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Research Article

Effects of Integrated Decomposed Cattle Manure and Inorganic Fertilizer on Yield and Yield Components of Food Barley (*Hordeum vulgare* L.) in West Region of Ethiopia

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Abstract

Food Barley (Hordeum vulgare L.) is important major cereal crop which cultivated widely over the word. It is very important and categorized as food security crop in highlands of Ethiopian. This research was carried out in west region of Ethiopia Arjo, Gedo and Shambo in 2021 and 2022 cropping season with the objective of determine optimum integrated inorganic fertilizer and cattle manure for food barley production. The experiment was arranged with five level of NPS (0,25%, 50%, 75%, and 100%) of recommended combined with four level of decomposed cattle manure 0, 3tone/hectare, 6tone/ha and 9tone/a using RCBD in factorial arrangement and replicated three times. Analysis of variance showed grain yield, 1000sw, biological yield and plant height significantly affected by integrated fertilizer. Highest grain yield 2665kg/ha was harvested from the plot received 100% and 3tone/ha. Harvest index, seed per spike, spike length and number of tillers per spike were not affected by the treatment. The partial budget analysis revealed two treatments integrated 100% in organic fertilizer and 3tone/ha cattle manure and 9tone/ha cattle manure and 50% inorganic fertilizer which their MRR 605 and 1482 respectively were economically feasible. Therefore, the farmers and investors are advised to use these selected treatments for food barley production and soil fertility improvement.

Keywords

In Organic, Fertilizer, Organic, Soil

1. Introduction

Barley (Hordeum vulgare L.) is one of the commonly grown food security crops in high altitude areas [7]. It is a cool-season crop that is adapted to high altitudes. Barley (Hordeum vulgare L.) is the fourth most important cereal crop in the world after wheat, maize, and rice and among the crops planted top ten. Globally, European Union, Russian Federation, Ukraine, Turkey and Canada are the top five largest world Barley producers where, European union's produce the greatest quantities of barley with an estimated production of nearly 60 million tons followed by Russian federations with a production of about 20 million tons [11]. On the African continent, Morocco, Ethiopia, Algeria, Tunisia and south Africa were the top five largest barley producers for the year 2014 with estimated production of approximately 2.1 million tones, 1.7 million tones, 1.3 million tones, 0.9 million tones and 0.307 million tons respectively.

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It is also one of the major cereal crops that are largely produced in central highlands and south east mid and high-altitude areas of Ethiopia and fifth most important cereal crop after teff, maize, wheat and sorghum [8, 12]. Its grain is mostly used as feed, food and different beverages. In Ethiopia, barley cultivation is reported to have started 5000 years ago and Ethiopia is considered as a center of diversity for barley. It is widely cultivated in central and northern parts of Ethiopia, with Oromia, Amhara, Tigray, and Southern Nations, Nationalities and People's Region (SNPPR) as the main areas of production [7].

The crop needs optimum soil nutrient that can be found from organic and in organic fertilizer or from the integration of the two fertilizers. According to [15] highest barley grain yield (2,792 and 3,279.3 kg ha-1) was recorded from combined application of NPK at the rate of 46/40/50 kg ha- that the application of optimum chemical fertilizer influences the yield of food barley with the consideration of influence of chemical fertilizer on the soil physicho-chemical property and environmental costs. Huge amount of using chemical fertilizer to increase yield of food barley, may increase soil acidity due to the influence of urea activities [4].

Animal manure is both a natural by-product of livestock production and an excellent source of plant nutrients [5]. It is known to be effective in maintenance of adequate supply of organic matter in soil, with improvement in soil physical and chemical condition and enhanced crop performance. Poultry, cattle, sheep and pig manure has been found to improve soil fertility and crop yield. Addition of poultry and cattle manure to soil lead to increase in soil PH, Organic Carbon, Nitrogen, Phosphorus, Calcium, Potassium, Magnesium, Sodium and CEC which highly improve crop growth and development that leads to increase crop yield [13] reported the livestock waste composts with minimum inorganic fertilizer as a soil amendment in low-input intensive farming has been well recognized as a vital agricultural practice to improve yield as well as soil health.

Combining the organic and inorganic fertilizer in the area of high rain fall, improve soil fertility status with the yield increment of food barley [1]. Organic manuring and nitrogen fertilization are considered among the most important cultural practices for increasing barley productivity and improved quality parameters [18, 19]. In crop production, nutrient availability from manure has been recognized for many centuries. Modern agriculture, which largely depends on chemical fertilizers, pesticides, herbicides etc., though increased production, has adversely affected the soil productivity and environmental quality [6]. In SSA countries farmers are using a very low amount of chemical fertilizer or below the recommendation of the research of that area due to unaffordability of fertilizer cost. An average of 9 kg-ha is used for crop production and low yield is recorded from the cultivated area. This can be supported by different organic fertilizer including cattle manure.

Even though the crop is important and categorized as major cereal crop in Ethiopia, major constraints phased the production of barley. The constraints are categorized in to two major constraints biotic and abiotic constraints. The most important abiotic stresses include low soil fertility, low soil pH, poor soil drainage, frost and drought. Soil fertility depletion is a key problem of cereal production including barley in Ethiopia [16]. To alleviate this problem farmers use huge amount of chemical fertilizer and that faces a number of potentially significant constraints; although these need framing in the overall context of whether more chemical fertilizer is optimal (current situation varies from one location to the next) and in particular the impact of other soil fertility issues (e.g. acidity) on fertilizer effectiveness., Besides of this as increased the cost of chemical fertilizer, subsistence farmers cannot afford to use this chemical fertilizer [14].

High-rate application of cattle manure for barley production and other cereal crops, contribute drastically yield reduction due to salt accumulation in the soil in the long run in the area of rain fed agriculture hence what economically optimal application levels could be imbalanced organic fertilizer or cattle manure also influence the environment and Soil phisico chemical properties of the soil that is also significantly influenced by different human activities [13].

Application of integrated inorganic fertilizer and organic fertilizer can be the solution for these constraints. The west part of Oromia also exposed to these problems that with high rain fall and high acidity with low soil fertility that can be amended by integration of organic and inorganic fertilizer.

Objectives

1) To study the effects of rates of cattle manure combined with inorganic fertilizer on yields and yield components of food barley (Hordeum vulgare L.)
2) To determine optimum integrated inorganic fertilizer and cattle manure for food barley (Hordeum vulgare L.) at the study area.

2. Materials and Method

2.1. Description of Study Area

The study was conducted at Shambu, Gedo and Arjo sub sites which found in west region of Oromia. The study area found in the west direction of Ethiopia 310km, 180km and380km far from city Addis Ababa respectively in crop growing season of 2021 and 2022. The study area popularized with high rainfall April to mid- October for the three locations and low temperature which is suitable for barley production. Shambu is located at $09^{0}29$N and $37^{0}26$E with the altitude of 2296masl and high temperature 23-27^{0}c January to March and low temperature 7-15^{0}c October to November (Hundie D. and Geleta G., 2015). Gedo located at $9^{0}30$N and $37^{0}32$E with the altitude 2450masl. The rain fall received by the study area is similar to that of Shambu.

2.2. Treatments and Experimental Design

The experiment was contained five level of inorganic fertilizer (NPS) (0, 25%, 50%. 75%, and 100%) of recommendation of the study area combined with four level of decomposed cattle manure (0,3.6 and 9 tons/ha). It was conducted with RCBD in factorial arrangement and replicated three times. A total of 20 treatments were created and 60 plots were put on the land after replicated three times on the area of a unit plot of 3m x 3m (9m2) which accommodated 15 rows. All other agronomic practices were applied for all plots in similar manner. The cattle manure used was decomposed up to the optimum to release nutrient for the crop growth.

2.3. Data Collected

Agronomic data like days to 50% emergence, plant height, Number of tillers, number of effective tillers, spike length, number of spikelets per spike, 1000grain weight, spike length. Days to maturity, grain yield were measured and subjected to analysis of variance based on Gomez and Gomez 1984 method. Compioutor software Gen Stat version 18 supported the method of data analysis.

2.4. Partial Budget Analysis

Mean grain yield of the selected treatment was used in partial budget analysis [2]. Economic analysis was performed to investigate the economic feasibility of the treatments (fertilizer rates). Partial budget, dominance and marginal analysis were done. The average open market price (Birr kg^{-1}) for food barley and the official prices of blended, Urea, NPSB fertilizers and improved seed were for economic analysis. The dominance analysis procedure as detailed in [2] was used to select potentially profitable treatments from the range. The selected and discarded treatments using this technique were referred to as un-dominated and dominated treatments, respectively. The un-dominated treatments were ranked from the lowest (the farmer's practice) to the highest cost treatment. For each pair of ranked treatments, % Marginal Rate of Return (MRR) was calculated. The % MRR between any pair of un-dominated treatments denoted the return per unit of investment in fertilizer expressed as a percentage.

3. Result and Discussion

3.1. Soil Physico-Chemical Properties of the Experimental Site of Pre-Planting

The result of soil of pre-planting of the areas showed that the soil of Shambu, Gedo and Arjo are 5.6, 5.53 and 5.22 respectively that moderately acidic. The soil of the research areas Shambu, Gedo anda Arjoo are containing low level of soil organic carbon and organic matter. The soil of the areas challenged with the low fertility or soil with low quality. The soil of the areas is challenged with low soil quality in terms of soil pH. Available nutrients and organic carbon and organic matter.

Table 1. *Pre-plant soil properties of Shambu, Arjo and Gedo.*

Number	Parameter	Shambu	Gedo	Arjo
1	pH (H_2O) 1:2.	5.6	5.53	5.22
2	%OC	2.89	3.35	3.24
3	%OM	4.98	5.78	5.58
4	%TN	0.25	0.29	0.28
5	avaP(ppm)	5.24	5.65	4.56

Based on analysis of variance grain yield of food barley significantly affected over location by organic and in organic fertilize (Table 2). The anova showed that biological yield was significantly influenced by the treatments.

Table 2. *ANOV table of different means of food barley.*

Source of variation	DF	GY	AGBM	1000SW	HI (%)	PH	SpiL	SPS	Tilpp
In-organic fertilizer	4	**	**	**	**	**	**	**	ns
Location	2	ns	ns	ns	ns	ns	*	ns	ns
Organic fertilizer	3	*	*	ns	ns	*	*	ns	ns
IOF.Location	8	*	*	ns	ns	*	ns	ns	*
IOF.OF	12	**	*	ns	ns	*	ns	ns	ns
Location.OF	6	*	*	ns	ns	*	ns	ns	ns
IOF.Location.OF	24	*	ns	ns	ns	*	ms	ns	ns

IOF=inorganic fertilizer, OF=Organic fertilizer, * significant difference, ** highly significant difference, ns= non-significant difference

3.2. Thousand Grain Weight (gm)

Integrated decomposed cattle manure and blended NPS fertilizer significantly (P<0.05) affected thousand seed weight of food barley in Gedo, Arjo and Shambu. The mean thousand seed weight 46.96gm was recorded on the treatment which received 6tone/ha of decomposed cattle manure and 25% recommended of in organic fertilizer that followed by the treatment combination of 3tone and 100% of in organic fertilizer which statistically at par with other treatments. The lowest thousand seed weight mean was recorded from the treatment combination of 9tone and 25% of in organic fertilizer.

Table 3. Interaction effect of NPSB blended fertilizer and cattle manure on 1000SW (gm) of food barley in Gedo, Shambu and Arjo.

Cattlemanure (tone/ha)	Inorganic fertilizer (% of recommendation)				
	0	25	50	75	100
0	43.34 ab	44.89 ab	43.08 b	43.95ab	44.11ab
3	44.85ab	43.33ab	44.47ab	42.94 b	45.19 ab
6	44.11 ab	46.96 a	43.41ab	43.81 ab	44.48 ab
9	43.61 ab	42.14 b	44.92 ab	44.59 ab	44.29ab
CV (%)		10.7			
F-prob		*			

* Significant difference, CV = coefficient of variation

3.3. Harvest Index (%)

The ANOVA result showed that harvest index significantly (P<0.05) not affected by integrated decomposed cattle manure and in organic fertilizer in Gedo, Arjo and Shambu. The mean harvest index was statistically at par for all treatments treated by integrated decomposed cattle manure and inorganic fertilizer. This result is not agreed with the result reported by [17] in Holeta and Robgabiye in Welmera Worada. The result they reported depicted mean of harvest index (p<0.05) affected by integrated organic fertilizer and in organic fertilizer.

Table 4. Interaction effect of NPSB blended fertilizer and cattle manure on harvest index (%) of food barley in Gedo, Shambu and Arjo.

Cattlemanure (tone/ha)	Inorganic fertilizer (% of recommendation)				
	0	25	50	75	100
0	34.89	33.86	37.21	32.90	33.45
3	40.66	33.32	35.15	31.12	30.73
6	27.94	33.15	30.83	33.49	34.33
9	31.29	35.84	35.01	34.39	32.91
CV (%)		47.3			
F-prob		Ns			

Ns= non-significant difference

3.4. Plant Height

The analysis of variance showed that the interaction of decomposed cattle manure and in organic fertilizer significantly ($p<0.05$) affected plant height of food barley. The longest plant height 89.81cm was recorded from the integration of 3tone/ha decomposed cattle manure and 100% recommended inorganic fertilizer followed by the plot treated by 9tone/ha and 100% recommended inorganic fertilizer which gave 89.70cm statistically at par with the former. The lowest plant height 75.46cm was recorded on control plot. The result showed that massive mean of treatments was statistically at par when difference in magnitude was recorded. This finding agrees with the finding of (Arzu Mutlu. 2020) increasing inorganic fertilizer and cattle manure boosts plant height that the cause for yield boosting. This finding also in line with the prevouse research finding integrated organic and in organic fertilizer improve grain yield as well as affected plant height positively in food barley [3].

Table 5. Interaction effect of NPSB blended fertilizer and cattle manure on plant height of food barley in Gedo, Shambu and Arjo.

Cattle manure (tone/ha)	Inorganic fertilizer (% of recommended)				
	0	25	50	75	100
0	75.46 g	79.68efg	85.28 abcdef	86.99 abcde	89.58 a
3	78.11 fg	80.46defg	83.29 abcdef	89.42 ab	89.81 a
6	81.83bdefg	78.73fg	84.43abcdef	89.38abc	89.58 a
9	81.01 defg	80.20defg	84.49abcdef	87.68 abcd	89.70 a
CV (%)		11.7			
F-prob		*			

*Significant difference, CV = coefficient of variation

3.5. Seed Per Spike

The analysis of variance showed that the integrated decomposed cattle manure and in organic blended fertilizer significantly ($p<0.05$) not affected the mean of number of seed per spike. All the means of the treatments statistically at par. The only magnitude difference was observed among treatment means. This finding is not coincided with the finding of [17] the application of organic and in organic fertilizer significantly influenced the number of seed per spike. But the result coincided with the result of (Saeideh Maleki Farahani and Mohammad [11] in organic and organic fertilizer not affected the number of grains per spice.

Table 6. Interaction effect of NPSB blended fertilizer and cattle manure on seed per spike of food barley in Gedo, Shambu and Arjo.

Cattlemanure (tone/ha)	Inorganic fertilizer (% of recommended)				
	0	25	50	75	100
0	46.92	45.87	45.07	46.37	46.26
3	44.69	44.82	45.10	47.04	46.38
6	45.31	45.92	46.28	43.96	44.02
9	44.63	44.44	46.36	45.54	44.79
CV (%)		15.6			
F-prob		Ns			

Ns= non-significant difference

3.6. Spike Length

The anova showed that the integrated decomposed cattle manure and in organic blended fertilizer significantly ($p<0.05$) not affected the mean of number of seed per spike. All the means of the treatments statistically at par. The only magnitude difference was observed among treatment means. This finding is not coincided with the finding of [3] the application of organic and in organic fertilizer significantly influenced the number of seed per spike.

Table 7. Interaction effect of NPSB blended fertilizer and cattle manure on spike length of food barley in Gedo, Shambu and Arjo.

Cattle manure (tone/ha)	Inorganic fertilizer (% of recommendation)				
	0	25	50	75	100
0	7.056	6.833	6.611	6.933	6.589
3	6.978	6.900	6.600	6.756	6.778
6	6.878	7.000	6.967	6.900	6.778
9	7.056	6.967	6.822	6.822	6.844
CV (%)		13.6			
F-prob		Ns			

Ns= non-significant difference

3.7. Tiller Per Plant

Significant variation was not observed among treatment means on tillers per plant by application of integrated decomposed cattle manure and in organic fertilizer. The treatments mean were statisticaly at par except the difference in magnitude (Table 8).

Table 8. Interaction effect of NPSB blended fertilizer and cattle manure on tiller per plant of food barley in Gedo, Shambu and Arjo.

Cattle manure (tone/ha)	Inorganic fertilizer (% of recommendation)				
	0	25	50	75	100
0	4.722	5.000	4.939	4.533	5.289
3	4.839	4.800	5.033	5.278	5.422
6	5.094	4.478	4.594	5.311	4.967
9	5.089	5.033	4.694	5.067	5.322
CV (%)		24.8			
F-prob		Ns			

Ns= non-significant difference

3.8. Biological Yield

The analysis of variance showed that the integrated decomposed cattle manure and in organic fertilizer significantly ($P<0.05$) affected the biological yield of food barley form the pooled data analysis. The highest biological yield 7650kg/ha was collected from the plot treated by the highest amount of cattle manure integrated with 100% recommended in organic fertilizer followed by the plot treated 6tone/ha of decomposed cattle manure and 100% recommended inorganic fertilizer which gave 7194kg/ha. The lowest biological yield 3547kg/ha was harvested from the control plot. This result agrees with the finding that supported in organic fertilizer with cattle manure improve dry bio mass of food barley. The result reported by [9] also coincided with this result that application of in organic fertilizer and organic fertilizer drastically increased grain yield as well as dry bio mass of food barley.

Table 9. Interaction effect of NPSB blended fertilizer and cattle manure on biological yield of food barley in Gedo, Shambu and Arjo.

Cattlemanure (tone/ha)	Inorganic fertilizer (% of recommendation)				
	0	25	50	75	100
0	3791 hi	4736 ghi	6019bcdefg	6709 abcde	6809 abcd
3	3547i	5150 efgh	5848 bcdefg	6389 abcdef	7179 ab
6	4939 fghi	5591 cdefg	5256defg	7044 abc	7194 ab
9	5179efgh	5575 cdefg	5691 bcdefg	6553 abcde	7650 a
CV (%)		34.4			
F-prob		*			

*Significant difference, CV = coefficient of variation

3.9. Grain Yield (Hectare)

The result show that there was significant difference among treatments (P=0.05) statistical level of significance. The heist amount of grain yield 2665kg/ha was harvested from the plot treated with 100% inorganic fertilizer combined with 3tone decomposed cattle manure that followed by the plot treated with 9tone and 100% recommendation of the area. The lowest amount of grain yield 1244kg/ha was collected from the control plot treated without any organic and in organic fertilizer. This result is coincided with the idea of Tamado Tana and Mitiku Woldesenbet that as in organic fertilizer combined with full recommendation, the yield increament will be happened [10]. [17] also agee with this result that integrated nutrient management improves food barley yields.

Table 10. Interaction effect of NPSB blended fertilizer and cattle manure on yield of food barley in Gedo, Shambu and Arjo.

Cattlemanure (tone/ha)	Inorganic fertilizer (% of recommended)				
	0	25	50	75	100
0	1244f	1684 ef	2003 bcde	2212 abcd	2368 abc
3	1659 ef	1897 cde	1900cde	2289abcd	2665a
6	1567 ef	1889cde	1923 cde	2357abc	2341abc
9	1797 de	1929cde	2359 abc	2372 abc	2494 ab
CV (%)		32.1			
F-prob		*			

*Significant difference, CV = coefficient of variation

4. Partial Budget Analysis

The economics different treatments in (table) indicated that the application of 9tone/ha decomposed cattle manure and 50% recommendation of in organic fertilizer showed the treatment that gave 91124 Birr net profit and MRR of 1482%. The integration of 3tone/ha and 100% recommendation of in organic fertilizer which gave 101628 Birr net profit with MRR of 605%. It was evident that integration of decomposed cattle manure and in organic fertilizer is profitable in west region of Ethiopia.

Table 11. Partial budget analysis.

Number	Cattle manure (tone/ha)	NPS and Urea (kg/ha)	Grain yield	Gross Return	Total cost	Net profit	DA	MRR (%)
1	0	0	1244	49760	0	49760		
2	3	0	1659	66360	300	66060		54.33333
3	6	0	1567	62680	600	62080	D	
4	9	0	1797	71880	900	70980		8.2
5	0	25	1684	67360	1168	66192	D	
6	3	25	1897	75880	1468	74412		6.042254
7	6	25	1889	75560	1768	73792	D	
8	9	25	1929	77160	2068	75092		1.133333
9	0	50	2003	80120	2336	77784		10.04478
10	3	50	1900	76000	2636	73364	D	

Number	Cattle manure (tone/ha)	NPS and Urea (kg/ha)	Grain yield	Gross Return	Total cost	Net profit	DA	MRR (%)
11	6	50	1923	76920	2936	73984	D	
12	9	50	2359	94360	3236	91124		14.82222
13	0	75	2212	88480	3504	84976	D	
14	3	75	2289	91560	3804	87756	D	
15	6	75	2357	94280	4104	90176	D	
16	9	75	2372	94880	4404	90476	D	
17	0	100	2368	94720	4672	90048	D	
18	3	100	2665	106600	4972	101628		6.050691
19	6	100	2341	93640	5472	88168	D	
20	9	100	2494	99760	5572	94188	D	

5. Conclusions and Recommendation

From the experiment it can be concluded integrated of cattle manure and in organic NPS blended fertilizer significantly affect the yield and biological yield of food barley in Gedo, Shambu and Arjo. Some parameters also significantly influenced by integrated cattle manure and in organic fertilizer at the study area. The highest gran yield 2665kg/ha with 605% MRR was harvested from the plot received 125kg/ha NPS and 76kg/ha Urea integrated with three tone per hectare of cattle manure and the good yield and economically feasible treatment was integration of 50% NPS and urea recommendation and 9tone/ha cattle manure which give 2359kg/ha grain yield that can be calculated 91124birr local market with MRR= 1482%. Therefore, the farmers of the area are advised to use the above 50% of in organic fertilizer and 9tone/ha of decomposed cattle manure that boost the yield of food barley considering yield together with soil fertility improvement.

Abbreviations

DF	Degree of Freedom
GY	Grain Yield
AGBM	Above Ground Biomass
1000SW	Thousand Seed Weight
HI (%)	Harvest Index in Percent
SpiL	Spick Length
Ph	Plant Height
SpiL	Spicke Length
SPS	Seed Per Spicke
Tilpp	Tiller Per Plant
CV	Coefficient of Variation
OF	Organic Fertilizer
IOF	Inorganic Fertilizer
Ns	Non-significant Difference
MRR	Marginal Rate of Return
DA	Dominancy Analysis

Author Contributions

Fufa Anbessa: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Hilu Feyisa: Data curation, Formal Analysis, Methodology, Software

Galata Garama: Validation, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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