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Research Article

Effects of Integrated Decomposed Cattle Manure and Blended (NPSB) Inorganic Fertilizer on Yield and Yield Components of Finger Millet (*Eleusine Coracana* (L) *Gaertn*.) in West Region of Ethiopia

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Abstract

Finger millet (Eleusine coracana L.) is major food crop of semi-aid of tropics of Africa and Asia which is indigenous to Ethiopia. The experiment was conducted in western part of Ethiopia Bako, B/Boshe and Gute in 2020-2022 cropping season with the objective of identifying the optimum and economically feasible integrated decomposed cattle manure and in-organic fertilizer for finger millet production in western part of Ethiopia. The experiment contains five level of in organic fertilizer 0, 25%, 50%, 75% and 100% of recommended inorganic fertilizer and four level of decomposed cattle manure 0, 3tone/ha, 6tone/ha and 9tone/ha combined in factorial arrangement in RCBD design. The integrated fertilizer affected grain yield, dry biomass, ear length, harvest index, effective tillers per plant, number of fingers per plant and plant height. The highest grain yield 2546kg/ha was observed on integration of 100% and 9tone/ha when 2195kg/ha from the integration of 6tone/ha and 75% recommended fertilizer. The number of effective tillers per plant was not affected by the fertilizer. In economic analysis both integration of 100% with 9ton and 75% with 6tone/ha were economically feasible having 758 and 998 MRR respectively. Using 75% recommended fertilizer and 6tone/hectare is more economical. Therefore, it is advisable for farmers using the integration of 6tone/ha and 75% recommended inorganic fertilizer.

Keywords

In Organic, Fertilizer, Organic, Soil, Finger Millet

1. Introduction

Finger millet (*Eleusine coracana* L.) is a major food crop of the semi-arid tropics of Asia and Africa and has been an indispensable component of dry land farming systems [10]. It is an indigenous important cereal crop in Ethiopia ranking sixth in total production and covers 399,267.00 hectares with average productivity of 1.3t ha^{-1} and most of the finger millet varieties grown in Ethiopia are landraces consisting of a large number of different genetic lines [1]. Ethiopia is one of the major producers of finger millet in addition to Uganda, India, Nepal and China and it is also native to the highlands of the country. Finger mille plays an important role in both the dietary needs and incomes of many rural households like other

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African countries due to its richness in fiber, iron and calcium [3].

The yields of finger millet are low in Ethiopia due to different production factors including: lack of improved varieties, little research emphasis given to the crop, non-adoption of improved technologies, poor attitude to the crop, disease like blast which is the most serious disease, lodging and moisture stress in dry areas, threshing and milling problem are some of the most serious production constraints in Finger millet production in Ethiopia. Fertilizer is the most production constraint of finger millet in declined soil fertility and acidified soils in western part of Ethiopia [9, 11].

It is reported that integrated nutrient supply system helps in maintenance and improvement of soil fertility for sustaining crop productivity on long term basis. Good quality farm yard manure and vermicompost are perhaps the most valuable organic manures to improve the yield and other soil properties [17]. The low yield of cereals in the Entisols under rain-fed conditions mainly attributed to poor nutrient status of soil, limited use of nitrogenous fertilizers either through organics or chemical sources coupled with insufficient moisture during crop growth period. [14]. This experiment was initiated to alleviate the problem of yield reduction in western region of Ethiopia due to nutrient problem of the soil by integrating organic and in organic fertilizer for increasing yield of finger millet.

2. Objective

To identify and recommend the optimum and economically feasible integrated cattle manure and in-organic fertilizer for finger millet production at the study area.

3. Materials and Methods

3.1. Experimental Site

The experiment was conducted in west region of Ethiopia Bako and Gute which found at 9º 06' N and 37º 09'E and 9' and latitude and longitude respectively. The study areas Bako and Gute are far away about 260km and 320km in the west direction of Addis Ababa respectively. Both are in mid-altitudes about 1650m.a.s.l. and 1880 m.a.s.l and Rain fed agriculture is most popular in the areas as they receive an inconsistent rainfall (1220 mm/annum) and (1220 mm/annum) throughout the crop growing season (Mekonnen, 2018). The rain fall starts at the mid of April and ceases by the end of September and sometimes extends up to mid-October or early November. Maximum rainfall is usually received in June to October. The average temperature of Bako is 21.7^{0}C while that of Gute is 20.2. The dominant soil texture of the research area was clay soil.

3.2. Experimental Design and Crop Management

In the experiment the popular variety Addis-01, Blended NPSB and well decomposed cattle manure was used. Five levels of blended NPSB and Urea 0, 25%, 50%rec, 75% and rec100% of recommendation of the research area combined with four levels of well decomposed cattle manure 0,3ton, 6ton and 9ton ha^{-1} was used in factorial arrangement in randomized complete block design with three replications. The recommended fertilizer rate for the area was 100kg NPS and 90kg urea with the mechanical mixture of 6kg borax fertilizer. Recommended seed rate for the variety Addis-01 that 15kg ha^{-1} was used. Six rows for each plot that accommodate the plot size 2.5mx2.4m. Each treatment was allocated to the plots randomly using electronic randomization system. The plots in the block were separated by 1m while the blocks were separated by 1.5m for the case of pass way and reject the mechanical mixture. Nitrogen was applied in split form half at planting and the rest half after removal of first weed on 35th day after planting. The water and soil erosion control were done using ditches among blocks and on the top side of the experimental field.

3.3. Soil Sampling and Preparation

Prior to the field experimentation, ten random samples (0-20cm depth) were collected and a composite soil sample was prepared in the laboratory. These composite samples were used for soil physical and chemical analysis. Similarly, post crop harvest soil samples were collected plot-wise from each replication from the surface 0-20 cm depth and composite per treatment for selected soil chemical analysis. The soil samples were oven dried, sieved to pass through 2 mm sieve, and placed in labeled plastic bags.

3.4. Data Collection and Statistical Analysis

All agronomic and soil data were collected using the international data collecting standard. The Central row plants were used for data collection rejecting the border effect. Growth indicating parameters such as plant height, number of effective and non-effective tillers, and biological yield, and ear length, number of ears per plant and grain yield was collected. The plant height was measured from the base of the plant to upper the top most leaves of the plant. The data was taken from five randomly selected plants and the average value was computed. The grain yield from the middle four rows was recorded and then converted to hectare basis. Analysis of variance was carried out for the yield studied following statistical procedures appropriate for the experimental design using GenStat 18 version computer software. Whenever treatment effects were significant, the means was separated using the least significant difference (LSD) procedures test at 5% level of significance.

3.5. Laboratory Analyses

The soil samples were oven-dried and ground to pass 2- and 0.5-mm sieves (for total N). All samples were analyzed following standard laboratory procedures [16]. Organic carbon, total N contents of the soil was determined following the wet combustion method of Walkley and Black, and wet digestion procedure of Kjeldahl method, respectively. The available P content of the soil was determined following Olsen method. Soil texture was analyzed by Bouyoucos hydrometer method. The pH (1:2.5 solid: liquid ratio) of the soils was measured in water using pH meter with glass calomel combination electrode.

3.6. Economic Analysis

Economic analysis was performed to investigate the economic feasibility of the treatments. A partial budget, dominance and marginal analysis was used to identify the economical feasible treatment for the farmers. The average yield was adjusted down wards to reflect the difference between the experimental plot yield and the yield farmers were expecting from the same treatment. The average open market price (Birr kg-1) for finger millet and the official prices of N and P fertilizers and the cost of cattle manure transportation was used for analysis.

4. Result and Discussion

4.1. Soil Physico-chemical Properties of the Experimental Site Pre-planting

The results of pre-planting soil analysis depict that the soil textural class clay loam at Bako and clay at Billo Boshe with acidified or 4.75 and 4.85 pH respectively that may affect the crop growth of the research area. Organic carbon contents of sites are low that 2.11% and 2.93 respectively. The amount of organic carbon in the soil indicated the soil quality of that area. Organic matter and soil organic carbon is positively correlated and soil of B/Boshe contain more organic matter then that of Bako. The soil of Bako contains about 0.16% of TN when that of B/Boshe contains 0.25% the areas of both sites capable of low containing both total nitrogen and available phosphorus.

Table 1. Pre-plant soil properties of Bako and B/Boshe.

Number	Parameters	Bako	B/Boshe
1	pH	4.85	4.75
2	%OC	2.11	2.93
3	%OM	3.29	5.04
4	%TN	0.16	0.25
5	avaP (ppm)	7.2	5.2
6	Ex. Ca (cmol/kg soil	5.5	10
7	Ex.Mg (cmol/kg soil)	4.5	2
8	CEC (cmol/kg soil)	18.75	18
9	Ex.k (cmol(+)/kg soil	0.94	0.90
10	Sand	48	42
11	Clay	39	45
12	Silt	13	13
13	Textural class	Clay loam	Clay

4.2. Ear Length

The analysis of variance revealed there was statistically significant difference among treatments mean concerning ear length of finger millet. The longest ear 6.267cm was recorded from the plot treated with 50% recommendation of in organic fertilizer and 3tone/ha of decomposed cattle manure followed by the treatment received 3tone/ha of decomposed cattle manure and 75% recommendation of in organic fertilizer which gave 6.167cm ear length. The shortest ear length of the treatments was recorded from the treatment that was treated by 0 inorganic fertilizer recommendation and 6tone/ha of decomposed cattle manure that 5.467cm was recorded from it. This result is similar with the result reported by [5] that the nutrient management significantly influenced ear length of finger millet and nutrient management that the increased nutrient highly increased ear length of finger millet. The finding was coincided with the finding of [6] the organic and inorganic fertilizer influenced ear length significantly

Table 2. Interaction effect of NPSB blended fertilizer and cattle manure on ear length of finger millet in Bako and B/Boshe.

Cattle manure (tone/ha)	In organic fertilizer				
	0	25	50	75	100
0	6.100ab	5.900abc	6.017abc	5.733abc	5.833abc
3	5.817abc	5.783abc	6.267a	5.900abc	6.233ab
6	5.467c	5.800abc	5.917abc	6.167ab	5.967abc

Cattle manure (tone/ha)	In organic fertilizer				
	0	25	50	75	100
9	5.667bc	5.933abc	5.833abc	5.933abc	5.917abc
CV (%)		10.0			
F-prob		*			

4.3. Harvest Index of Finger Millet

The analysis of variance revealed there was highly significant difference among treatments concerning harvest index (Table 5). The maximum harvest index 47.42% was recorded on the plot treated with integrated 100% recommendation of inorganic fertilizer and 6tone/ha decomposed cattle manure followed by the control treatment from which 43.5% was recorded. The lowest harvest index 27.93% was recorded from the plot received 0 inorganic fertilizer and 9tone/ha decomposed cattle manure. This result agreed with the result reported by [5, 8] harvest index was not influenced by fertilizer.

Table 3. *Interaction effect of NPSB blended fertilizer and cattle manure on harvest index of finger millet in Bako and B/Boshe.*

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
0	43.52ab	37.60abcd	42.14abc	34.10 bcd	30.95cd
3	35.97abcd	31.29bcd	34.70bcd	32.61bcd	31.49bcd
6	31.36bcd	36.09abcd	32.59bcd	34.12 bcd	47.42a
9	27.93d	35.11bcd	34.84bcd	40.12abcd	42.53abc
CV (%)		34.7			
F-prob		*			

*=significant difference, CV=coefficient of variation.

4.4. Number of Effective Tillers per Plant

Statistically significant difference was observed among treatments due to the integration of in organic fertilizer and decomposed cattle manure (Table 6). The average highest number of tillers per plant 2 was observed from control followed by the treatment received 100% inorganic fertilizer and 6tone decomposed cattle manure from which 1.933 was recorded. The least number 1.258 was recorded from the treatment received maximum both organic and in organic fertilizer and some treatments were at par.

Table 4. *Interaction effect of NPSB blended fertilizer and cattle manure on number of effective tiller per plant of finger millet in Bako and B/Boshe.*

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
0	2.000a	1.217c	1.200c	1.150c	1.500abc
3	1.733abc	1.383bc	1.550abc	1.433abc	1.567abc

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
6	1.650abc	1.433abc	1.483abc	1.267c	1.933ab
9	1.667abc	1.517abc	1.317c	1.317c	1.258c
CV (%)		41.5			
F-prob		*			

*=significant difference, CV=coefficient of variation.

4.5. Number of Fingers per Plant

Analysis of variance revealed there was statistically significant difference among treatments due to the effect integrated in organic fertilizer and decomposed cattle manure (Table 7). The highest average number of fingers per plant was recorded from the integration of 9tone/ha decomposed cattle manure and 75% recommendation of in organic fertilizer followed by the treatment treated with the integrated decomposed 9tone/ha and 100% recommended inorganic fertilizer from which 5.500 was recorded. The lowest number of fingers per plant 4.00 was recorded from the integration of 0 in organic fertilizer and 3tone/ha decomposed cattle manure and some treatments statistically at par. The result was aligned with the finding of [2] the number of fingers per plant significantly affected by the variable nutrients. It also agrees with the finding of [18] the number of fingers significantly influenced by the level of fertilizer [15].

Table 5. *Interaction effect of NPSB blended fertilizer and cattle manure on number of fingers on finger millet in Bako and B/Boshe.*

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
0	4.717bcde	4.950abcd	4.850abcde	5.100abcd	4.350de
3	4.500cde	4.533cde	5.217abcd	5.450ab	5.375abc
6	4.033e	4.700bcde	5.017abcd	5.367abc	5.117abcd
9	4.650bcde	4.833abcde	5.083abcd	5.617a	5.500ab
CV (%)		18.1			
F-prob		*			

4.6. Number of Non-effective Tillers Per Plant

Analysis of variance revealed that there was no ($p<0.05$) significant difference among treatments because of application of integrated decomposed cattle manure and in organic fertilizer concerning non-effective tillers per plant (Table 8).

Table 6. *Interaction effect of NPSB blended fertilizer and cattle manure on non-effective tiller of finger millet in Bako and B/Boshe.*

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
0	0.5833	0.3833	0.3500	0.2833	0.3000
3	0.5333	0.4667	0.2500	0.3500	0.4667

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
6	0.5417	0.4333	0.4167	0.4667	0.3167
9	0.4833	0.6000	0.3000	0.4500	0.2500
CV (%)		82.9			
F-prob		Ns			

*=significant difference, CV=coefficient of variation, ns=non-significant difference.

4.7. Plant Height

The plant height of finger millet significantly (P<0.05) affected by the application of integrated decomposed organic fertilizer and in organic fertilizer (Table 9). The highest plant height 81.53cm was recorded on the plot received 9tone/ha decomposed cattle manure and 75% in organic fertilizer followed by the plot treated with the integration of 3tone/ha decomposed cattle manure and 75% in organic fertilizer. The lowest plant height was recorded from the plot received 0 the integration of 0 inorganic fertilizer and 9tone/ha decomposed cattle manure. This may relate with the nutrient which initiates plant growth. This finding is not agreed with the finding of [12, 13] that the pooled data of 2015 and 2016 searched on integrated nutrient not showed difference amongst treatments. But the finding was in line with the finding of [14] that the plant height was significantly respond to the integrated nutrient applications.

Table 7. *Interaction effect of NPSB blended fertilizer and cattle manure on plant height of finger millet in Bako and B/Boshe.*

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
0	62.24 def	69.53 bcde	71.10 abcd	75.42 abc	65.12cdef
3	60.37 ef	65.20 cdef	75.05abc	76.33 ab	72.70 abc
6	62.24def	69.10 bcdef	73.63 abc	76.12 ab	72.82abc
9	58.95 f	67.12 bcdef	75.02abc	81.53 a	74.83 abc
CV (%)		15.8			
F-prob		0.748			

4.8. Dry Biomass Yield

Application of integrated in organic and decomposed cattle manure significantly (p<0.01) affected biological yield of finger millet. The highest biological yield 7091kg/ha which statistically at par with integrated 75% with 0 and 3tone decomposed cattle manure was harvested from the plot treated with the integration of 9tone/ha and 100% of recommended inorganic fertilizer followed by 6624kg/ha which harvested from the plot treated with 6tone/ha decomposed cattle manure and 75% inorganic fertilizer. The result is in line with the result reported by [19]. which after harvesting soya bean and planting finger millet and Appling more farm yard manure, the amount of biomass yield was increased [4]. The result also agreed with the result of [4] that the increament of application of organic and in organic fertilizer, biological yield was significantly increased.

Table 8. Interaction effect of NPSB blended fertilizer and cattle manure on Biomass yield of finger millet in Bako and B/Boshe.

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
0	3904 fgh	4889 defg	5042 def	6739 ab	5218 de
3	3780gh	5467 de	4817 defg	6769 ab	4881 defg
6	4515efgh	5573 cde	5067 def	6624 abc	4800 defg
9	3450 h	5298 de	5818 bcd	5964 bcd	7091a
CV (%)		23.5			
F-prob		**			

*=significant difference, CV=coefficient of variation.

4.9. Grain Yield

The result show that the interaction effect of in organic fertilizer and decomposed cattle manure as was the main effects affected grain yield of finger millet significantly at significance level of (p 0.01) (Table 2). The highest grain yield 2546kg/ha was harvested from the plot treated with the integration of 9tone/ha decomposed cattle manure and full recommended in organic fertilizer 100kg/ha NPSB and 90kg/ha urea followed by the plot received 6tone/ha decomposed cattle manure and 75% in organic fertilizer recommendation that gave 2195kg/ha (Table 1). The lowest amount of grain yield 928kg/ha was harvested from the plot received 9tone/ha decomposed cattle manure. The anova reviled some treatments are statistically at par and the difference is the magnitude. This yield increament by this treatment may related to the nutrient optimization and soil chemical and physical property improvement by the fertilizer [7]. Therefore, this finding agrees with the finding of [18] that evaluation of some varieties with rate of fertilizer significantly influenced grain yield. [11] also agree with this finding that the difference of fertilizer influenced finger millet grain yields.

Table 9. Interaction effect of NPSB blended fertilizer and cattle manure on yield of finger millet in Bako and B/Boshe.

Cattle manure (tone/ha)	In organic fertilizer in (%) recommended				
	0	25	50	75	100
0	1544efg	1688 de	2040 bc	2076 bc	1371 fg
3	1294 g	1648def	1526 efg	2024 bc	1375 fg
6	1333 g	1513 efg	1430 efg	2195 b	1716 de
9	928h	1581defg	1855 cd	2087 bc	2546 a
CV (%)		18.3			
F-prob		**			

**=highly significant difference, *=significant difference, CV=coefficient of variation.

5. Partial Budget Analysis

The analyzed data indicated that cost of cultivation, gross profit, net profit and partial budget were significantly influenced by the treatments. The highest gross profit and economically feasible treatment that 147260 ET birr and 2546kg/ha gross return was estimated form the treatment integration of 100% in organic fertilizer and 9tone/ha of decomposed cattle manure. This treatment showed acceptable and higher MRR was recorded and this treatment is the most profitable of other treatments compared with this treatment.

Farmers of the study area are advised to use integrated in organic and decomposed cattle manure at the level of 9tone/ha with 100 kg/ha NPS and 90kg/ha Uerea. This finding should not be the final and it need further study.

Table 10. Profitability of the treatments.

Cattle manure tone/hectare	Recommended fertilizer (%)/hectare	Grain Yield	Growth profit	Total cost	Net profit	Dominance analysis	Marginal rate of return
0	0	1544	92640	0	92640		
3	0	1294	77640	300	77340	D	
6	0	1333	79980	600	79380	D	
9	0	928	55680	900	54780	D	
0	25	1688	101280	1150	100130		6.51
3	25	1648	98880	1450	97430	D	
6	25	1513	90780	1750	89030	D	
9	25	1581	94860	2050	92810	D	
0	50	2040	122400	2300	120100		17.36
0	75	2076	124560	2400	122160		26.03
3	50	1526	91560	2600	88960	D	
3	75	2024	121440	2750	118690	D	
6	50	1430	85800	2900	82900	D	
6	75	2195	131700	3050	128650		9.98
9	50	1855	111300	3200	108100	D	
9	75	2087	125220	3350	121870	D	
0	100	1371	82260	4600	77660	D	
3	100	1375	82500	4900	77600	D	
6	100	1716	102960	5200	97760	D	
9	100	2546	152760	5500	147260		7.59

6. Conclusion and Recommendations

The present study showed integrated decomposed cattle manure and in organic fertilizer application influenced grain yield of finger millet. The treatment 100% recommended in organic fertilizer and 9tone/ha decomposed cattle manure significantly changed the grain yield of finger millet and 2546kg/ha was found from this treatment with profitable money value 147260 ETB. The biological yield of finger millet also influenced by integration of cattle manure and in organic fertilizer. The integration of 6tone/ha decomposed cattle manure and 75% inorganic recommended fertilizer gave 2195kg/ha and 998 MRR good economic meaning then the dominated treatments. The farmers of the area advised to use the application of 6tone/ha decomposed cattle manure and 75% of recommended inorganic fertilizer that 75kg/ha NPSB and 67kg/ha urea for their finger millet production in Bako and B/Boshe.

Abbreviations

OC	Organic Carbon
OM	Organic Matter
TN	Total Nitrogen
AVA.p	Available Phosphorus
Ex.Ca	Exchangeable Calcium
Ex.Mg	Echangeable Calcium
CEC	Excation Exchange Capacity
Ex.K	Echangeable Potacium

CV Cofficint of Variation

Conflicts of Interest

The authors declare no conflicts of interest.

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