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RESEARCH PAPER

Effect of green manuring in combination with nitrogen on soil fertility and yield of bread wheat (*Triticum aestivum*) under double cropping system of Sinana-dinsho, Southeast Ethiopia

Taye Belachew[1*], Yifru Abera[2]

[1]Department of School of Plant Sciences, Wollo University, P.O. Box 1145 Dessie, Ethiopia

[2]Debre zeit Agricultural Research Center, P.O. Box 32, Debre zeit, Ethiopia

*Corresponding author: tabelachew@gmail.com

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Abstract

An experiment was conducted at Sinana-Dinsho from 2001 to 2003 to evaluate the short term effects of substituting vetch green manuring for fallow in '*Ganna*' season under double cropping system. Three land preparation treatments (weedy fallow, Vetch harvested and Vetch under ploughed) were used in the main plots with three nitrogen rates (0, 20.5 and 41 kg N/ha) in the subplot. After three weeks of green manuring, a slight decrease in pH and available phosphorus and an increase in organic carbon content was observed. Green manuring vetch and fallow treatments gave comparable plant height, grain yield and straw yield. But, when vetch biomass was harvested and removed at flowering stage, yield of bread wheat was reduced. However, the total farm productivity could be higher when livestock production was considered. Hence, growing forage legumes is preferable to fallowing the land.

Key words: Land preparation, forage legumes, mono-cropping, double cropping, fertility.

Introduction

Wheat is an important crop in Ethiopia. In Sub-Saharan Africa, Ethiopia is second in both wheat area and production only to South Africa (Sarah and Gemechu, 1996). Southeast Ethiopia, known for wheat belt region in East Africa where bread wheat is one of the major crop occupying the largest portion of cultivated land each season (Hailu *et al*., 1990). However, poor soil fertility, especially low levels of nitrogen and phosphorus, has been demonstrated to be a major constraint to wheat production in Ethiopia (Asnakew *et al.,* 1991). This is largely a consequence of the cereal dominated cropping history of most fields and continuous nutrient mining by crop removal (Amanuel *et al.,* 1991; Amsal *et al.,* 1997b) which eventually leads to depletion of soil nutrients (Asnakew *et al*., 1991; Tanner *et al.,* 1993).

Mono-cropping of wheat or barley is the dominant farming practice among farmers of Bale highlands. They rotate these cereals with small amount of fertilizer application irrespective of soil fertility level, owing to their low income and lack of access to use proper fertilization (Tilahun *et al.,* 2000). Though there are two rainy seasons in some districts of Bale like Sinana-Dinsho, few farmers utilize both rainy seasons to produce two crops annually on the same piece of land- most prefer to fallow the land during one of the two seasons (Alemayehu and Franzel, 1987).

Soil fertility is an important consideration in the development of double cropping systems. Double cropping cereals with leguminous species have potential implications for the nitrogen requirement of and usage by the cereal component(s) (Hargrove *et al.,* 1983; Narwal *et al.,* 1983) and, less frequently, on phosphorus use efficiency (Sinha *et al* 1983). The advantages of green manuring for increased crop productivity has also been reported elsewhere (Kelssa, 1988; Tadesse, 1989; Yeshanew and Asgelil, 1999). However, no work has been done so far in the region on the use and contribution of green manure to soil fertility improvement. Bread wheat production in Ethiopia is constrained by low availability of nitrogen and phosphorus in the soil. This is exacerbated by continuous mono-cropping of cereals without replacing nutrients lost by crop harvest. Moreover, chemical fertilizers are costly for most subsistence farmers to correct the deficiency. Hence, other fertility management technologies like green manuring which could supplement chemical

fertilization need to be studied. Thus, this study attempted to evaluate the short-term effects of substituting green manure for fallow in double cropping system. In view of this, the present study was carried out with the objective to study the value of Vetch (*V. vilosa*) as green manure and to assess its effect on soil fertility and yield of bread wheat.

Materials and methods

The study area

The study was conducted at two sites in Sinana-Dinsho district, South-eastern Ethiopia, on a farmers' field characterized by bimodal rainfall pattern. The seasons include '*Ganna*' (March-July) and '*Bona*' (August-December). The experimental field was under continuous cereal production for long time. The long-term (1991-2001) mean total annual rainfall is 808 mm with mean maximum and minimum temperatures of 21 and 9^{o}C, respectively.

Experimental designs and procedures

The study was conducted for three consecutive years (2001-2003). In each site the main factor treatments (weedy fallow, Vetch harvested and Vetch ploughed under) were set during '*Ganna*' cropping season. Vetch (*V. Vilosa*) was sown at the rate of 30 kg/ha. Just at mid-flowering stage it was either under-ploughed as green manure or harvested and removed. In the second cropping season i.e. *'Bona'*, the whole experimental area was planted to wheat variety '*Sofumer',* released from Sinana Agricultural Research Center, Ethiopia with three nitrogen levels (0, 20.5 and 41 kg N/ha) as sub-plot treatments. Phosphorus fertilizer was applied for all plots of wheat as a non-experimental variable at the rate of 20 kg P/ha. The size of each experimental plot was 4x5-m (20m^2), with the spacing of 1.5 m and 1 m between blocks and plots, respectively.

Statistical Analysis

Data were analyzed using analysis of variance Gomez and Gomez 1984 and the treatment means were compared relative to control following MSTAT C analytical software. Least Significant Differences was calculated for mean separation.

Results and discussion

Effect on plant height

At Selka Oda site, the differences among main plots as well as subplot treatments were non-significant for plant height (Table 1). But, the tallest plant (93cm) was recorded with green manuring vetch followed by fallow treatment, which recorded 91cm. In contrast, both main plot and subplot treatment effects were found to be significant at Selka Jafera. The tallest plant (72cm) was recorded from fallow treatment followed by vetch green manuring (68cm), but the differences between them were statistically non-significant. Application of 20.5kg N/ha gave a statistically comparable wheat height to 41kg N/ha. The interactions of nitrogen fertilizer and land preparation treatments were non-significant for plant height over both sites.

Table 1. Effect of different land preparation and nitrogen on plant height (cm) of bread wheat.

	Selka Oda				Selka Jafera			
	Nitrogen rates (kg/ha)							
	0	20.5	41	Mean	0	20.5	41	Mean
Vetch green manure	92.50	93.00	93.13	92.88	94.25	89.25	95.08	68.11
Vetch harvested	84.63	86.88	87.13	86.21	55.25	56.58	58.42	67.08
Weedy fallow	88.38	91.38	93.00	90.92	54.83	55.42	62.58	72.03
Mean	88.50	90.42	91.08		68.06	69.00	70.17	
CV (%)	4.91				5.06			

Significance: green manure treatments *
Nitrogen rates n.s.
Interactions n.s.

Effect on grain yield

As depicted in Table 2, the variations among main plot treatments were significant at Selka Oda. The highest biological yield of wheat (3039kg/ha) was obtained using

vetch as green manure followed by fallow treatment, which gave 3013kg/ha. This is in agreement with Khan (1968) who reported significantly maximum number of grains per ear was produced in case of wheat crop when guara, as a green manure crop, was buried into the soil. However, the yield variations between green manuring and fallow were statistically non-significant. This is probably due to the contribution of weeds as green manure during fallow period. The significantly lowest yield recorded on plots where vetch biomass was removed at flowering could be due to depletion of nutrients and moisture as a result of double cropping. However, neither land preparation treatments nor nitrogen fertilization affected the grain yield of wheat at Selka Jafera. This could be due to the associated terminal moisture stress, which is compensated by high water holding capacity of soils in the case of Selka Oda. Related research findings showed vetch crop is good green manure crop option, recommended for dry conditions, and on lighter textured soil. It has the ability to fix more moisture, as well as more N in dry areas versus areas with heavier soils.

Table 2. Effect of different land preparation and nitrogen on grain yield (kg/ha) of bread wheat.

	Selka Oda				Selka Jafera			
	Nitrogen rates (kg/ha)							
	0	20.5	41	Mean	0	20.5	41	Mean
Vetch green manure	2989	3305	2824	3039	1484	1546	1488	1506
Vetch harvested	2712	2273	2716	2567	1484	1631	1532	1549
Weedy fallow	2856	2964	3218	3013	1919	1874	1786	1859
Mean	2852	2846	2919		1629	1684	1602	
CV (%)	21.21				19.00			

Significance: land preparation treatments * (for Selka Oda)
Nitrogen rates n.s.
Interactions n.s.

Effect on straw yield

As shown in table 3, there is a significant variation in straw yield of wheat among main plot treatments as well as sub-plot treatments in both sites. But, the interaction effects were non-significant at Selka Oda, while significant at Selka Jafera.

Using vetch as a green manure gave a statistically comparable straw yield to fallow treatment. However, growing vetch with removal of above ground biomass at flowering stage resulted in a decrease in straw yield of wheat. This could be attributed to the net removal of nutrients by vetch in the double cropping season. This could also imply that the contributions of legumes such as vetch in double cropping system as a nitrogen fixer are minimal when most of their biomass is removed.

Table 3. Effect of different land preparation and nitrogen on straw yield (kg/ha) of bread wheat.

	Selka Oda				Selka Jafera			
	Nitrogen rates (kg/ha)							
	0	20.5	41	Mean	0	20.5	41	Mean
Vetch green manure	6656	8163	8436	7752	4703	4939	4546	4729
Vetch harvested	5153	5654	5524	5444	3259	4521	4204	3995
Weedy fallow	7217	8922	8657	8265	4421	4563	5103	4696
Mean	6342	7580	7539		4127	4675	4618	
CV (%)	21.42							

Significance: green manure treatments *
Nitrogen rates *
Interactions n.s (for Selka Oda) and * (for Selka Jafera)

Nitrogen fertilization also resulted in an increase of wheat straw yield. Application of 20kg N/ha gave a comparable straw yield to the application of 41kg N/ha. The increase of wheat straw yield from nitrogen fertilization seems to be an indication of importance of nitrogen for vegetative growth.

Effect on soil properties

A slight decrease in soil pH was observed following incorporation of vetch. It is for the fact that decomposition of vetch material which initially acidifies the soil. Such finding is in agreement with McVay *et al.* (1989) who reported a decrease in soil pH after three weeks of vetch green manuring. But, its effect on soil pH after wheat harvest was found to be non-significant.

Table 4. Effect of different land preparation on some soil properties after three weeks.

Treatments	Selka Oda			Selka Jafera		
	pH (1:2.5)	OC (%)	P_{av} (ppm)	pH (1:2.5)	OC (%)	P_{av} (ppm)
Vetch green manure	7.9	2.69	4.5	6.9	2.60	19.52
Vetch biomass removed	8.1	2.65	4.46	7.1	2.40	19.12
Weedy fallow	8.2	2.40	6.22	7.1	2.30	21.50

The organic carbon content of the soil also increased after three weeks of vetch biomass incorporation by 13% at Selka Jafera and 12% at Selka Oda. However, such increase didn't observe after wheat harvest which most likely due to the degradation of organic matter by microorganism. Similarly, several scientists proved the increased content of organic matter as a result of green manuring. Green manuring is the most economical means of increasing organic matter content in the soil. It has been observed to maintain and improve soil structure by the addition of organic matter (Repetto, 1986) and to minimize the NPK fixation losses in all types of soil (Dreyfus *et al*., 1983).

On the other hand, the available phosphorus treated with green manure was however lower than fallow plot, this could explain the higher utilization of phosphorus by vetch for growth and its less contribution through biomass to the subsequent crop. Few data are found in the literature on the effect of green manure on phosphorus nutrition of cereals grown after them. Maiksteniene and Arlauskiene (2004) reported that green manuring is not rich in phosphorus, however, it improves soil physical properties and at the same time stimulate microbiological activity, which makes available phosphorus in the soil more readily available to plants. In a similar finding in harvested winter wheat grown after different preceding crops, the highest contents of available phosphorus remained after vetch as preceding crops. Research report indicated by Boparai *et al*. 1992 stated the importance of green manuring in improving the physical properties of soils of wet-land rice as the incorporation of green manure (*Sesbania aculeate*) increased root density and grain yield of wheat grown after rice. Though data were not indicated optimum rate of N for wheat

considered the lowest when it is grown after a green manure crop vetch as discussed in Kumar *et al*. (1998).

In conclusion, incorporation of vetch before main cropping season is paramount importance in boosting yield for the preceding crop and improving soil physical property in particular. It should be noted that maximum grain yield was exhibited due to vetch crop harvested and incorporated than removed. Similarly, Höök (1993) concluded that the annual species Persian clover (*T. resupinatum* L.) and common vetch (*Vicia sativa* L.) and the biennial yellow sweetclover (*Melilotus officinalis* Lam.) hold the most promise as green-manure species to be used as spring sown main crops while sweetclover has a lower regrowth capacity, especially in late development stages (Bengtsson, 1961; Wivstad, 1989; Höök, 1993). On the other, significant contribution from fallow land also reported from the study provided the occurrence of moisture stress during the experimental period could allow conserving more soil water from evaporation for the critical growing stages of the main crop wheat *'Sofumar'*. Based on the findings it could be suggested incorporation green manured forage legumes like vetch can supplement a lot for soil fertility than simply fallowing the land. Thus, experiencing the benefit of vetch and other forage legumes for the purpose of green manuring will best and highly recommendable in areas where two peak rainfall periods in a year exhibited. In the future long term research about the impact of green mannuring is papramount important that might not been addressed in this piece of work though it could be a good test in tropical soils since these nations are highly affected owing poor soil fertility which hinder crop productivity and the associated problems.

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