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Effect of Rhizobial Inoculants and Vermicompost Application on Growth and Yield of Faba Bean (*Vicia faba L.*) in Arsi Zone, Southeastern Highlands of Ethiopia

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Abstract

A field experiment was conducted to study the effect of rhizobial inoculants and vermicompost on the yield and quality attribute of fababean (*Vicia faba L.*) and some soil properties after planting. The experiment consists of seven treatments as follows: T1: control, T2: full recommended mineral fertilizer (RRN), T3: rhizobia inoculation, T4: 100% nitrogen from vermicompost, T5: rhizobia inoculation with 50% nitrogen from vermicompost, T6: rhizobia inoculation with 75% nitrogen from vermicompost and T7: rhizobia inoculation with 100% nitrogen from vermicompost. The experiment was conducted according to RCBD design with three replications. The results indicated that the use of rhizobia inoculation with vermicompost has improved some soil properties, growth, and yield parameters of fababean at all experimental sites. Rhizobia inoculation with 50% nitrogen from vermicompost was superior in most of the traits, including the number of tiller (3.83), number of pods per plant (26.56), number of seed per plant(54.20), biomass yield (13427.6 kg ha^{-1}) and adjusted grain yield (4525.9 kg ha^{-1}). Hence, the application of Rhizobium and vermicompost is needed to boost the productivity of faba beans and enhance soil fertility in the study site.

Keywords: Vermicompost; Rhizobia; Fababean; Grain yield; Inoculation

Introduction

Applications of chemical fertilizers have increased the social and environmental risks across the globe. It has also affected soil microbes and fertility. The uses of these synthetic fertilizers have also adversely affected human health and agricultural products (Rai et al., 2014). Recently, the scientific community has been trying to adopt environmentally friendly, economically viable, safe, and sustainable ways of soil fertilization to avoid the danger of chemical fertilizers by replacing them chemical fertilizers by organic fertilizers (Derib et al., 2017, Hiranmai, Y. R. and Anteneh Argaw, 2016).

Vermicompost (compost from earthworms raised on useless waste such as household and farm waste, office, market, etc.) is used as a biological organic fertilizer in agriculture, it also provides the soil with nutrients, growth regulators, and enzymes, to increase the productivity of the crop, it also improves the physical properties of the soil and creates a safe environmental system for food production, as using it can drop out or reduce the use of chemical fertilizers that harm public health and environmental pollution, as well as producing good-quality natural crops (Anshu, S. and S. Sharma. 2013). The importance of vermicompost is reflected in the fact that in addition to the presence of organic nitrogen, phosphorus, and potassium in it, it is considered a good source for the supply of micronutrients such as iron, manganese, copper, zinc, molybdenum and iodine, and more importantly, the nutrients are released from vermicompost in quantities appropriate to the needs of the plant as a result of microbial activity in the soil and the decomposition of compost (Alper et al., 2017).

Rhizobia-legume symbiosis is one of the alternative solutions and promising technologies that play an important role in decreasing the consumption of inorganic N-fertilizers, enhancing soil fertility, and reducing production costs. Nitrogen (N_2) fixed by nodulated legumes (pulses and oilseeds) is estimated to contribute 21.45-million-ton N annually to global agricultural systems (Herridge et al., 2008). Inoculation of rhizobia is also one of the sustainable and environment-friendly practices to increase the nitrogen fixation potential of the crops since there might be a low population of effective indigenous rhizobia or due to maximum competition with non-effective ones (Tolera et al., 2009). Moreover, organic fertilizer application is considered to be a key cultural practice to avert the problem of crop production by enhancing soil fertility. A soil fertility problem in Ethiopia is solved by applying bio-organic fertilizers. The application of bio-organic fertilizers such as organic manure, bio fertilizers, and biogas manure as well as compost or vermicompost and its derivatives could resolve these issues and make our ecosystem healthier (Ritika and Utpal, 2014). Many organic materials have been proposed as a source of nutrients for plant crops (Mupambwa et al., 2015). Therefore, this study aimed to evaluate the effect of rhizobia inoculation and vermicompost fertilizer application on the growth and yield of fababean (*Vicia faba* L.).

Materials and Methods

The study sites

The field experiment was conducted in four districts (Kulumsa, Bekoji, Boru FTC, and Gonde) during the main cropping seasons of 2020 and 2021. The soils are classified as follows: at Bekoji a haplic Nitisol and at Kulumsa an intergrade between a haplic Nitisol and a luvic Phaeozem (Amanuel Gorfu et al., 2000) where Wheat is dominantly produced with mean annual rainfall 823 mm and 1020 mm respectively of Kulumsa and Bekoji (Table 1).

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Table 1: Soil chemical property (2020/2021).

Site	pH(1: 2.5 soil water ration)	Available P	% N	%OC	%OM
Kulumsa	6.1	10.77	0.14	0.878	1.755
Gonde	6.2	11.24	0.15	0.968	1.936
Boru FTC	6.0	13.42	0.17	1.066	2.133
Bekoji	5.4	10.19	0.12	0.650	1.300

Table 2: The chemical composition of vermicompost prepared.

Parameters	pH(1:2.5)	Available P(ppm)	%TN	%OC	%OM
Value	7.6	82.39	1.53	2.49	4.29

Soil sampling and analysis

Composite soil samples were collected from random spots of the experimental plots at a depth of 0-20 cm before land preparation. The soil samples were air-dried and ground to pass through a 2 mm sieve. Soil pH was measured in a 1: 2.5 soil-to-water ratio. The Walkley and Black (1934) wet digestion method was used to determine soil organic carbon. The total nitrogen content of the soil was determined by the wet-digestion procedure of the Kjeldahl (1883) and available phosphorus was determined by the Bray-II extraction method [1-18].

Vermicompost preparation

Vermicompost was produced at the Kulumsa Agricultural Research Center. Wheat straw, Faba bean straw, and partially decomposed cattle dung were used in 1:1:2 ratios (w/w) for vermicomposting. Matured vermicompost samples were collected for analysis of major chemical properties. The result of the analysis is presented in Table 1. Vermicompost was applied by hand a week before sowing and was immediately incorporated after application with a spade (Table 2).

Sources of seeds and Rhizobium strain

Faba bean variety Numan was supplied by Highland Pulse Research of Kulumsa Agricultural Research Center, Ethiopia. Variety was selected based on their yield, maturity time, and recentness of year of release. Strain of Rhizbium spp. ($FB^{-1}017$) was obtained from the Holetta Agricultural Research Center.

Treatments and experimental design

To examine the effects of vermicompost application and rhizobia inoculation on yield and yield components of faba bean, the experimental design was randomized complete block design where 7 treatments were randomized within a block and there were three blocks (7 treatments × 3 replications=21 plots). 7 treatments were, T1: No input (-control), T2: RRN (+control), T3: Inoculated, T4: 100% N from V.com, T5: Rhizobia noculation+50% N from V.com, T6: Rhizobia inoculation+75% N from V.com and T7: Rhizobia inoculation+100% N from V.com. Vermicompost applications were rated on a dry-weight basis. Faba bean seeds were sown at the rate of 150 kg seeds ha^{-1} and were cultivated in strips. Each block (4 m× 24.5 m) consisted of seven plots. Each plot area was 10.4 m^2 and consisted of 10 rows, spaced 0.4 m apart. Each strip was spaced apart by 1 m apart to prevent bacterial migrations. Weeds, insects, and fungal pathogens were controlled by chemical spray applications, as required, at rates according to manufacturers' recommendations.

Data collection and analysis

The agronomic parameters collected (determined) were seedling stand count, number of tillers per plant, plant height, number of pods per plant, number of seeds per pod, number of seeds per plant, grain and above-ground total biomass yields, and hundred seed weights of fababean. When the crop was physiologically mature, harvesting was done from a net plot area of 4 m^2 (2 m by 2 m) by hand for yield determination. The harvested samples were subjected to air drying to constant moisture content, threshed, cleaned, and the grain weight recorded. The weighed samples were adjusted to 10% moisture content and converted into kg ha^{-1} for statistical analysis. All yield and yield components data were combined across sites and subjected to analysis of SAS statistical package version 9.2 (SAS, 2009). The significance of differences among treatment means was compared using the Duncan multiple range test at the 5% level of probability.

Result and Discussion

Effect of treatments on some soil properties after planting

The effect of experiment treatments on pH, OM, total nitrogen, and available phosphorus for soil after planting were present in Tables 3a and 3b. It is clear from the table that the addition of vermicompost and rhizobia significantly reduced soil pH compared with the addition of mineral fertilizers only (recommended nitrogen). It is may due to the decomposition of vermicompost with the presence of rhizobia resulting in the formation of some organic acids as a result of decomposition and increased activity of microorganisms, and this in agreement with the finding of Edwards C. E, 2004 and Margit O, 2016.

The results in Tables 3a and 3b showed an increase in the ratio of organic matter, total nitrogen, available phosphorus, and pH in the soil after planting as a result of adding vermicompost and rhizobia together. This is due to the properties of vermicompost and rhizobia, which increase the availability of nutrients in the soil by improving the active chemical and biological properties in the soil, as well as through the liberation of the materials and nutrients that vermicompost contains when decomposed by microorganisms (Hossein et al.,2014), in addition to that vermicompost leads to the formation of organic acids and stimulates the efficiency of the beneficial microorganisms and lowers the soil pH, all of these factors will increase the dissolution of the compounds of the fixed or precipitating elements and thus increase their availability in the soil and the plant. Also, the presence of the vermicompost with rhizobia and its stimulation of microorganisms will work to produce growth regulators and enzymes, and these all work to increase the organic matter and elements ready for the plant, especially the macro-nutrients such as N, P and K. Inoculation+100% N from V.com and Inoculation+75% N from V.com recorded a significant superiority with the highest values for the pH, total nitrogen (TN) and organic matter (OM) compared to other treatments in all experimental sites (Tables 3a and 3b). These results were agreed with the findings of Manivannan et al. (2009).

Effect of rhizobia inoculants and vermicompost application on growth and yield attributes of Faba bean

Table 3a: Effect of vermicompost with rhizobia inoculation on some soil parameters after planting.

	Parameters (Kulumsa)				Parameters (Bekoji)			
Year	**pH**	**TN**	**AvaP**	**OM**	**pH**	**TN**	**AvaP**	**OM**
2019	6.62^{a}	0.17^{b}	10.04^{b}	1.73^{b}	6.44^{b}	0.17^{b}	14.44^{b}	3.24^{a}
2020	6.99^{a}	0.22^{a}	14.43^{a}	2.12^{a}	7.25^{a}	0.21^{a}	19.85^{a}	3.98^{a}
Mean	6.81	0.19	12.24	1.92	6.85	0.19	17.14	3.63
LSD	0.19	0.02	1.45	0.23	0.14	0.02	1.35	0.41
Treatment								
No input(-control)	6.13^{b}	0.14^{b}	11.47^{b}	1.58^{b}	5.90^{a}	0.14^{b}	15.14^{c}	1.89^{d}
RRN(+control)	6.42^{ab}	0.17^{ab}	12.10^{ab}	1.87^{ab}	5.94^{a}	0.17^{ab}	16.12^{b}	2.72^{c}
Inoculated	6.85^{a}	0.20^{ab}	12.38^{ab}	2.12^{a}	6.78^{a}	0.20^{ab}	16.33^{bc}	3.26^{b}
100% N V.com	6.88^{a}	0.20^{ab}	13.31^{ab}	2.14^{a}	6.80^{a}	0.20^{ab}	16.44^{bc}	3.56^{b}
Inoc+50% N V.com	6.91^{a}	0.22^{a}	13.88^{a}	2.17^{a}	6.85^{a}	0.21^{a}	17.35^{ab}	3.84^{ab}
Inoc+75% N V.com	7.07^{a}	0.24^{a}	14.08^{a}	2.22^{a}	7.04^{a}	0.23^{a}	18.92^{a}	3.88^{a}
Inoc+100% N V.com	7.08^{a}	0.24^{a}	14.02^{a}	2.15^{a}	7.06^{a}	0.23^{a}	18.99^{a}	3.94^{a}
CV	4.21	5.56	3.46	4.01	3.13	3.32	3.54	5.03
LSD	0.33	0.04	2.62	0.43	0.28	0.03	2.53	0.41

Notes. Means in the same column followed by the same letter are not significantly different at the 5% probability level by Duncan's test, pH: measure of acidity or alkalinity, TN: Total Nitrogen, AvaP: Available Phosphorous, OM: Organic matter

Table 3b: Effect of vermicompost with rhizobia inoculation on some soil parameters after planting.

	Soil Parameters (Boru)				Soil Parameters (Gonde)			
Treatment	**pH**	**TN**	**AvaP**	**OM**	**pH**	**TN**	**AvaP**	**OM**
No input(-control)	6.02^{c}	0.14^{c}	13.53^{c}	1.56^{b}	6.27^{b}	0.15^{b}	11.09^{c}	1.81^{b}
RRN(+control)	6.47^{b}	0.18^{b}	15.06^{bc}	1.64^{b}	6.74^{ab}	0.17^{b}	13.44^{b}	2.17^{ab}
Inoculated	7.03^{ab}	0.21^{ab}	17.28^{ab}	2.81^{ab}	6.87^{ab}	0.21^{ab}	16.05^{a}	2.21^{ab}
100% N from V.com	7.05^{ab}	0.21^{ab}	17.31^{ab}	2.88^{ab}	6.90^{ab}	0.21^{ab}	16.65^{a}	3.29^{ab}
Inoc+50% N from V.com	7.16^{a}	0.24^{a}	17.70^{ab}	3.89^{a}	7.11^{a}	0.23^{ab}	16.66^{a}	3.55^{a}
Inoc+75% N from V.com	7.25^{a}	0.25^{a}	18.87^{a}	3.79^{a}	7.23^{a}	0.26^{a}	17.36^{a}	3.54^{a}
Inoc+100% N from V.com	7.27^{a}	0.26^{a}	19.39^{a}	3.92^{a}	7.36^{a}	0.26^{a}	17.43^{a}	3.61^{a}
LSD	0.39	0.04	2.92	0.56	0.46	0.05	1.87	0.43
CV	3.14	4.53	3.67	3.32	4.77	3.07	6.77	4.59

Notes. Means in the same column followed by the same letter are not significantly different at the 5% probability level by Duncan's test, pH: measure of acidity or alkalinity, TN: Total Nitrogen, AvaP: Phosphorous, OM: Organic matter

Table 4: Growth and yield parameters affected by rhizobia inoculation with vermicompost application at Bekoji (2020 and 2021).

	Parameters								
Year	**SD**	**NTL**	**PH(cm)**	**NPPL**	**NSPP**	**NSPL**	**100SW (gm)**	**BY (kg/ha)**	**AdjGY (kg/ha)**
2020	3.57^{b}	2.63^{b}	110^{b}	10.23^{b}	3.14^{a}	32.2^{b}	92.0^{a}	6570.0^{b}	3059.7^{b}
2021	4.37^{a}	3.05^{a}	120^{a}	18.47^{a}	3.35^{a}	61.2^{b}	94.3^{a}	7044.5^{a}	3784.2^{a}
Mean	3.97	3.04	115	14.35	3.24	46.75	93.1	6807.2	3222.3
LSD	0.22	0.42	4.66	1.37	0.17	4.49	2.53	678.2	367.9
Treatment									
No input(-control)	3.70^{a}	2.03^{b}	105^{b}	11.93^{b}	2.90^{b}	31.96^{b}		4978.5^{c}	1863.7^{d}
RRN(+control)	3.88^{a}	2.70^{ab}	105^{b}	13.70^{ab}	3.20^{ab}	43.83^{ab}	91.5^{a}	6883.3^{ab}	2940.2^{c}
Inoculated	4.10^{a}	3.02^{a}	110^{ab}	15.13^{a}	3.33^{a}	47.56^{ab}	94.6^{a}	7374.0^{ab}	3892.9^{ab}
100% N from V.com	3.90^{a}	2.82^{ab}	110^{ab}	14.33^{ab}	3.22^{ab}	44.76^{ab}	94.6^{a}	7100.0^{ab}	3282.7^{bc}
Inoc+50% N from V.com	4.06^{a}	3.12^{a}	110^{ab}	15.63^{a}	3.40^{a}	51.93^{a}	92.7^{a}	7891.7^{a}	4294.0^{a}
Inoc+75% N from V.com	4.06^{a}	3.08^{a}	120^{a}	15.01^{a}	3.33^{a}	50.70^{a}	92.3^{a}	7240.0^{ab}	3921.4^{ab}
Inoc+100% N from V.com	4.00^{a}	2.91^{ab}	120^{a}	14.60^{ab}	3.26^{ab}	46.53^{ab}	93.1^{a}	6183.0^{bc}	3461.2^{b}
LSD	0.42	1.12	8.72	2.65	0.32	10.42	4.78	1268.7	695.44
CV	8.91	10.05	10.88	15.13	8.22	15.31	11.02	15.85	16.07

Notes. Means in the same column followed by the same letter are not significantly different at the 5% probability level by Duncan's test, SD: Seedling density, NTL: Number of tillers per plant; PH: Plant height, NPPL: Number of pods per plant; NSPP: Number of seeds per pod; NSPL: Number of seeds per plant, 100SW: 100 Seed weight, BY: Total biomass yield, AdjGY: Adjusted Grain yield

The result of the current study revealed a remarkable increase in the number of tillers, plant height, number of pods per plant, number of seeds per pod, biological yield, and adjusted grain yield of faba bean with inoculation of rhizobia and application of vermicompost together.

Application of vermicompost and rhizobia inoculation significantly increased the plant height of fababean where the highest plant height (165.0 cm) was recorded from rhizobia inoculation with 100% nitrogen from vermicompost at Gonde in 2021 while the lowest plant height (105 cm) was recorded from negative control (no input) (Table 6). The possible reason for maximum height in vermicompost and rhizobia

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Table 5: Growth and yield parameters of fababean affected by rhizobia inoculation with vermicompost application at Kulumsa (2020 & 2021).

	Parameters								
Year	**SD**	**NTL**	**PH(cm)**	**NPPL**	**NSPP**	**NSPL**	**100SW (gm)**	**BY (kg/ha)**	**AdjGY (kg/ha)**
2020	3.38^{a}	3.29^{a}	90.6^{b}	12.20^{b}	2.98^{b}	36.41^{b}	78.0^{b}	6234.1^{b}	2789.5^{b}
2021	3.61^{a}	3.59^{a}	156.7^{a}	14.35^{a}	3.18^{a}	40.02^{a}	93.8^{a}	7940.2^{a}	3475.8^{a}
Mean	3.5	3.44	123.6	12.27	3. 08	38.21	85.9	7087.1	3132.6
LSD	0.29	0.28	6.9	1.65	0.17	4.8	11.6	622.6	372
Treatment									
No input(-control)	3.2^{a}	2.2^{b}	117.6^{b}	11.3^{b}	2.9^{a}	24.0^{b}	83.1^{b}	4667.7^{b}	2070.4^{c}
RRN(+control)	3.4^{a}	2.8^{ab}	122.0^{ab}	13.1^{ab}	2.9^{a}	34.6^{ab}	84.4^{a}	6901.6^{a}	3282.5^{b}
Inoculated	3.5^{a}	3.2^{ab}	122.1^{ab}	13.8^{ab}	3.1^{a}	36.2^{ab}	85.4^{a}	7130.9^{a}	3669.7^{ab}
100% N from V.com	3.4^{a}	3.5^{a}	124.3^{ab}	14.0^{ab}	3.1^{a}	38.8^{ab}	86.4^{a}	7856.0^{a}	3667.5^{ab}
Inoc+50% N from V.com	3.7^{a}	3.6^{a}	131.3^{a}	16.6^{a}	3.2^{a}	42.5^{a}	87.3^{a}	7993.4^{a}	4007.8^{a}
Inoc+75% N from V.com	3.5^{a}	3.5^{a}	124.3^{ab}	14.1^{ab}	3.1^{a}	41.2^{a}	88.7^{a}	7873.2^{a}	3851.2^{ab}
Inoc+100% N from V.com	3.5^{a}	3.3^{ab}	123.8^{ab}	13.2^{ab}	3.0^{a}	40.0^{ab}	86.0^{a}	7187.2^{a}	3780.9^{ab}
LSD	0.51	0.68	12.92	2.8	0.32	9.97	46.6	1164.7	698.7
CV	13.1	12.8	12.4	11.8	8.7	13.97	14.55	13.97	14.89

Notes. Means in the same column followed by the same letter are not significantly different at the 5% probability level by Duncan's test, SD: Seedling density, NTL: Number of tillers per plant; PH: Plant height, NPPL: Number of pods per plant; NSPP: Number of seeds per pod; NSPL: Number of seeds per plant, 100SW: 100 Seed weight, BY: Total biomass yield, AdjGY: Adjusted Grain yield

Table 6: Growth and yield parameters affected by rhizobia inoculation with vermicompost application at Gonde (2021).

	Parameters								
Treatment	**SD**	**NTL**	**PH(cm)**	**NPPL**	**NSPP**	**NSPL**	**100SW (gm)**	**BY (kg/ha)**	**AdjGY (kg/ha)**
No input(-control)	3.63^{b}	1.93^{b}	113.6^{b}	10.20^{c}	3.20^{a}	31.40^{c}	74.1^{c}	5950.6^{c}	1941.1^{d}
RRN(+control)	4.40^{ab}	2.06^{ab}	137.6^{ab}	13.46^{b}	3.26^{a}	42.80^{b}	75.8^{c}	9753.2^{b}	3319.9^{c}
Inoculated	4.80^{a}	2.40^{ab}	160.0a	20.20^{ab}	3.33^{a}	45.60^{ab}	81.8^{ab}	10361.4^{b}	3706.9^{bc}
100% N from V.com	4.80^{a}	2.33^{ab}	162.6^{a}	20.06^{ab}	3.26^{a}	45.60^{ab}	76.0^{c}	11884.3ab	3360.4^{c}
Inoc+50% N from V.com	4.86^{a}	3.53^{a}	158.6^{a}	26.56^{a}	3.26^{a}	54.20^{a}	83.5^{a}	13427.6^{a}	4525.9^{a}
Inoc+75% N from V.com	4.86^{a}	2.60^{ab}	159.3^{a}	23.11^{ab}	3.26^{a}	50.26^{ab}	77.6^{bc}	12700.7^{a}	4014.3^{ab}
Inoc+100% Nfrom V.com	4.46^{ab}	2.13^{ab}	165.0^{a}	23.13^{ab}	3.26^{a}	44.26^{ab}	77.0^{bc}	13128.7^{a}	3626.2^{bc}
Mean	4.47	2.42	150.9	19.53	3.26	42.44	78	11029.5	3499.24
LSD	0.85	1.17	21.67	4.91	0.3	18.21	56.2	2158.6	628
CV	10.79	17.15	6.7	11.56	10.05	13.57	14.04	11	10.08

Notes. Means in the same column followed by the same letter are not significantly different at the 5% probability level by Duncan's test, SD: Seedling density, NTL: Number of tillers per plant; PH: Plant height, NPPL: Number of pods per plant; NSPP: Number of seeds per pod; NSPL: Number of seeds per plant, 100SW: 100 Seed weight, BY: Total biomass yield, AdjGY: Adjusted Grain yield

treatment may be due to organic fertilizer sources fulfilling the macro and micronutrient requirements providing the crop with maximum nutrients in later stages (Chala. et al., 2021). The result indicated that applying vermicompost to the soil might considerably improve the nutrient availability, particularly micro, and macronutrients since it improves soil pH under which maximum availability of the nutrients may be obtained. In addition, increased plant height could also be due to the growth-promoting substances, which are present in vermicompost. The increase in plant height due to Rhizobium inoculation produced a higher rate of N2 fixation by inoculum, which plays a vital role in the vegetative growth of the faba bean. The results obtained here are in agreement with those of Gopinath et al. (2011) who revealed a significant increase in growth and yield by the organic input.

The productive potential of fababean is ultimately determined by the number of pods per plant which is a main yield component. The analysis showed a significant effect ($p < 0.05$) on the number of pods produced per plant. The application of vermicompost with rhizobia inoculation influences the number of pods per plant (Chala et al., 2021). The maximum number of pods per plant (26.56) was produced at the rhizobia inoculation with 50% nitrogen from vermicompost application at Gonde (Table 6). The results obtained here are in agreement with those of Anshu, S. and S. Sharma. 2013 revealed a significant increase in growth and yield by the application of vermicompost and inoculation of rhizobia.

Aboveground biomass was significantly ($p < 0.05$) influenced by the effects of Rhizobium inoculation with vermicompost. The maximum aboveground biomass (13427.6 kg ha^{-1}) was obtained from the application of 50% nitrogen from vermicompost with rhizobia inoculation at Gonde in 2021, while the lowest aboveground biomass (4667.7 kg ha^{-1}) was recorded in the control treatment (no input) at Kulumsa. The availability of macro and micronutrients in the vermicompost facilitates photosynthesis and increases biomass. In agreement with these results, authors reported that the biomass yield of fababean increased significantly with the application of vermicompost with the rhizobia inoculation (Anteneh and Abere, 2017) (Tables 4 and 5).

The analysis of this study showed that the effects of rhizobia inoculation with vermicompost application significantly ($p<0.05$) influenced grain yield. Thus, the highest grain yield (4525.9 kg ha^{-1}) was obtained from the application of 50% nitrogen from vermicompost with rhizobia inoculation at Gonde while the lowest grain yield (1863.7

Table 7: Growth and yield parameters affected by rhizobia inoculation with vermicompost application at Boru (2020).

	Parameters								
Treatment	**SD**	**NTL**	**PH(cm)**	**NPPL**	**NSPP**	**NSPL**	**100SW (gm)**	**BY (kg/ha)**	**AdjGY (kg/ha)**
No input(-control)	4.06^{a}	1.98^{c}	121.6^{b}	11.66^{c}	3.13^{a}	39.60^{b}	90.1^{a}	5371^{b}	1914.7^{f}
RRN(+control)	4.06^{a}	2.67^{b}	153.6^{a}	14.80^{b}	3.26^{a}	42.86^{ab}	90.9^{a}	6451^{ab}	2809.7^{e}
Inoculated	4.33^{a}	3.22^{ab}	156.0^{a}	20.12^{ab}	3.26^{a}	46.13^{ab}	91.3^{a}	6544^{ab}	3643.3^{c}
100% N from V.com	4.26^{a}	3.06^{ab}	155.6^{a}	20.26^{ab}	3.40^{a}	43.80^{ab}	89.1^{a}	6454^{ab}	3049.9^{e}
Inoc+50% N from V.com	4.40^{a}	3.83^{a}	159.9^{a}	24.86^{a}	3.46^{a}	52.93^{a}	91.6^{a}	8128^{a}	4309.4^{a}
Inoc+75% N from V.com	4.53^{a}	3.66^{ab}	156.8^{a}	21.20^{ab}	3.33^{a}	46.66^{ab}	91.7$_{a}$	7518^{ab}	3957.3^{b}
Inoc+100% Nfrom V.com	4.40^{a}	3.33^{ab}	160.3^{a}	20.33^{ab}	3.33^{a}	44.20^{ab}	95.2^{a}	6854^{ab}	3318.1^{d}
Mean	4.29	2.15	146.37	19.03	3.31	45.45	91.3	6759.91	3286.05
LSD	0.67	0.78	19.25	4.36	0.3	12.85	4.9	2280.7	267.12
CV	8.86	10.32	11.97	13.84	14.1	15.9	15.75	13.96	14.56

Notes. Means in the same column followed by the same letter are not significantly different at the 5% probability level by Duncan's test, SD: Seedling density, NTL: Number of tillers per plant; PH: Plant height, NPPL: Number of pods per plant; NSPP: Number of seeds per pod; NSPL: Number of seeds per plant, 100SW: 100 Seed weight, BY: Total biomass yield, AdjGY: Adjusted Grain yield

kg ha^{-1}) was recorded without the application of vermicomposting and under no inoculation. This higher yield from the combined application of vermicompost and Rhizobium inoculation may be attributable to the availability of macro and micro-nutrients the occurrence of different beneficial microorganisms, presence of growth-promoting substances. In conformity with this result, the combined use of vermicompost and bio-fertilizers leads to higher yields on fababean (Anteneh and Abere, 2017).

Rhizobia inoculation with the application of 50% nitrogen from vermicompost recorded the highest values in all growth and yield parameters at all experimental sites followed by rhizobia inoculation with 75% nitrogen from vermicomposting (Tables 6 and 7). The study revealed that inoculating Rhizobium with vermicompost in the year 2021 had significantly increased all investigated traits of faba bean when compared to the year 2020. This difference could be related to rainfall distribution in 2020 was not as good as the 2021 crop season.

Conclusion and Recommendation

The field trials conducted for the two consecutive main cropping seasons in the selected districts of Arsi Zone have revealed that growth, yield, and yield components of faba bean have been improved through the inoculation of rhizobia with vermicompost application. In conclusion, the result shows a remarkable improvement in faba bean production in the study site by rhizobia inoculation with vermicompost application. Rhizobia inoculation with the application of 50% nitrogen from vermicompost recorded the highest values in all growth and yield parameters of fababean. In general, the application of high-quality organic fertilizer (vermicompost) and Rhizobium inoculation is needed to boost fababean production and enhance soil fertility.

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