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Maize-Haricot Bean Intercropping on Soil Fertility Improvement under Different Planting Methods, at Kiremu District, Eastern Wollega Zone, Oromia Region, Ethiopia

Ferede Abuye Jeldu

Department of Forestry, Bedele College of Agriculture and Forestry, Mettu University, Ethiopia

Abstract: ***Mono cropping is the dominant factor influencing plant nutrient uptake and loss of soil quality in Ethiopia whereas intercropping of cereal-legume has positive environmental qualities. Likewise drought and moisture stress condition is widely expanding from all direction to the center of the country. Therefore, the objective of this research was to evaluate influence of planting methods, tied ridge and cropping system on different soil chemical properties in case of Kiremu district, Eastern Wollega Zone, Ethiopia. It was undertaken at Arja-Dubuq from March 2017 to January, 2018. In this experiment, one maize variety (Melkassa 2) and one haricot bean variety (Nasir) were used. Treatments include open end and closed end tied ridge; sole cropping and intercropping; and in furrow, on ridge and flat bed planting. Each treatment has been triplicate and the experiment plots were laid out in randomized complete block design. Intercropping of maize-haricot bean with tied ridge and planting methods were highly influenced soil pH, exchangeable potassium, available phosphorous, soil organic matter and total soil nitrogen. Generally, the use of intercropping and closed end tied ridge in combination with in furrow planting significantly increased (p0.05) soil fertility in the system, which could be promising for sustainable improvement of crop production and productivity for semi arid areas of Eastern Wollega zone.***

Keywords: Haricot bean, Intercropping, Maize, Planting Methods

1. Introduction

Soil degradation is expressed in quality and quantity of soil nutrients, physical and biological soil characteristics which is linked to stagnation and decline in yields in the most intensive agriculture [1]. The decline in these soil properties is interconnected to the improper use of inorganic fertilizer and lack of organic fertilization, practices that are now widespread in the most intensive agriculture in developing countries [2]. For instance, repeated-application of urea under crop production and soil fertility improvement program is not only causing nutrient imbalances, but also negatively affecting the physical and biological properties of the soils [3]. Thus under common nitrogen fertilizer applications, natural nutrient cycling, microbial biomass, enzymatic activity and water-holding capacity of the soil are dramatically reduced whereas acidification and nitrate accumulation in water bodies increases [2] [4].
Therefore, by considering the environmental problems associated with current cropping systems in Ethiopia particularly Oromia region, Eastern Wollega Zone, kiremu district, it seems reasonable to continue research on the possibilities of growing cereal-legumes intercropping which will rival the current mono cropping systems. Further studies by [5] indicated that failure by smallholder farmers in Bale zone of Oromia region to implement intercropping system and lack of plant nutrients due continuous mono cropping nutrients uptake, nutrients leaching and soil erosion are the principal causes of low agricultural productivity and food insecurity in Ethiopia.

Cereal-legumes cropping system is advanced as one of the integrated soil fertility management practices consisting of growing two or more crops in the same space at the same time, which have been practiced over the years and achieved the soil fertility restorations and crops yield in agriculture [6]. Likewise in Ethiopia Highland growing of several crops in association or in mixtures mainly being cereal and legumes is not new a technology for soil fertility improvement and reducing evapotranspiration from the field [7]. A study by [8] noted the decline in soil fertility and moisture stress being the major limitation to crops yield in cereal based cropping systems in Eastern and Southern Africa.

Similarly, due to soil and crop moisture stresses are dramatically expending in the country moisture retention structures and planting methods plays a vital role for successful and sustainable crop production. Therefore, planting crops using insitu moisture conservation reduces problems of soil moisture stress. Thus different tied ridge and planting methods with spaced fixed distance apart to form a series of micro catchment basin created to catch and hold rainwater, minimizing surface runoff, improve downward infiltration of water [9]. Therefore the objective of this research was to evaluate effects of planting methods, tied ridge and cropping system on different soil chemical properties.

2. Materials and Methods

Description of the Study Area

Kiremu district is located between 8˚45' N, 37˚40'E latitude and longitude respectively. It is one of the districts in the Oromia Region of Ethiopia. In addition it is bounded by Gidda Ayana in the West, Abe Dongoro in south, Amuru district in the East, Amara Regional in the North.

The district has a distance of 474 km from capital city of the country Addis Ababa and 144km from zone capital called

Nekemte. The mean annual temperature of the district is 30˚C. The lowest temperature is 20˚C and highest is 40˚C respectively. The mean annual rainfall is 600 mm whereas the lowest and highest rainfall is 400 mm and 800 mm respectively. Cereals, pulses, Oilseed, fruit, vegetables and spice are the known crop grown in the District. Cereals are the main crops that are produced during Maher season and pulses, oil seed, vegetables, fruit, and spices are followed [10].

Soil Sampling and Analysis

Sampling for soil pH, organic carbon, total nitrogen available phosphorous and Potassium was accomplished. The soil samples were collected from the depth of 0 - 20 cm using auger. Five samples (in zigzag pattern) were collected before land preparation and after harvesting to form composite soil samples (45), which has been transported to the laboratory for further processing. Plant roots and shoots were handpicked and discarded. Then soil samples were air dried, mixed well before analyses. Likewise, soil pH was measured in ratio of soil to water (1:2.5), using pH meter whereas Ec was measured by conductivity meter using suspension of 1:5 soil: water ratio. Organic carbon was determined by following [11]. Then, percent soil organic matter was calculated by multiplying the percent organic carbon by a factor of 1.724. Total Nitrogen (TN) was determined by the micro-Kjeldahl digestion, distillation and titration method [12]. Available phosphorus (AP) was determined using the standard Bray II and Olsen test based on the results of pH [13] [14]. Finally, exchangeable potassium was determined using flame photometer [15].

Data Analysis

All data collected were subjected to Paired Sample T-test using IBM SPSS 20. Significance differences between treatments were delineated by LSD (Least Significant Difference) test at 5% level of significance.

3. Result and Discussion

Effect of Planting Methods, Tied Ridge and Cropping System on Soil Chemical Properties

1) Soil pH

Soil pH was significantly different due to interaction of maize-haricot bean intercropping with both tied ridge and planting methods. Thus the maximum mean of soil pH was observed before planting at sole haricot bean with flat bed whereas the minimum soil pH were observed after planting of maize-haricot bean intercropping with closed end tied ridge and in furrow planting. When before and after planting values of pH was compared by t-test it was indicated that there was reduction due to influence of maize-haricot bean intercropping (Table 1). Relatively lower pH values in the soil after planting due to maize-haricot bean intercropping with tied ridge and planting methods as compared to those sole maize and haricot bean, might be due to depletion of basic cations by the harvested crop biomass, leaching and phosphorus fixation. Also findings of [16] shows that, a lower pH value in intercropping land was attributed to a high rate of organic matter oxidation. This is important to produce organic acids and provide H+ to the soil solution, and thereby reduces soil pH values.

2) Available Potassium

Intercropping of maize-haricot bean with tied ridge and planting methods were highly influenced available potassium in soil which is easily uptake by the crop. So that the mean of available potassium was significantly different due to interaction of maize-haricot bean intercropping with both tied ridge and planting methods. Likely available potassium in the soil was increased after planting due to maize-haricot bean intercropping (Table 1). Similarly, it was observed that by [17] K levels can be maintained when haricot-bean is grown in intercropping with cereals. Results obtained by [18] at Kadawa, Kano clearly indicated that under continuous cultivation with intercropping of maize-haricot been the available K can be improved.

Also this finding is in line with the finding of [28] ,the mean of available potassium increased due to interaction of maize-haricot bean intercropping with both tied ridge and planting methods.

Table 1: Maize-haricot interaction effects of bean intercropping on soil fertility with different cropping system and planting methods

CS*TR*PM	PH			AV.K			AV.P			%OM			TN		
	BEF	AF	t-test	BEF	AF	t-test	BEF	AF	t-test	BEF	AF	t-test	BEF	AF	t-test
IC*CE*IF	6.04	5.09	0.032	2.21	3.87	0.036	4.03	7.42	0.011	3.25	8.01	0.002	0.22	0.41	0.025
IC*CE*OR	6.01	5.13	0.002	2.07	3.13	0.007	3.74	6.58	0.002	5.86	6.33	0.018	0.22	0.36	0.004
IC*OE*IF	6.06	5.18	0.008	1.92	3.29	0.004	4.33	6.19	0.002	4.33	6.70	0.248	0.22	0.36	0.029
IC*OE*OR	5.93	5.41	0.006	2.1	2.9	0.005	3.68	5.77	0.014	5.97	7.05	0.178	0.21	0.31	0.184
IC*FB*NO	5.9	5.53	0.154	2.15	2.46	0.178	3.75	4.97	0.002	5.37	6.14	0.602	0.21	0.26	0.44
SM*CE*OR	5.89	5.11	0.022	2.24	2.59	0.079	3.65	3.38	0.877	4.71	5.36	0.202	0.22	0.24	0.817
SM*FB*NO	6.04	6.15	0.711	2.16	2.12	0.02	4.07	3.78	0.056	3.12	4.98	0.135	0.22	0.24	0.095
SM*OE*OR	5.89	5.69	0.052	2.03	2.29	0.074	4.18	4.57	0.573	4.56	4.23	0.604	0.21	0.24	0.25
SM*OE*IF	5.76	5.49	0.258	2.11	2.56	0.033	4.21	4.75	0.017	6.03	1.28	0.233	0.21	0.24	0.338
SM*CE*OR	6.02	5.58	0.025	2.00	2.69	0.008	3.37	4.97	0.009	5.49	7.82	0.035	0.22	0.21	0.423
SH*OE*OR	5.78	5.81	0.423	2.14	2.37	0.423	3.65	3.88	0.423	4.79	6.10	0.423	0.22	0.24	0.423
SH*OE*IF	5.99	5.71	0.423	2.26	2.18	0.423	3.89	4.04	0.423	5.48	5.54	0.423	0.22	0.22	0.423
SH*FB*NO	6.28	6.24	0.423	2.11	2.12	0.423	3.69	3.91	0.423	4.95	4.21	0.423	0.21	0.2	0.423
SH*CE*OR	5.92	6.14	0.423	2.15	2.24	0.423	4.19	3.74	0.423	5.69	4.41	0.423	0.22	0.22	0.423
SH*CE*IF	5.88	5.89	0.423	2.18	2.16	0.423	4.02	3.97	0.423	4.76	4.33	0.423	0.23	0.22	0.423

Where; IC = intercropping; CE = closed end tied ridge; IF = In furrow planting; OR = on Ridge Planting; OE = Open end Tied ridge; FB = Flat Bed; SM = Sole maize; NO = Not Flat Bed; SH = sole Haricot bean.

3) Available Phosphorus

Comparison AP, before and after planting, was significantly different ($P \leq 0.05$) under interaction of maize with tied ridge and planting methods (Table 1). Therefore the values of available phosphorus was increased due to intercropping and available soil moisture Reduction of AP could be related to degree of its fixation which occurs at low pH levels where iron and aluminum activity actually increases [19].

4) Soil Organic Matter

On plot maize-haricot bean intercropping with tied ridge and planting methods soil organic matter was significantly different (LSD0.05) by their interaction effect. The highest amount of soil organic matter (8.01%) was observed after planting; under maize-haricot bean intercropping with closed end tied ridge and in furrow planting whereas the minimum (3.12%) were observed before planting at sole maize planting on flat bed (Table 1). This result was in line with [20] that reported the amount f soil organic matter can alter rapidly and drastically as a consequence of legumes-cereals intercropping. In addition, [21] were obtained availability of soil moisture in arid and semi arid environment improved decomposition of organic matter by 20% in comparison to low temperature areas. These authors support the result of this research because high organic matter observed under close tied ridge and in furrow planting. Similarly, [22] reported that intercropping cereals with legumes can address losses of soil organic matter in tropical, rain fed, low-input systems.

5) Total Nitrogen

Before and after planting total soil nitrogen was significantly different by interaction of maize-haricot bean intercropping with both tied ridge and planting methods. This might be because of legumes have capability to fix atmospheric-N through symbiosis (Table 1). It was agreed with works of [23] that reports, cereal-legumes intercropping patterns' effect on total soil N as significant. Likewise, [17] reports legume is grown in a mixture with a cereal, it can improve the N economy of the cereals both by contributing N to the soil for uptake by the cereal or simply by the legume removing less N than if the cereal was grown as a pure stand. Similarly, [24] were observed amount of mineral-N remaining in the soil after cereal-legume intercropping was greater than that after planting of non-legume crop with an equal amount of N in harvest products. This was might be because of legumes can satisfy part of its N-requirement through atmospheric N-fixation. Likely, [25] also quantified N-savings on the order of 18 to 23 kg N per ha by Maize-haricot bean intercropping when compared with sole maize. Accordingly, biological nitrogen fixation is the major source of nitrogen in legume-cereal mixed cropping systems when nitrogen fertilizer is limited [26]. In addition, roots of the legume component can decompose and release nitrogen into the soil where it made available to subsequent crops.

6) Water Use Efficiency

The crop yield and soil fertility status was significantly different (P0.05%) due to tied ridge with intercropping of maize-haricot bean than tied ridge with sole maize and flat bed. Specifically, under closed end tied ridge this difference was mostly observed. This might be because of tied ridge was used as in-situ soil moisture conservation and maize used as a shade to haricot bean from direct sunlight intensity (Table 1). Likely, haricot bean was used as life mulching that can be reduced evaporation from the soil whereas maize was improved haricot bean water use efficiency by minimizing transpiration. The finding reported by [27] indicates that the advantage of the maize-haricot bean intercropping system under tied ridge is reflected in the water use and the water use efficiency value. The same authors were reported, in 1986 these crops together used 597 mm as opposed to 374 mm for the sole crop of maize and in 1987 total water used by maize and haricot bean in intercropping was 585 mm, in contrast to 398 mm by the sole crop maize.

4. Conclusions and Recommendation

Soil pH was significantly different due to interaction of maize-haricot bean intercropping with both tied ridge and planting methods. Intercropping of maize haricot bean with tied ridge and planting methods were highly influenced available potassium in soil which is easily absorbed by the crop. Available phosphorus, before and after planting, was significantly different ($P \leq 0.05$) under interaction of maize with tied ridge and planting methods. The highest amount of soil organic matter (8.01%) was observed after planting; under maize-haricot bean intercropping with closed end tied ridge and in furrow planting whereas the minimum (3.12%) were observed before planting at sole maize planting on flat bed.

Before and after planting total soil nitrogen was significantly different by interaction of maize-haricot bean intercropping with both tied ridge and planting methods. The soil fertility status was significantly different (P0.05%) due to tied ridge with intercropping of maize-haricot bean than tied ridge with sole maize and flat bed. Specifically, under closed end tied ridge this difference was mostly observed.

Therefore, the use of intercropping and closed end tied ridge in combination with in furrow planting significantly increased soil fertility in the system, which could be promising for sustainable improvement of crop production and productivity for semi arid areas of Bale zone.

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