0.34 b	17.55±1.24 b	19.53±0.32 b	84.07±3.81 b
Leaf Litter	48.46±1.16 b	29.99±2.24 d	12.84±0.51 d	12.70±0.31 d	62.90±1.90 d
Treatments (Vermicompost derived products)	6.Pods Weight (g)	7.Seeds plant-^{1}	8.Seeds Wt (g)	9.1000 Seed Wt (g)	10.Seed Protein %
Control	12.81±0.17 f	1.27±0.03 e	3.73±0.10 f	19.17±0.17 e	21.14±0.73 e
Rhizobium	14.15±0.11 e	1.53±0.03 d	4.24±0.07 e	21.40±0.06 d	23.73±0.61 d
Cow Dung	25.04±0.72 a	2.17± 0.03 a	9.40±0.07 a	24.52±0.08 a	28.73±0.12 a
Vegetable Waste	20.63±0.11 c	1.80±0.06 c	7.96±0.06 c	22.82±0.07 c	26.44±0.24 bc
Wheat Straw	22.76±0.14 b	2.00±0.00 b	8.61±0.22 b	23.61±0.15 b	27.01±0.46 b
Leaf Litter	19.20±0.45 d	1.73±0.03 c	6.62±0.05 d	22.41±0.27 c	25.28±0.31 c
Treatments (Vermicompost derived products)	11.Nod-No	12.Nod-Wt (mg)	13. BY (kg/ha)	14. SY (kg/ha)	15. HI% (kg/ha)a
Control	9.47±0.20 f	9.97±0.17 f	2136±92 d	670±59 e	31.24±1.55 d
Rhizobium	20.83±1.38 e	21.39±1.39 e	2244±70 d	809±77 d	35.91±2.31 c
Cow Dung	46.53±1.14 a	47.14±1.15 a	2997±106 a	1371±160 a	45.49±3.73 a
Vegetable Waste	39.30±0.49 c	39.91±0.47 c	2450±127 c	962±108 c	39.04±2.40 bc
Wheat Straw	43.50±0.17 b	44.08±0.19 b	2656±167 b	1197±100 b	43.79±1.62 a
Leaf Litter	36.53±0.35 d	37.13±0.34 d	2619±78 b	1127±99 b	42.91±2.62 ab

composition of vermicompost derived from different raw materials and also attributed due to inherent potential of variety. Increased number of pods plant^{-1} by application of vermicompost have been reported by[26] who studied effect of organic manures on growth and yield attributes of lentil and concluded that vermicompost application performs better than ordinary compost due to balanced worms microbial activities and more nitrogen content which enhanced pods formation and remaining yield parameters.

Weight of Ten Pods (g)

Weight of ten pods is an important yield parameter and has a positive impact on the overall yield of plant. Highest results for increase in weight of ten pods were obtained with application of cow dung derived vermicompost (25.04±0.72) followed by wheat straw derived vermicompost (22.76±0.14), which was statistically significant with rest of treatments. While, lowest results was obtained with control treatment (12.81±0.17). The higher weight of pods were attributed due to combined action of vermicompost+rhizobium due to essential nutrients, higher chlorophyll content and soil microbial activity which enhance accumulation of proteins, carbohydrates thereafter, translocation towards reproductive organs that ultimately increase weight and yield mechanisms. These results coincide with findings of (27) and (28).

Number of Seeds Pod^{-1}

This particular parameter is a significant component, that directly imparts effect on potential yield. The data showed a statistical difference among different treatments. Maximum number of seeds were formed with application of cow dung derived vermicompost (2.17±0.03) however, minimum seed number pod^{-1} were formed with control treatment (1.27±0.03).[29] revealed effect of combined application of vermicompost, cow dung, poultry manure and chemical fertilizers that indicate higher number of seeds pod^{-1} as compare to control. The minimum number of seeds in control was due to no application of vermicompost+rhizobium whereas, increase number of seeds pod^{-1} was due to more nutrition supplied in the form of vermicompost and microflora, more nodule formation which ultimately uptake more nitrogen to build yield products.

Seed Weight Plant^{-1} (g)

The data showed a statistically significant difference among treatment means. Highest seed weight plant^{-1} was obtained with application of cow dung derived vermicompost (9.40±0.07), followed by remaining vermicompost types that were statistically still higher than control. Whereas, lowest seed weight plant^{-1} was attained in control (3.73±0.10) which was different with rest of the treatments. This could be due to better ultilization and uptake of vermicompost nutrients+activity of rhizobial strains which increased seed weight of plant.

1000-Seed weight (g)

The maximum 1000 seed weight was produced with cow dung derived vermicompost (24.52±0.08), while other treatments showed varied degrees of freedom and minimum 1000 seed weight was produced with control treatment (19.17±0.17). Balanced nutrition is important for better plant growth and development, in the form of essential nutrients N and P which increase supply of assimilates in the seed, which ultimately results in more seed weight. The promotive effect of Phosphorous on seed has been reported by[30]. Similar results are supported with findings of[31] which observed that combination of different dozes organic and inorganic fertilizers increased seed weight.

Seed Protein Concentration (%)

The data shows that maximum seed protein concentration was obtained with application of cow dung derived vermicompost (28.73±0.12). Whereas, minimum seed protein concentration was attained in control (21.14±0.73). Increase in protein contents might be due to more number of nodules and their nitrogen fixing ability with combined effect of vermicompost+rhizobial strains.[32] stated that increased P levels increases protein contents of seeds. Similar results coincide with which reported high protein content in Markaz-09 seeds due to vermicompost application and activity of microbes.

Number of Nodules per Plant at Flowering

It was noted that all treatment means showed statistically significant results. The highest number of nodules plant^{-1} was produced by cow dung derived vermicompost (46.53±1.14) which was followed by treatment, wheat straw derived vermicompost (43.50±0.17) while least number of

nodules plant^{-1} was recorded at control treatment (9.47±0.20).[33] found the promotive effect of strains on number on nodules per plant. Ditta et al. (2015) stated that effect of compost and vermicompost increased nodulation potential along with rhizobial strains. These results also coincide with findings of Saini & Khanna (2012) who reported that increased number of nodules attributed to the ability of rhizobial strains.

Weight of Nodules Plant^{-1} at Flowering

The highest weight of nodules plant^{-1} was produced by cow dung derived vermicompost (47.14±1.15) which was followed by treatment, wheat straw derived vermicompost (44.08±0.19) while least weight of nodules plant^{-1} was recorded at control treatment (9.97±0.17). These results coincide with findings of *Singh et al*. (2010) who reported that weight of nodules were increased after inoculation with rhizobial *s*trains. Similarly results were stated by[37] that weight of nodules was increased due to balanced nutrition of vermicompost and manures along with activity of rhizobial strains.

Biological Yield (kg ha^{-1})

More plant height, yield and yield components are possible for more biological yield in plots by application of nutritional diet either manures or fertilizers. Maximum biological yield (kg ha^{-1}) was obtained with cow dung derived vermicompost (2997±106) followed by wheat straw derived vermicompost (2656±167). While minimum biological yield (kg ha^{-1}) was obtained with control treatment (2136±92).

Combination of cow dung, animal manures, composts, vermicomposts, and chemical fertilizers created favorable growth for lentil growth and development (38) and (39) who studied morphoagronomic characterization study on lentil, they reported that increased and nutritional manures along with best agronomic practices gives enormous biological yield for lentil.

Grain Yield (kg ha^{-1})

Grain yield is one of the most important and phenomenal yield components which describes the overall potential of the varieties. The data clearly showed statistically significant results among all treatment means. Highest seed yield (kg ha^{-1}) was attained with cow dung derived vermicompost (1371±160), followed by wheat straw derived vermicompost (1197±100). While lowest seed yield (kg ha^{-1}) was attained with control treatment (670±59). These results coincide with findings of Hussain et al. (2002). The results clearly showed promotive role of vermicomposts manures along with rhizobial strains in improving yield potential of lentil. The possible and logical reason was due to fact that all yield components are highly utilized by application of vermicompost as soil and foliar application to gave maximum yields in plots as compared to control. Increased in seed yield by increasing level of P and organic manures has also been reported by[41].

Harvest Index (%)

Harvest index is an indication of the physiological ability of a cultivar to convert dry matter into economic yield. The data clearly showed statistically significant results among all treatment means. Highest HI % was attained with cow dung derived vermicompost (45.49±3.73), which was at par with wheat straw derived vermicompost (43.79±1.62). While lowest HI % was attained with control treatment (31.24±1.55) which was statistically different with rest of treatments. These results coincide with findings of (Jamil et al, 2008) who reported HI of lentil in range of 34-41%. Harvest index is increased by more nutritional compostion of vermicompost and by phosphorous application[42].

CONCLUSION

Based on previous researches and results of these experiments showed that vermicomposting activity is such worthwhile and exciting venture and was found to be efficient in increasing nodulation potential along with rhizobium inoculum which fixes maximum nitrogen which ultimately gives maximum growth and yield attributes in lentil. Statistical results revealed that vermicompost types significantly affected growth and yield of lentil by application of vermicompost @ 5 tonns/ha and maximum was attained with cow dung derived vermicompost+rhizobium followed by wheat straw, vegetable waste and minimum with leaf litter derived vermicompost. Cow dung vermicompost was found to be efficient for all growth and yield parameters of lentil.

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Conflict of Interest

We have no conflicts of interest to delare.

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