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Verification of Vermicompost Technology on Faba Bean Production at Welmera District, Birbo Watershed, Central Highlands of Ethiopia

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Abstract

Vicia faba, usually known as faba bean, which is commonly cultivated as a crop for human consumption, is the world's leading source of protein. However, due to the low availability of basic cations, excess of hydrogen and aluminium in exchangeable forms, soil fertility limits its productive potential. Thus, this verification trial was intended to show the effects of Vermicompost technology on faba bean production, productivity and soil properties improvement on Nitisol of Birbo watershed in Welmera district in 2020/23. This verification work indicated that vermicompost application had contributed to the improvement of soil's chemical properties and yields of faba bean, even if statistically non-significant results were observed. Soil chemical properties like pH, TN and OC were observed due to their application. From this study it is concluded that fifty per cent of nitrogen (0.47 ton ha^{-1}) from Vermicompost and fifty per cent of nitrogen from urea would be recommended to be applied in the areas which have the same agro-ecology and soil properties as Welmera Districts.

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Introduction

It has been indicated that Ethiopia is one of the major faba bean (Vicia faba L.) producing countries in the world.[1] Also, the fourth largest faba bean exporting country next to France, Australia, and the United Kingdom.[2] Also, a country of diverse agro-ecologies and natural resource bases. The highlands, which account for 43% of the total land area, host 88% of the human and 86% of the livestock populations.[3] Ninety five percent of the total cultivated land area also concentrates in the highlands.[4]

Vicia faba is one of the main crop legumes that are mostly cultivated by smallholder farmers in Verti and Nitisol of the highlands of Ethiopia. It is commonly used as a food and income source. In terms of area coverage and volume of annual pulse crop production, vicia faba is still ranked first in Ethiopia.[6]

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The average national yield of this crop is about 2.1 t ha^{-1} .[7], which is very low compared to the average yield of 3.7 t ha^{-1} in major producer countries.[8] This is due to biotic and abiotic yield limiting factors, thus declining soil fertility and low biological and organic fertilizer technology are among the problems. Poor agronomic practice, climatic, edaphic and biotic factors, diseases, pests and weeds are the foremost causes for the low yield of vicia faba in Ethiopia.

The on-farm average yield of released faba bean varieties reaches up to 3.5 t ha^{-1}.[9] Showing the presence of a significant yield gap between farmers' managed and researcher-managed plots. Several studies showed a significant increase in growth and yield by the application of organic inputs.[10] This is through delivering greater amounts of available C, Mg, Ca, P, and K for the plant.[11] As most pulse crop fertilizer usage is very rare by producers, the aim of this study was to verify vermicompost on faba bean productivity at central highlands of Ethiopia, particularly Welmera woreda's.

Materials and Methods

Depiction about the Trials Location

The trial was done on Nitisol of Birbo watershed, Welmera woreda, Oromia Regional State of Ethiopia for the past three consecutive years (2020/23) on six farmers' fields in the leading cropping period under rain-fed field conditions. The trial spots are positioned at 0902'.232" N latitude and 038034.2431" E longitudes and 2479 meters above sea level. The trial range is situated East of Holeta town and west of Addis Ababa about 10 km and 60 km distance, respectively. Welmera woreda has unimodal rainfall pattern, which starts at the end of April and extends to mid-November, with maximum rainfall received from June to October. The total annual average rainfall of Welmera Woreda is 115.78mm. The minimum and maximum temperatures are 7.2°C and 24°C respectively. The Relative humidity of the woreda is 77gm^{-3}. 77%. (The weather station of Holeta Agricultural Research Center, Ethiopia). The main soil type of Welmera area is Nitosols with the soil pH ranges from 5.71 to 5.71- 5.97, which are moderately acidic as rated.[12]

Experimental Design and Treatments

The best-performed treatment in the evaluation phase was selected and verified for three consecutive years on the farmers' field Vermicompost was produced at Holeta Agricultural Research Center, in the vermicompost unit of the Biological and organic soil fertility management program. Well-prepared vermicompost with TN = 1.9% in dry weight base was applied N equivalency base two weeks prior to planting. Preparation of Rhizobium inoculant was made earlier for planting at the soil microbiology laboratory, Holeta. Rhizobium strain 500gm/ha was used. The plot size was 10 m x 10m, consisting of 20cm between rows and 10 cm between plants. The treatments consisted of 50% N from Urea + 50% N from vermicompost (0.47 ton ha^{-1}), Rhizobium strain (FB-1017), and 100% N from Urea. Faba bean seeds The Numan/Moti /Gebelecho variety were planted in rows at the amount of 200 kg per hectare. Likewise, the fertilizer used was Triple superphosphates (100 kg per hectare), Borax (8.5kg per hectare), K_2SO_4 (44.8 kg per hectare) and Urea (36 kg per hectare).

Soil Sample Collecting and Analysis

Pre-planting composite soil samples were extracted from the depth of 0-20cm on the trial fields and analysed for particular soil chemical properties. The soil pH was resolute as defined Carter Method by.[13] Organic carbon was resolute as defined Walkely and Black method by.[14] The TN (%) of the soils were resolute using the Kjeldahl procedure as Kjeldahl Method described by.[15] Olsen methods were used to determine available phosphorus in soil as defined Olsen method by.[16]

Agronomic Managements and Data Collection

All necessary agronomic practices were undertaken as per the standard recommendations. All the yield and yield related parameters were taken using quadrants. Seed and haul yield data were collected at harvest while above ground biomass yield was measured at the early podding stage.

Statistical Analysis

The data that was collected from the trials were analysed using R-statistical software (R for Windows 4.2.3) with a significant difference (LSD) at a five per cent probability level.

Analysis of Soil Properties before Planting

Soil pH of the studied area before planting was 5.63 -5.83 which are moderately acidic.[12] The total

Nitrogen was 0.144-0.316 which are very low to high.[12] Organic Carbon recorded was (1.52 %) which are moderate.12. Available phosphorus was 14.799 -16.4 which are moderate.[17]

Table 1: Soil Chemical Properties Before Planting

Year	Location	Soil parameters				
		pH	E. Acidity	TN (%)	OC(%)	P(ppm)
2022/23	L1	5.63	0.192	0.316	1.52	14.799
	L2	5.80	0.216	0.144	1.52	16.400

Results and Discussion

Effects of Faba bean N Sources on Selected Soil parameters After Harvesting

The soil's pH of the studied area was 5.71 -5.97 ranges which are moderately acid according to Tekalign.[12] (1991). According to Brook (1983) the favourable pH for obtainability of plant nutrients agrees crudely with the finest assortment of 6 to 7.[18] the range of soil reaction in the trial site may not limit the crop production by impelling the obtainability of essential plant nutrients. The soil pH less than 5.5 may possibly be a signal of the occurrence of a substantial amount of exchangeable acidity and exchangeable Al^{+3}, and exclusion of exchangeable cations, such as calcium and magnesium.[19] as shown by Landon (1991).

In the trial locations, soil's exchangeable acidity was low, and may not hamper the growth and development of plant roots. Total nitrogen was found in the range of (0.110 – 0.24%) which is very low to high.[12, 20]

The recorded value of organic carbon can be regarded as low to medium.[12] Available phosphorus from the studied area was ranged from 5.989 – 24.395, which is low to high.[21] In this study the candidate N source (50%N from Urea+ 50%N from vermicompost (0.47-ton ha^{-1}) was better in enhancing OC (%) and TN (%) content of the soils of the different locations despite irregularity in pH.

The noticeable decline in total N in the soils that did not receive vermicompost as compared to vermicompost soils was because of larger quantities of tota C and N in vermicompost that could have provided a good source of N for mineralization.[22]

More residual nitrogen might be produced in vermicompost soil than in control plots. The highest organic carbon (2.81%) was recorded on treatment that received the vermicompost, this comply with the study of (23) increasing soil organic matter contents were reported with increasing Vermicomost doses. Also, various studies state that soil/the treatment that has received organic waste has been reported to upgrade soil organic matter.[24,25]

The analysis of soil chemical properties after harvesting showed that there is an improvement of soil parameters like organic carbon and total nitrogen due to the application of vermicompost. Vermicompost products confer plant nutrient elements, various hormones, enzymes, humic substances and especially organic matter to the soil. Thus, it improves the soil structure while preparing a suitable environment for plant growth as well. Application of vermicompost also increased the organic carbon content in the soil over recommended dose of fertilizers.

Analysis of Variance for the Different Factorsof the Study Across Responses

The analysis confirmed that treatment and farm differences were statistically insignificant for the three responses.

The year effect showed statistically significant response mainly due to high measurements obtained during the 3rd year which will be attributed to seed dressing of Noble Table 3. The significant result of this study was that certain chemical inducers used had contrary reaction to the growth and yield of faba bean under farm conditions (pathogen-free conditions).

Table 2: Analysis of Soil Chemical Properties After Harvesting

years	Location	Treatments	Parameters			
			pH1:2.5 H_2O	TN (%)	OC(%)	P(ppm)
2020/21	L1	50%N from Urea+ 50%N from vermicompost	5.73	0.148	1.29	10.798
		FB-1017	5.92	0.146	1.40	10.396
		100% Rec N from Urea	5.88	0.144	1.36	9.599
	L2	50%N from Urea+ 50%N from vermicompost	5.79	0.114	2.21	17.587
		FB-1017	5.95	0.114	1.09	15.994
		100% Rec N from Urea	5.89	0.110	0.86	(11).16.792
2021/22	L1	50%N from Urea+ 50%N from vermicompost	5.71	0.14	1.52	13.586
		FB-1017	5.63	0.13	1.44	18.361
		100% Rec N from Urea	5.52	0.14	1.44	12.793
	L2	50% N from Urea+ 50%N from vermicompost	6.68	0.22	2.81	5.594
		FB-1017	5.97	0.24	2.61	5.989
		100% Rec N from Urea	5.95	0.15	1.75	10.380
2022/23	L1	50% N from Urea+ 50%N from vermicompost	5.71	0.158	2.07	13.996
		FB-1017	5.73	0.171	1.83	24.376
		100% Rec N from Urea	5.83	0.169	1.71	11.987
	L2	50% N from Urea + 50%N from vermicompost	5.69	0.158	1.67	23.582
		FB-1017	5.73	0.173	1.79	19.991
		100% Rec N from Urea	5.86	0.179	1.99	24.395

Table 3: Analysis of different factors

Factor	Seed Yield	Above ground biomass yield	Haulm Yield
Treatment	None significant	None significant	None significant
Farm	None significant	None significant	None significant
Year	*	*	None significant
Treatment*farm	None significant	*	None significant

N.B. Yields were weighing in kg/ha, *= significant

Biological Yield Response of Faba bean for Treatments

The candidate faba bean nitrogen source (50%N from urea +50%N from Vermicompost (0.47 ton ha^{-1}) had statistically the same seed and haulm yield as the recommended N (100%N from urea or rhizobia-FB-1017 Table 4). This verifies that the candidate N source is agronomically competent to the existing recommended practices at Birbo watershed conditions. This study agrees with others who stated that the role of organic fertilizer on the leaves, stems and in root growth, and yield features may be due

to the organic fertilizer content of several sources on the organic compounds liquefied in water, such as sugars, amino acids, humic acids and organic acids in all these compounds add directly or indirectly to the growth and development of the plant are boosting growth by enzymatic or hormonal as it contains nutrients needed by the plant or they disturb the nutrient obtainability previously existing in the soil by enhancing soil pH and thus enhancing plant productivity.[27] This study evidently disclosed that an application of Vermicompost integrating with chemical fertilization had improved soil chemical properties and brought the same yields with rhizobium strain and Urea under field conditions.

Table 4: Analysis of Biological yield response of fababean

S/N	Treatments	Seed yield	Above ground biomass yield	Haulm yield
1	50%Nfromurea+50%N from VC	2493	4197	1854
2	FB-1017	2579	3807	2080
3	100%N from urea	2747	3836	1757
	LSD (5%)	None significant	None significant	None significant
	CV (%)	8.06	13.37	31.47
	Grand mean	2606	3946	1897

N.B. Yields were weighing in kg/ha.

Conclusion

The verification works were carried out in Welmera District, Birbo watershed, the central high land of Ethiopia. The three-year data showed that seed yield, above ground biomass and Haulm Yields were not statistically significant due to the application of fifty percent of nitrogen from urea and fifty percent of nitrogen from vermicompost. However, in this study, the candidate N source (fifty percent of nitrogen from urea and fifty percent of nitrogen from vermicompost) was better in enhancing at OC (%) and TN (%) content of the soils of the different locations despite irregularity in pH. Therefore, from this study it is recommended that the application of 50% Nitrogen from Urea and 50% Nitrogen from vermicompost (0.47 ton ha^{-1}) is important in major fababean growing areas of the region having similar climatic conditions with the study areas.

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Conflict of Interest

The authors do not have any conflict of interest.

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