

The Effects of Green Manures Integrated with In-Organic Fertilizer on Yield of Bread Wheat [Triticum Aestivum] in Middle Awash, Ethiopia

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Abstract
Green manures integrated with inorganic fertilizers are well known for improving productive capacity of soil and rehabilitation of the degraded farm lands. An experiment was conducted during 2016 -2018 at Fentale woreda, Oromia region and Amibara woreda, Afar region; to evaluate the integrated effect of green manures with nitrogen fertilizer rates and identify appropriate forage legumes for green manure. Randomized complete block design was employed with three replications. Three forage legumes: Alfalfa (Medicago sativa), Cowpea (Vigna unguiculata) and Lablab (Lablab purpureus) in factorial arrangement with four levels of nitrogen fertilizer (0, 11.5, 23, and 34.5 kg ha^{-1} N); while, 46 kg ha^{-1} of nitrogen fertilizer was applied as a control. Pre-sowing and after harvest soil samples were collected and analyzed following the standard procedures. Twenty one days prior to wheat seed sowing, the forages were harvested at early flowering stage, chopped and incorporated in to the soil; while, 100 g of the fresh field weight was took for laboratory analysis. Wheat grain yield and other parameters were subjected to analysis of variance using SAS software. The analysis of variance revealed that, year, location and treatment effects were significant ($P < 0.001$). The highest mean grain yields (3079.87, 3015.99, 3000.16, and 2964.79 kg ha^{-1}) were recorded at 34.5 kg ha^{-1} N + Alfalfa, 34.5 kg ha^{-1} N + Lablab, 23 kg ha^{-1} N + Lablab, 11.5 kg ha^{-1} N + Alfalfa) respectively. As a result, Alfalfa or Lablab integrated with 34.5, 23, and 11.5 kg ha^{-1} nitrogen fertilizer were suggested as alternative management options.
Keywords/Phrases: bread-wheat, fertility, green manures, integrated, middle awash, nitrogen fertilizer
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1. Introduction

Land degradation is one of the most challenging problems in sub-Saharan countries (Betru Nedessa *et al*., 2005; Hurni *et al.*, 2005). As Ethiopia is one of the countries exposed to this problem, land degradation plays a significant role in reducing the soil productivity (Melak Mesfin Ayenew and Kopainsky, 2014). The soil productivity potential in the country, Ethiopia, has been ought to be in question due to the depletion of soil organic matter that is caused by low productivity, excessive tillage and competing uses for biomasses (Gete Zelleke *et al*., 2010). Likewise, the productivity of the soil in Middle Awash Valley, Amibara area has been deteriorated due to irrigation water miss-management that aggravates salinity problems (Ashenafi Worku and Bobe Bedadi, 2016).

Since soil productivity cannot be improved with the sole application of either inorganic fertilizers, or organic fertilizers, integration of green manure with inorganic fertilizers are valuable in improving the soil productivity in long-term (Raju and Reddy, 2000; Bora *et al*., 2008). Integration of different types of legume forages as green manures with inorganic fertilizers can contributes a lot in improving the degraded soil by increasing its productivity (Raju and Reddy, 2000; Wakene Negassa *et al.,* 2007; Bora *et al*., 2008). Thus, this experiment was designed to evaluate the combined effect of different forage legumes as green manure and nitrogen fertilizer rates; and differentiate between appropriate forage legumes for green manure integration with nitrogen fertilizer on irrigated wheat.

2. Material and Methods

2.1. Description of the Study Areas

The experiment was conducted on one farmer's field (Serweba kebele) Fentale Woreda, Oromia region; and at Werer Agricultural Research Center on-station Hali Deba kebele, Amibara Woreda, Afar region Ethiopia during 2016/ – 2018 off-cropping seasons. The study areas are geographically located between 8°49'0" N and 9°44'0" N latitude; and 39°40'0" E and 40°20'0" E longitude (Figure 1.) with an altitude of 740 m.a.s.l. The average annual rainfall of the area is 593 mm, and the average maximum and minimum temperatures of the study areas are 34 °C and 19 °C, respectively. The dominant soil type is Fluvisols that had been deposited by alluvial deposition.

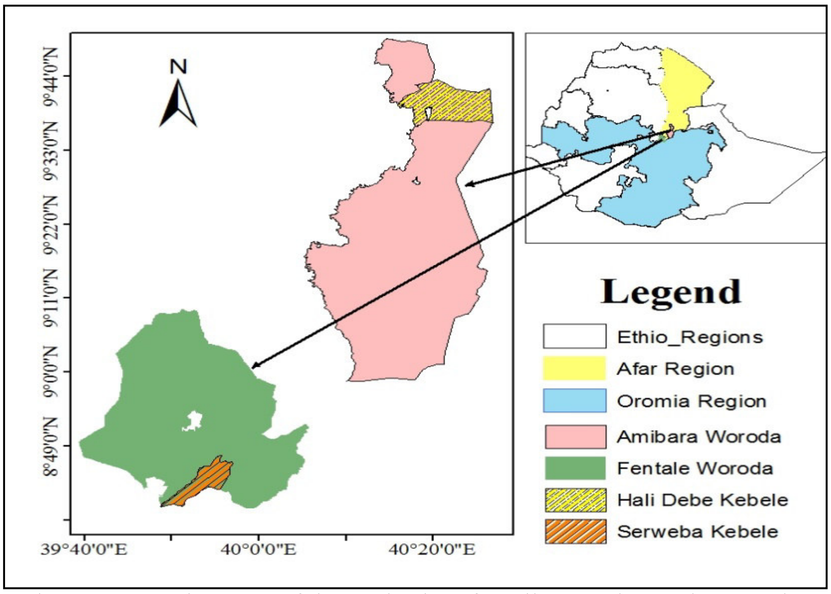

Figure 1: Location map of the study site of Amibara and Fentale Woredas

2.2. Experimental design and treatment setup

Factorial randomized complete block design was employed with three replications and 13 treatments (Table 1). Three different forage legumes (Alfa-alfa- *Medicago sativa*, Cowpea- *Vigna unguiculata* and Lablab- *Lablab purpureus*) were sown with 10cm and 40cm intra and inter row spacing respectively. These forage legumes were factorized with four different level of inorganic Nitrogen fertilizer (0, 11.5, 23, and 34.5 kg N/ha) to form 12 treatment combinations; while, 100% recommended nitrogen (46 kg/ha) was used as a control. The experimental plot size for the wheat crop was 4*3.6m (14.4m^2) with the net plot size of 2.4*3(7.2m^2). Nitrogen fertilizer was applied in two splits (1/3 at tillering and 2/3 at booting or early flowering stage).

Table 1. Treatment set up of the experiment

Treatment	Fertilizer combination
1	Alfalfa
2	Cowpea
3	Lablab
4	46 kg N/ha (Is the recommended rate)
5	11.5 kg N/ha + Alfalfa
6	11.5 kg N/ha + Cowpea
7	11.5 kg N/ha + Lablab
8	23 kg N/ha + Alfalfa
9	23 kg N/ha + Cowpea
10	23 kg N/ha + Lablab
11	34.5 kg N/ha + Alfalfa
12	34.5 kg N/ha + Cowpea
13	34.5 kg N/ha + Lablab

2.3. Data Collection and Analysis

2.3.1. Soil Sampling and Analysis

A composited soil sample was collected from the experimental plots in each study sites before planting and for each treatment after harvest at 0-30 cm soil depth. The chemical compositions of the soil samples were analyzed at the Soil Laboratory of Werer Agricultural Research Center following standard procedure. Soil pH and electrical conductivity (EC) using 1:1 soil to water ratio were measured from a solution of saturated paste extract by pH-meter (Peech, 1986). Organic matter was determined using Walkley and Black wet-oxidation method (Walkley and Black, 1934) and the total N by Kjeldahl procedure (Bremner, 1996). Available phosphorous was determined following the Olsen method (Olsen *et al.*, 1954) after extraction with sodium bicarbonate solution (pH 8.5). Based on the above soil data collection procedures, the selected soil physico-chemical properties of the experimental sites were identified before sowing. Accordingly, the textural class at Werer Agricultural Research

Center was Silty Clay Loam (Table 2); while the Fentale experimental site was Clay Loam.

Table 2: Selected soil physico-chemical properties of the study sites before sowing

Location	Textural classes	pH	EC (dS/m)	K (ppm)	A. P (mg/kg)	OM (%)	TN (%)
Werer	Silty Clay Loam	8.40	1.04	6.58	22.45	1.16	0.07
Fentale	Clay Loam	7.74	0.385	1.57	26.30	1.21	0.08

***Notes: EC** (dS/m) is Electrical conductivity; **K** (ppm) is soluble potassium, **Avail. P** (mg/kg) is available phosphorus, **OM** (%) is Organic matter and **TN** (%) is Total nitrogen.

2.3.2. Plant Sampling and Analysis

2.4.1. Legume forages dry biomass Analysis

Before plowed, three replicated 1-m^2 areas of each green manuring crop were cut at the soil surface level for the determination of aboveground dry matter yield. The roots of those sampled areas were removed from 0–30 cm soil depth, washed and weighed. Harvested herbages and roots were chopped at flowering stage and redistributed (incorporated in to the soil) in the harvested area, with the exception of the small samples that was sampled for determination of total dry biomass. Later 21 days, wheat was sown (row drilling) on the plot in the first experimental year; continued with fixed plot through the two remaining years. From the fresh field weight, 100g composite samples were taken to determine the oven-dry to wet mass ratio (Pearson *et al*., 2005). The samples were oven dried for 24 hours at 70^{o}C to take dry weight (Jina *et al*., 2008). Accordingly, total dry mass of legume forages that added before wheat seed sowing was summarized (Table 3). Legume forages dry mass (LFB) was calculated.

$$\text{LFB} = \frac{\text{W Field}}{\text{A}} * \frac{\text{W subsample(dry)}}{\text{W subsample (fresh)}} * \frac{1}{10000} \quad (1)$$

Where: - 'LFB' is legume forages dry biomass (Mg ha^{-1}). 'W field' is weight of wet field sample of legume forages sample within an area of size 1m^2 (g). 'A' is the size of the area in which forages were harvested (ha), W-subsample (dry) is the weight of the oven-dry subsample of forages (g), and 'W subsample (fresh)' is the weight of the fresh sub-sample of forages that was taken to the laboratory to determine moisture content (g).

Table 3. Average dry mass of legume forages buried in the soil before wheat seed sowing

Forage types	Average dry mass (ton/hectare)
Alfa-alfa	0.05
Cowpea	0.03
Lab-lab	0.09

2.3.3. Statistical Analysis

The wheat biomass yield, grain yields and plant height of the field experiment were subjected to analysis of variances using SAS software program version 9.0 (SAS Institute, 2003). Significant differences between treatment means was compared and separated using the least significant difference (LSD) test at 0.05 probability levels (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Soil Properties after harvest

As indicated in Table 4 below, the highest pH value was observed with 46 kg ha^{-1} N (the recommended rate) at Werer site. While, the lowest pH value was recorded from plot receive 34.5 kg ha^{-1} N + Alfalfa as a green manure treatment. Green manure showed better reduction of soil pH compared to sole application of 46 kg ha^{-1} N. However, similar trend was not observed at Fentale site. Regarding the electrical conductivity, the soil of the study site was not saline. Likewise, available potassium did not show variation between green manure and recommended N-fertilizer. Conversely, mean values of organic matter percentages found to be slightly different among plot treated with green manures and sole application of nitrogen fertilizer.

Table 4: The soil chemical properties after harvest at the two experimental sites

Trt.	pH		EC (dS/m)		K (ppm)		A. P (mg/kg)		OM (%)		TN (%)	
	WARC	Fentale	WARC	Fentale	WARC	Fentale	WARC	Fentale	WARC	Fentale	WARC	Fentale
1	7.95	7.65	0.55	0.31	3.21	0.98	23.3	22.81	1.45	1.55	0.15	0.16
2	8.01	7.33	0.61	0.28	3.79	0.52	25.6	23.62	1.2	1.24	0.14	0.15
3	8.09	7.48	0.87	0.28	6.29	0.71	20	20.81	1.27	1.23	0.19	0.18
4	8.37	7.58	0.83	0.27	5.91	0.62	32.3	21.8	1.15	1.14	0.16	0.17
5	8.1	7.36	0.59	0.31	3.6	0.98	32.3	24.83	1.52	1.53	0.16	0.17
6	8.16	7.48	1.43	0.25	11.69	0.23	25.9	28.86	1.22	1.22	0.13	0.14
7	8.1	7.54	0.84	0.23	6.01	0.23	38.5	21.72	1.27	1.28	0.18	0.17
8	8.22	7.65	1.66	0.28	18.73	0.52	27.4	21.82	1.42	1.45	0.23	0.22
9	8.07	7.55	1.32	0.28	10.63	0.71	29.5	28.88	1.31	1.38	0.23	0.24
10	8.01	7.47	0.7	0.31	4.66	0.81	21.7	22.75	1.36	1.33	0.19	0.18
11	7.28	7.72	1.08	0.47	8.32	2.33	21.1	28.87	1.56	1.57	0.25	0.24
12	8.03	7.62	1.03	0.28	7.84	0.71	20.5	29.65	1.34	1.27	0.18	0.19
13	7.94	7.51	0.69	0.35	4.56	1.18	18.8	29.87	1.34	1.29	0.22	0.21

***Notes: Trt no**. means Treatment number **pH** is potential of Hydrogen, **EC** (dS/m) is Eletrical conductivity, **K (ppm)** is soluble potassium, **Avail. P (mg/kg)** is available phosphorus, **OM (%)** is Organic matter and **TN** (%) is Total nitrogen, **WARC = Werer Agricultural Research Center**

3.2. Biomass and grain yield of wheat

The year, location and treatment effects on plant height were highly significant ($P < 0.001$) and also the interaction effects, except the year by location interaction. In terms of biomass yield, the year and year interaction with treatment were highly significant (Table 5 and 6). Additionally, year, treatment, location, year interact with location and year interact with treatment were highly significant on grain yields.

Table 5: Effects of green manure and nitrogen fertilizer on wheat grain and biomass yields

Source of variations	Parameters		
	Plant height (cm)	Biomass yield (Kg ha^{-1})	Grain yield (Kg ha^{-1})
Year	***	***	***
Location	***	Ns	***
Treatment	***	*	***
Year*Location	Ns	Ns	***
Year*Treatment	***	***	***
Location*Treatment	***	***	Ns
Year*Location*Treatment	***	***	Ns
CV (%)	4.13	15.95	7.03

*, **, = show significance at 5 and 1 % probability levels respectively, Ns =Non-significant

Table 6: Effects of nitrogen and green manure on plant height, biomass and grain yield of wheat at Werer and Fentale

Factors	Parameters		
	Plant height (cm)	Biomass yield (Kg/ha)	Grain yield (Kg /ha)
Year			
2016	85.91[a]	10669.7[a]	3102.16[a]
2017	78.92 [b]	9369.4 [b]	3095.94[a]
2018	71.11[c]	6236.9 [c]	2221.96[b]
LSD	***1.03***	***441.94***	***62.44***
Location			
Werer	83.22 [a]	8892.1[a]	3283.18 [a]
Fentale	74.07 [b]	8625.3[a]	2330.20 [b]
LSD	***0.84***	***360.84***	***50.98***
Treatment			
Alfalfa	78.35 [bcde]	7792.6 [d]	2709.06 [d]
Cowpea	78.97[abcd]	8477.2 [bcd]	2561.58 [e]
Lablab	78.53 [bcd]	8466.6 [bcd]	2530.84 [e]
46- N (recommended rate)	76.38 [e]	8790.8 [abc]	2816.27 [dc]
11.5 Kg/hac N + Alfalfa	80.09 [ab]	9461.0 [a]	2964.79 [ab]
11.5 Kg/hac N + Cowpea	77.60 [cde]	9586.7[a]	2558.02 [e]
11.5 Kg/hac N + Lablab	79.71 [abc]	8950.1 [ab]	2795.63 [dc]
23 Kg/hac N + Alfalfa	77.95 [cde]	8417.2 [bcd]	2885.80 [bc]
23 Kg/hac N + Cowpea	78.22 [bcde]	8802.1 [abc]	2877.02 [bc]
23 Kg/hac N + Lablab	80.95 [a]	7955.4 [cd]	3000.16 [ab]
34.5 Kg/hac N + Alfalfa	77.30 [de]	8918.4 [ab]	3079.87 [a]
34.5 Kg/hac N + Cowpea	77.30 [de]	9195.9 [ab]	2691.89 [d]
34.5 Kg/hac N + Lablab	81.06 a	9048.8 [ab]	3015.99 [a]
CV	***4.13***	***15.95***	***7.03***
LSD	***2.14***	***919.97***	***129.98***

Means with the same letter in each column are not significantly different at ($\alpha = 0.05$)

The highest wheat mean grain yields (3079.87 kg ha^{-1}, 3015.99 kg ha^{-1}, 3000.16 kg ha^{-1}, and 2964.79 kg ha^{-1}) were recorded at the integration of (34.5 kg ha^{-1} N + Alfalfa, 34.5 kg ha^{-1} N + Lablab, 23 kg ha^{-1} N + Lablab, 11.5 kg ha^{-1} N + Alfa-alfa) respectively (Table 5 and 6). While, the cowpea integrated with different levels of nitrogen fertilizer did not exhibit a significant grain yield advantage except the biomass yield. Other sole applications of leguminous forages had exhibited significantly lower grain yields.

The highest grain yields recorded at the plots received combination of Lablab or Alfalfa with different levels of nitrogen fertilizer than the plots received a sole application of nitrogen fertilizer might be due to the incorporated biomass of leguminous forages as green manure (Table 3) and the highest total nitrogen that recorded from plots received Lablab and Alfalfa integrated with different levels of nitrogen fertilizer at both sites (Table 4). Similar findings have confirmed this finding (Bora *et al.*, 2008; Islam *et al.*, 2015) in which highest grain yields were recorded at the integrated application of green manure and inorganic fertilizer. In other way, the insignificant grain yield recorded at cowpea integrated with different levels of nitrogen fertilizer was due to the lowest dry matter (Table 3) and lowest dry matter translocation efficiencies of cowpea (18.7%) in relation to other green manure forages (Aynehband *et al.*, 2013).

4. Conclusion and Recommendations

The result of this experiment has evaluated the combined effect of different forage legumes as green manure with N-fertilizer rates. Here, the integrated application of these plants with 34.5 kg ha^{-1} N, 23 kg ha^{-1} N and 11.5 kg ha^{-1} N-fertilizer produced higher grain yield than sole applications of nitrogen fertilizer and leguminous forages. Likewise, the application of integrated nitrogen fertilizer with cowpea (*Vigna unguiculata)* green manure also yields higher wheat biomass, though the grain yield was not satisfactory. Consequently, *Medicago sativa* and *Lablab purpureus* were found to be effective green manure leguminous forage crops when integrated with 34.5, 23, and 11.5 kg ha^{-1} nitrogen fertilizer. Therefore, one can use the alternative combination for better soil fertility management and to produce bread wheat in irrigated condition of middle awash area.

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