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Original Research Article

Impact of Ecoterra Biofertilizer on Wheat Yield and its Components in the Central Highlands of Ethiopia

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Abstract
Currently, the increasing demand for sustainable agriculture is driving the use of biological fertilizers, which are composed of different beneficial microorganisms. Ecoterra biofertilizer was reported to be effective in different countries in promoting plant health and yields, improving soil conditions, and controlling pathogens. It has the potential to significantly enhance wheat yield and its components. Studies have shown that its application can lead to increased grain yield, higher number of grains per spike, and improved thousand-grain weight. These positive effects are attributed to the biofertilizer's ability to improve soil health, enhance nutrient uptake, and promote plant growth and development. Thus, this activity was aimed to evaluate the effectiveness of this Ecoterra biofertilizer on yield and yield components of wheat in the central highlands of Ethiopia under field and rainfed conditions. The study consisted six treatments. The treatments were replicates three times and laid down by Randomized complete Block design (RCBD). This biofertilizer was evaluated as a sole fertilizer or in combination with different inorganic fertilizer rates on wheat productivity on Vertisols and Nitisols. The study was conducted on 6 farmers' fields in Nitisols and on one farmer's field in Vertisols. The pooled analysis from 6 fields in Nitisols showed that the full recommended inorganic fertilizer (NPS + Urea) was found to be both agronomically and economically preferable over sole Ecoterra biofertilizer or its combination with different inorganic fertilizer rates. Whereas, the combination of 50% inorganic fertilizers with the recommended rate of Ecoterra gave the highest marginal rate of return (752%) compared to the other treatments.

Keywords: *Biofertilizer, Districts, Ecoterra and Wheat.*

INTRODUCTION
Soil fertility decline is the main challenge that causes serious food insecurity and poverty in Africa including Ethiopia (Kihara *et al.*, 2016; Tilahun *et al.*, 2022). Increasing crop production and productivity is the most critical and indisputable exit to feed developing countries' ever-increasing population (Edgerton, 2009; FAO, 2017). Soil fertility improvement approaches are compulsory to increase soil fertility, since soil nutrient shortage is one of the foremost limiting causes for cereal crop yield reduction including wheat in Ethiopia and elsewhere (Workineh, 2020; Majee *et al.*, 2021).

Wheat (*Triticumaestivum*) is one of the most important food crops among the widest community in Ethiopia. Ethiopia is the greatest wheat producer in sub-Saharan Africa (SSA) this is because of the availability of favorable agroecology and soils in the country (Tadesse *et al.*, 2019). In terms of area coverage, wheat ranked fourth next to tef, maize and sorghum. Despite the significance of the area of wheat production and its importance in Ethiopia, the current annual production of wheat is approximately 4,838,074 tones with an overall yield of 2.76 tons ha^{-1} in 2019(CSA,2018), compared to the world average of 3.4-tons ha^{-1} and top producer countries in the world (e.g., Egypt, 6.7-tons ha^{1}) (FOSTAT, 2018).

Fertilization of soil with organic or inorganic sources, or their combination serves as a source of plant nutrients. Principally organic and biological fertilizers are serving not only as nutrient sources but also enrich the soil microbial community, soil preservation capacity, increase nitrogen use efficiency, soil structure and eventually, the quality of agricultural products (Chinnadurai *et al*., 2014; Elka and Laekemariam, 2020; Hafez *et al*., 2021).

Soil microorganisms play an irreplaceable role in nutrient recycling and they are the only link between the dead and living components of the ecosystem (Kibble white, 2008; Bar-On, 2018). They serve as decomposers of organic matter, bio-fertilizers, produce growth-promoting substances, and bio-control, etc (Bar-On, 2018). However, in this day and age soil, microbes are threatened by natural and to a most extent by human interventions. Studies have shown that associated with the misuse of agro or industrial chemicals microflora and fauna are reached the threshold of extinction.

Therefore, there must be some sort of rescue strategy that can save micro-organisms and in turn production and productivity of crops and even life on this planet earth. Soil can be restored to its natural balance with the use of microbial 'inoculants'. Microbial inoculation is a sure and natural means of increasing the number of useful micro-organisms in the soil and restoring its balance. As reported by the manufacturer (Soil and More Ethiopia Composting PLC) their product; *Ecoterra biofertilizer* was effective in different countries in promoting plant health and yields, improving soil conditions, and controlling pathogens. Thus, this activity is aimed to evaluate the effectiveness of this *Ecoterra biofertilizer* on yield and yield components of wheat in the central highlands of Ethiopia under field and rainfed conditions.

Objectives

- To determine the efficacy of Ecoterra biofertilizer on wheat yield and its components
- To determine the efficacy of Ecoterra biofertilizer on improving grain quality of wheat

MATERIALS AND METHODS

Description of the Study Area

The trials were conducted during the 2022 main cropping season (June-October) on 7 farmers' field (Table 1), where 6 are in Welmera, Ejere and Burayu areas (representing Nitisols) and the rest one was in Sebeta Hawas district (representing Vertisols). The six farms in the Nitisols area receive an average annual rainfall of 970 to 1184 mm. As shown in Table 3, their composite pre-planting surface soil (0-20 cm) test result showed that the soils were clay in texture and the pH ranges from 4.9 to 5.6 indicating that the soils are very strongly to strongly acidic (Murphy, 1968). These soils tend to fix a considerable amount of phosphorus and hence limiting P availability to crops. The total nitrogen content ranges from 0.16 to 0.21% which falls in the moderate N content (Tekalign, 1991). The available phosphorus content was classified as low to high according to Jones's (2003) classification with ranges from 12.0 to 31.6 pm.

The organic content ranges from 1.52 to 1.87% and is classified as moderate in organic carbon content (Tekalign, 1991). The most common crops produced in the area are wheat, faba bean, teff, and potato. On the other hand, the experimental field in Sebeta Hawas district receives an average annual rainfall of 1055 mm (Figure 2). The textural class of the experimental field was clay. The pre-planting composite surface (0-20cm) soil test result of Sebeta Hawas experimental field showed that the soil pH was neutral with values of 7.05, low in total organic carbon content (1.09%), medium in available P (14.8 ppm) and moderate in TN content (0.15%) (Tekalign, 1991). It has been shown that most plant nutrients are optimally available to plants within the pH range of 6.5 to 7.5 and this range of pH is generally very compatible to plant root growth (Jensen, 2010). The commonest crops of the site are wheat, teff, chickpea and faba bean.

Table1. GPS coordinates of the trial sites at Welmera, Burayu, Ejere and Sebeta Hawas districts

Farm number	Latitude	Longitude	Attitude	Location Kebele	District
Farm-1	09° 07.748'	038° 26.599'	2615 m.a.s.l	Rob-gebeya	Welmera
Farm-2	09° 01.130'	038° 35.294'	2702 m.a.s.l	Sadamo	Welmera
Farm-3	09° 07.647'	038° 26.645'	2599 m.a.s.l	Robgebeya	Welmera
Farm-4	09° 04.039'	038° 25.745'	2458 m.a.s.l	Damotu	Ejere
Farm-5	09° 03.448'	038° 26.580'	2461 m.a.s.l	Chiri	Ejere
Farm-6	09° 01.130'	038° 25.294'	2702 m.a.s.l	Guje	Burayu
Farm-7	09° 03.448'	038° 26.580'	2461 m.a.s.l	Geja Koye	Sebeta Hawas

m.a.s.l = meter above sea level

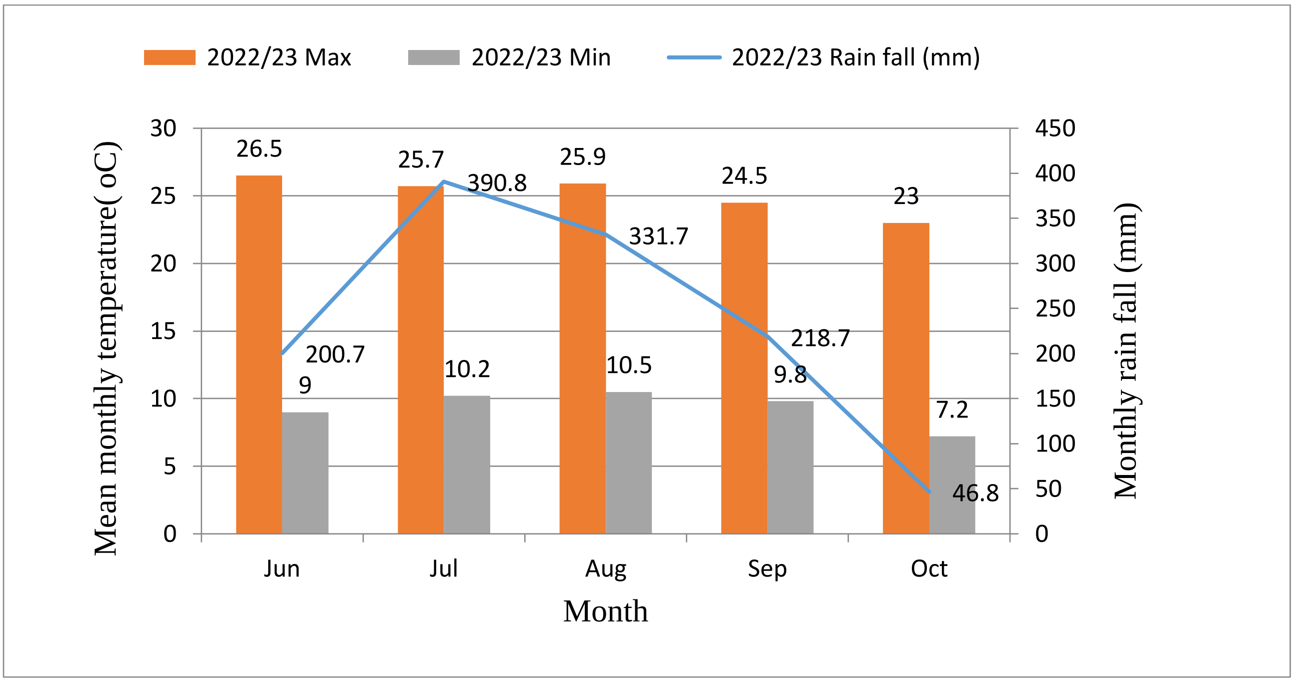

Figure 1: Monthly Rainfall, and mean monthly maximum and minimum temperatures patterns of the experimental sites at Welmera, Ejere and Burayu districts. (Source: Holeta Agricultural Research Center weather station)

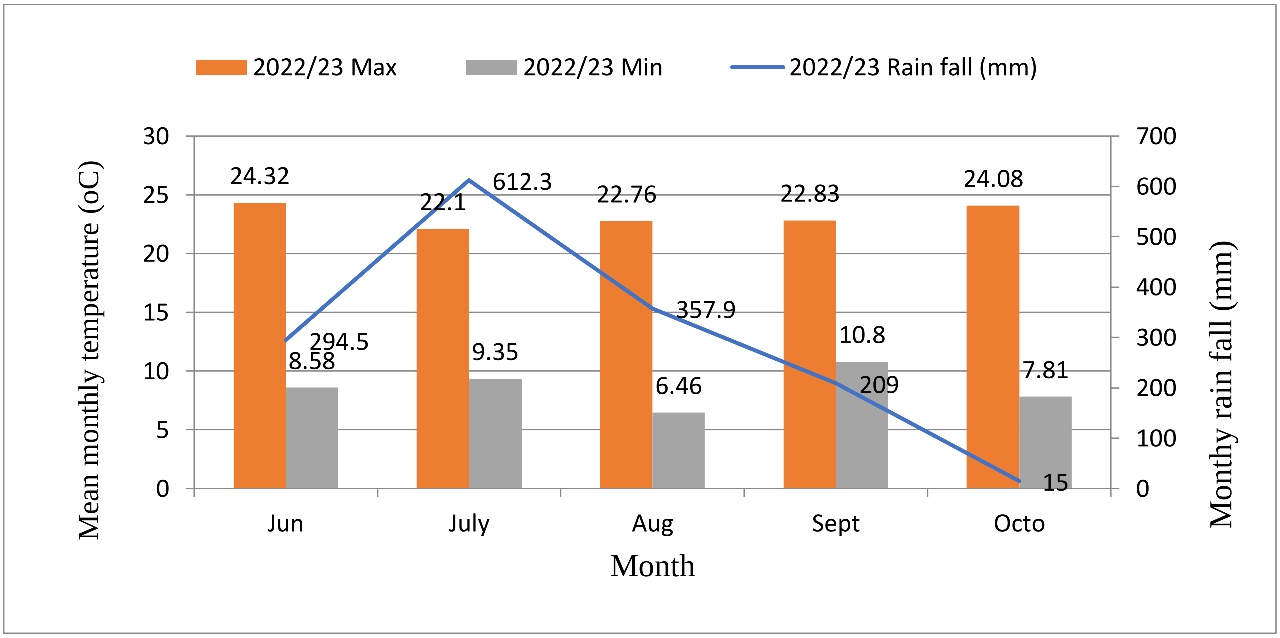

Figure 2: Monthly rainfall, and mean monthly maximum and minimum temperature patterns of the experimental sites at Sebeta Hawas district. (Source: Sebeta Fishery and Aquatic Life Research Center weather station).

Experimental setup

The field experiments had 6 treatments (Table 2). These treatments were laid out in randomized complete block design (RCBD) with three replications. The gross experimental plot size was 4m by 5m. To reduce cross-contamination of treatments, un-inoculated treatments were planted before *Ecoterra* inoculated treatments and the space between plots, blocks and rows were 0.5 m, 1m and 0.2 m, respectively. *Dendea and Taye* varieties of wheat were sown at the rate of 150 kg ha^{-1} at Welmera, Ejere and Burayu, and Sebeta Hawas districts, respectively. The sources of N and P were NPS (19 N, 38 P_2O_5, 7 S) and Urea (46 kg N). The NPS fertilizer was applied as a basal application at sowing whereas, urea was applied in two equal splits (at 15 and 35 days after crop emergence).

Table 2. Full description of the treatments evaluated in the study

No	Treatment
1	Negative control (No Nitrogen, no phosphorus and no *Ecoterra*)
2	Recommended inorganic fertilizer rate (182 kg NPSha^{-1} + 54 kg Urea ha^{-1})
3	Recommended inorganic fertilizer rate+ Recommended *Ecoterra*
4	75% of the recommended inorganic fertilizer rate + Recommended Ecoterra
5	50% of recommended inorganic fertilizer + Recommended *Ecoterra*
6	Recommended *Ecotera* only

Ecoterra was dressed at the rate of 2kg ton^{-1} of grain in 5% water suspension and hence 300g of grain was dressed in a suspension composed of 0.6g Ecoterra and 12 ml water for each plot (according to the manufacturer's recommendation). All the other agronomic practices, fertilizer application and other crop management practices were applied according to the recommended practices.

Data Collection, Management and Statistical Comparisons

Yield attributes, crop growth data, grain quality, soil properties, weather and economic data were collected at the appropriate time of the trials. Prior to analysis, data curing was done to inspect outliers, and the fulfilments of the ANOVA assumptions were checked. For grain yield, moisture adjustment was made to 12.5%. Descriptive (mean) and inferential (ANOVA) statistics were used to summarize the different data sets. The results of the field experiment were subjected to analysis of variances using the SAS software program version 8.2 (SAS Institute, 2000). Significant differences between treatment means were compared and separated using the least significant difference (LSD) test at the 0.05 probability levels (Gomez and Gomez, 1984).

Partial Budget Analysis

Partial budget analysis (PBA) was computed to assess the costs and benefits associated with different treatments using the technique described by CIMMYT (1988). The farm gate prices of inputs which vary across the treatments and the farm gate output costs during harvesting were collected. Application costs of Ecoterra and mineral fertilizers were considered negligible. All costs and benefits of treatments during the season of application were calculated in aggregate on a hectare basis in Ethiopian currency (Birr ha^{-1}). Grain yield was scaled down by 10% just to approximate the yield that farmers can obtain on their farms. For a treatment to be considered a worthwhile option for farmers, the minimum acceptable rate of return (MRR) was set at 165% (CIMMYT, 1988).

RESULTS AND DISCUSSION

Response of wheat to Ecoterra biofertilizer and inorganic fertilizer applications on Nitisols of Welmera, Ejere and Burayu areas

The mean result of the study obtained from three districts representing Nitisols (Table 3) indicated that the effect of different treatments significantly ($p \leq 0.05$) affected all agronomic parameters of wheat. The recommended inorganic fertilizer alone or in combination with the recommended rate of *Ecoterra* showed statistically higher ($p \leq 0.05$) plant height compared to all the rest treatments. But there was no significant difference between plants that received recommended inorganic fertilizer and its combined application with recommended *Ecoterra*. On the contrary, the shortest plant height (66 cm) was recorded from the unfertilized control followed by plants treated *Ecoterra* alone (67 cm). This implies that the sole application of Ecoterra at the recommended rate didn't improve the growth performance of wheat. The highest number of grains per spike (61 grains/spike) was recorded in plants that received 75 % recommended inorganic fertilizer in combination with the recommended rate of *Ecoterra* followed by plants that received the recommended rate of inorganic fertilizer in combination with the recommended rate of *Ecoterra* (58 grains/spike). However, both treatments are statistically at par with all the rest treatments except the unfertilized control and sole application of recommended *Ecoterra* that recorded 43 grains/spike and 45 grains/spike, respectively.

This clearly indicated that the application of recommended rate of inorganic fertilizer alone or the combination of 50% and 75% of the recommended inorganic fertilizer rate with the recommended rate of Ecoterra favored the development of a higher number of grains per spike. Similarly, thousand grain weight (TGW) was significantly affected by the application of different treatments. The least TGW was recorded from the unfertilized control (42 g) and sole application of Ecoterra (41 g), while the highest TGW (46 g) was recorded from the full recommended rate of inorganic fertilizer combined with the recommended rate of Ecoterra. However, no significant statistical differences were noticed among RIOF, RIOF +REcot, 75%RIOF +REcot and 50% RIOF + REcot in TGW.

The number of spikes/m^2 was also significantly affected by the application of different treatments. The highest number of spikes/m^2 (184) was recorded from plots that received the full recommended inorganic fertilizer rate alone followed by combined application of full recommended inorganic fertilizer and recommended *Ecoterra* (168 spikes/m^2). The least number of spikes/m^{2}was recorded from the sole application of *Ecoterra* (120 spikes/m^2) followed by the unfertilized control (131 spikes/m^2). The different combination of inorganic fertilizer with *Ecoterra* resulted in a moderate number of spikes/m^2 which were statistically better than the sole application of Ecoterra or the unfertilized control. The significantly highest straw yield (6450 kg ha^{-1}) was recorded from plots that received the sole recommended inorganic fertilizer followed by combined application of the recommended fertilizer and recommended *Ecoterra* (5480 kg ha^{-1}) and 75% of recommended inorganic fertilizer plus recommended Ecoterra (5120 kg ha^{-1}). The lowest straw yield (2184 kg ha^{-1}) was recorded from the sole application of Ecoterra, which was statistically comparable with the unfertilized control (2494 kg ha^{-1}).

Table 3. The mean agronomic response of wheat to *Ecoterra* biofertilizer at Welmera, Ejere and Burayu areas in the 2022 main season

Treatment	Plant height(cm)	Grains no/spike	Spike no/m^2	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	TGW (g)	HI (%)
Control	66d	43b	131c	1077d	2494d	42b	30c
RIOF	94a	57a	184a	3274a	6450a	45a	35ab
RIOF+ REcot	95a	58a	168ab	3364a	5480b	46a	38a
75% RIOF+Recot	92b	61a	158b	2863b	5120b	45a	36ab
50% RIOF+ Recot	85c	57a	151b	2213c	3939c	45a	36ab
REcot	67d	45b	120c	1137d	2184d	41b	34b
LSD (P<0.05)	2.3	4	17	233	673	2	3
CV (%)	4	11	17	15	24	6	14
Mean	83	53	152	2321	4278	44	35

RIOF = recommended inorganic fertilizer, REcot= recommended Ecoterra, TGW = thousand grain weight, HI= harvest index

The treatments that ranked first to fourth in grain yield; RIOF+ REcot, RIOF, 75% RIOF+ Recot, and 50% RIOF + Recotshowed212%,204%,166%,106%, and196%,188%,152%,95%grain yield percentage increase over the negative control and the recommended Ecoterra, respectively. The grain yield (1137 kg ha^{-1}) recorded from the sole application of recommended Ecoterra was statistically comparable with the unfertilized control (1077 kg ha^{-1}), indicating the absence of grain yield benefit from the sole application of recommended *Ecoterra.* The lowest HI (30) was recorded for unfertilized control plots followed by the sole application of recommended Ecoterra (34). Although the highest HI (38) was obtained for the combined application of recommended inorganic fertilizer with the recommended rate of Ecoterra, a significant statistical difference was not detected among the sole application of inorganic fertilizer (RIOF) plus 50% RIOF+ Recot, 75% RIOF + Recot in terms of HI (%).

Response of wheat to Ecoterra biofertilizer and its combination with different rates of inorganic fertilizer on Vertisols of Sebeta Hawas district

The results of the study obtained from Vertisols of Sebeta Hawas district (Table 4) depicted that the application of different treatments exhibited a significant ($p \leq 0.05$) effect on all agronomic parameters except on TGW and HI (%). The highest number of grains per spike (67) which was higher than the unfertilized control and sole application of recommended Ecoterra were recorded for plants that received the combinations of recommended inorganic fertilizer and recommended Ecoterra. The other combinations of recommended Ecoterra and different inorganic fertilizer rates tested were statistically comparable with unfertilized control and REcot in terms of the number of grains per spike.

On the other hand, the highest number of spikes/m^2 (251) was recorded for plots that received sole inorganic fertilizer, followed by the combinations of 75 % of recommended inorganic fertilizer with recommended Ecoterra (244) and the combinations of 50% inorganic fertilizer with recommended Ecoterra (243). However, all of these treatments were statistically comparable with the combinations of both fertilizers at their recommended rate which recorded 220 tillers per square meter. Both unfertilized control and sole recommended *Ecoterra* received plots registered lower spikes/m^2 compared to the rest treatments. Similarly, the significantly shortest plant height (93 cm) was recorded from the unfertilized control plots and sole application of recommended Ecoterra. All the remaining four treatments showed statistically comparable plant heights to each other, but higher than both unfertilized control and recommended *Ecoterra*.

Even though, significant statistical differences were not detected among (RIOF + REcot), sole RIOF, (75% RIOF + REcot) and (50% RIOF + REcot) in plant height, straw yield and grain yield, they showed statistically higher results over that of the unfertilized control and the sole application of REcot. This may indicate that the combination of recommended rate Ecoterra with different rates of inorganic fertilizer favored the growth and development of wheat on Vertisols of the area. Based on numerical differences in straw and grain yields, RIOF+ REcot, sole RIOF,75% RIOF+Recot, and 50% RIOF+Recot ranked first to fourth in the above-indicated order. The above-mentioned treatments that ranked first to fourth in straw and grain yields had shown 43.9%, 43.3%, 35.1% and 25.6% in straw yield and 43.7%, 41.8%, 40.6%, and 34.4%grain yield over the unfertilized control, respectively. The corresponding increases over the sole application of recommended Ecoterra for the aforementioned treatments were 42.1%, 41.5%, 33.3%, and 24% for straw yield and 43.9%, 42%, 40.7%, and 34.5%, respectively for grain yield.

Table 4. Agronomic response of wheat to *Ecoterra* biofertilizer at Sebeta Hawas in 2022 main season

Treatment	Plant height(cm)	Grains no/spike	Spike no/m^2	Straw yield (kg ha^{-1})	Grain yield (kg ha^{-1})	TGW (g)	HI (%)
Control	93b	56b	197b	5364b	2586b	36	33
RIOF	105a	60ab	251a	7688a	3667a	35	32
RIOF+ REcot	105a	67a	220ab	7721a	3717a	37	32
75% RIOF+Recot	103a	61ab	244a	7247a	3635a	36	33
50% RIOF+ Recot	102a	59ab	243a	6739a	3475a	36	34
REcot	93b	58b	189b	5435b	2583b	36	32
LSD (P<0.05)	4	8	36	1272	582	Ns	Ns
CV (%)	2	7	9	10	10	3	9
Mean	100	60	224	6699	3277	36	35

RIOF= recommended inorganic fertilizer, REcot= recommended Ecoterra, TGW= thousand grain weight, HI= harvest index

The effect of different treatments on the grain protein content of wheat

The results on grain protein content due to different treatments were shown in Table 5. Even though no significant difference ($p \leq 0.05$) was observed among different treatments, the lowest protein content (9.23%) was observed in unfertilized control plots followed by plants that received sole recommended Ecoterra (9.83%) in Nitisols. The data from Vertisols are non-replicated and hence difficult to make comparisons. However, the overall protein contents for wheat grown on Vertisols are relatively higher than wheat grown on Nitisols. This could be attributed to the low nitrogen use efficiency of wheat in acidic soils. In general, the sole or co-application of Ecoterra biofertilizer did not improve the grain protein content of wheat in both soil types.

Table 5. The effect of Ecoterra biofertilizer on the protein content of wheat grain (pooled from location replications) in 2022

Treatment	Nitisols area	Vertisols area
	Grain protein content (%)	
Control	9.23	11.7
RIOF	9.8	11.5
RIOF+ REcot	9.9	11.5
75% RIOF + REcot	9.88	11.6
50% RIOF + REcot	10.12	11.7
REcot	9.83	11.6
LSD(p<0.05)	NS	-
CV(%)	6.8	-
Mean	9.8	11.6±0.090

Effect of different treatments on selected soil properties

The post-harvesting surface (0-20cm) soil chemical properties test results are shown in Tables (6 and 7). In the Nitisols (Table 6), none of the soil chemical properties were significantly affected ($P \leq 0.05$) by the sole or co-application of Ecoterra with mineral fertilizer as compared to the control. Even though it was a single-season trial, the product did not directly or indirectly improve the pH of the soils of the Nitisols. Moreover, slight numerical differences observed in the other soil properties could be due to chance and hence difficult to justify.

Table 6. Mean effect of Ecoterra on selected soil chemical properties of Nitisol (pooled from location and plot) during 2022

Treatment	**pH**	**EX. Acidity (cmol+ kg^{-1})**	**Ava.P (ppm)**	**TN (%)**	**OC (%)**
Control	5.91	0.62	9.87	0.177	1.83
RIOF	5.87	0.75	12.96	0.175	1.91
RIOF+ REcot	5.83	0.88	12.28	0.177	1.92
75% RIOF + REcot	5.85	0.81	13.19	0.174	1.91
50% RIOF + REcot	5.90	0.72	11.65	0.177	1.88
REcot	5.90	0.69	12.11	0.182	1.90
Mean	**5.88**	**0.75**	**12.01**	**0.18**	**1.89**
CV (%)	**0.98**	**30**	**23**	**5.25**	**3.25**
LSD (P ≤0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
Method	1:2.5 H_2O	L.P. Van Reeuwijk 1N KCl leaching titration	Bray II	Modified Kjeldhal	Walkley and Black (1934)

Similarly, in Vertisols (Table 7), the sole or co-application of *Ecoterra* with mineral fertilizer did not exhibit a substantial change in all of the soil parameters as compared to the control. Relatively modest improvements in available P and OC contents are observed on T3, T4 and T5 as compared to the control. However, these improvements might not be attributed to the presence of Ecotera as it was not held same on sole Ecotera treatment. When we look into the pre-planting and post-harvest scenarios and the associated changes in the rating status of OC, available P and pH, both of the soil types showed a similar trend. In general, the relatively higher productivity of the farm (as evidenced by the high grain yield of the control plot) and the poor TN and OC amount (Table 6) require further investigation.

Table 7. Mean effect of Ecotera on selected soil chemical properties of chromic Vertisol area (pooled from plots) during 2022

Treatment	pH	Avail. P (ppm)	N (%)	OC (%)
Control	7.71	6.7	0.09	1.17
RIOF	7.77	8.4	0.09	1.17
RIOF +REcot	7.59	14	0.10	1.25
75%RIOF +REcot	7.67	12.0	0.09	1.21
%50RIOF +REcot	7.75	8.8	0.09	1.36
REcot	7.59	8.4	0.09	1.17
Method		Olsen		

Partial budget analysis

The partial budget analysis result (Tables 8 and 9) showed that the highest net benefits (123998ETBha^{-1} and 141547 ETBha^{-1}) were obtained from the application of RIOF + REcot on Nitisols, and Vertisols, respectively. For Nitisols, the lowest benefit (41159ETB ha^{-1}) was obtained from the unfertilized control treatment whereas, the lowest net benefit (103983ETB ha^{-1}) for Vertisols was obtained from recommended *Ecoterra* treated plots. The total variable costs (TVC) invested by farmers in this study include the farm gate prices of urea (3578 Birr/100kg), NPS (3443 Birr/100kg), wheat grain (4000 Birr/100kg), wheat straw (240 Birr/100kg) and Ecoterra (744.3 ETB ha^{-1}). The recommended rates of nitrogen and phosphorus per hectare for wheat across the trial sites were 60 kg N/ha and 69 kg P_2O_5/ha. The dominance analysis showed that none of the treatments were dominated on Nitisols. However, on Vertisols of Sebeta Hawas, the recommended *Ecoterra* was dominated. Since no beneficiary will prefer an alternative that gives lower net benefits than one with higher net benefits and lower total variable costs, the dominated treatment was eliminated from further economic analysis.

The minimum acceptable rate of return assumed in this experiment was 165% and hence recommended in organic fertilizer on Nitisols and 50% recommended inorganic fertilizer plus recommended *Ecoterra* on Vertisols were profitable options. In relative terms, fertilization of wheat with recommended *Ecoterra* on Nitisols, and the combined use of 50% RIOF with Recot on Vertisols gave the highest marginal rate of return amounting to 1254 % and 752%, respectively. This means that for each ETB1.00 investment in wheat production using recommended in organic fertilizer on Nitisols and (50% RIOF + Recot) on Vertisols the farmer can get an additional return of ETB 12.50 and 7.52, respectively. Thus, the other treatments in Nitisols are not promising fertilizer options for wheat production. However, in the case of Vertisols of Sebeta Hawas district, the combined application of 50% recommended in organic fertilizer plus recommended *Ecoterra* is the best promising candidate for further verification over farmers' fields at different agro-ecologies to consider it as commercial wheat fertilizer in wheat growing areas of Ethiopia.

Table 8. Economic analysis for Welmera, Ejere and Burayu Districts

Treatment	Adj GY	Adj SY	GB GY	GB SY	GB GSY	TVC	Net B	D	MC	MNB	MRR (%)
Control	969	2245	38772	5387	44159	0	44159				
REcot	1023	1966	40932	4717	45649	744	44905	ND	744	746	100
50% RIOF+ Recot	1992	3545	79668	8508	88176	4843	83333	ND	4099	38428	937
75% RIOF+Recot	2577	4608	103068	11059	114127	6893	107234	ND	2049	23901	1166
RIOF	2947	5805	117864	13932	131796	8198	123598	ND	1305	16364	1254
RIOF+ REcot	3028	4932	121104	11837	132941	8942	123998	ND	744	400	54

Adj GY=adjusted grain yield, Adj SY=adjusted straw yield, GB GY= grosses benefit of grain yield, GB SY= grosses benefit straw yield, GBGSY= sum of grosses benefits of grain and straw yields, TVC= total variable cost, NB= net benefit, D= dominance, MC=marginal cost, MNB= marginal net benefit, MRR (%) = marginal rate of return

Table 9. Economic analysis for Sebeta Hawas District

Treatment	Adj GY	Adj SY	GB GY	GB SY	GB GSY	TVC	NetB	D	MC	MNB	MRR (%)
Control	2327	4828	93096	11586	104682	0	104682				
REcot	2325	4891	92988	11740	104728	744	103983	D			
50% RIOF+ Recot	3127	6065	125100	14556	139656	4843	134813	ND	4099	30830	752
75% RIOF+Recot	3271	6522	130860	15653	146513	6893	139621	ND	2049	4808	235
RIOF	3300	6919	132012	16606	148618	8198	140420	ND	1305	799	61
RIOF+ REcot	3345	6949	133812	16677	150489	8942	141547	ND	744	1127	151

Adj GY=adjusted grain yield, Adj SY=adjusted straw yield, GB GY= grosses benefit of grain yield, GB SY= grosses benefit straw yield, GBGSY= sum of grosses benefits of grain and straw yields, TVC= total variable cost, NB= net benefit, D= dominance, MC=marginal cost, MNB= marginal net benefit, MRR (%) = marginal rate of return

SUMMARY AND CONCLUSION

Based on yield and partial budget analysis results, neither the sole application of *Ecoterra* or its combination with different inorganic fertilizer rates (50 and 75%) showed promising results. On the other hand, the application of fully recommended inorganic fertilizers alone was found to be a profitable option for bread wheat production on Nitisols. Similarly, there was no improvement in soil chemical properties due to the inclusion of the new fertilizer product in the wheat production package. The trial on Vertiols was conducted in a single location and single year and hence difficult to give conclusive recommendations. However, this single field trial showed that the combined application of *Ecoterra* with 50% recommended inorganic fertilizer was found to be the profitable option for wheat on Vertisols. There is a need to confirm this result by conducting further research work on different Vertisols at different locations or through field verification over different agro-ecologies. The high grain yield on unfertilized plots on Vertisols may indicate that there is no need to apply the full recommended inorganic fertilizer for economic wheat production on this soil. This could due to the neutral soil pH which enhances the availability of most nutrients.

Conflict of Interest

Authors have declared that no competing interests exist.

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