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Research Article

The Influence of Cropping systems and Tillage practices on Growth, Yield, and Yield Components of Maize (*Zea may L.*) in Shalla District, West Arsi Ethiopia

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Abstract

Low productivity is a feature of Ethiopian agriculture, which can be ascribed to soil deterioration and inadequate water utilization. In view of this, a field experiment was conducted over four years in a permanent plot to assess the effects of cropping systems and tillage methods on growth, yield, and yield components of Maize and to determine optimum management options for better yield production and land use management. The experiment was factorial with two factors: two tillage systems (conservational tillage with crop residue cover and conventional tillage), and two cropping systems (sole and intercropping). The treatments were arranged in a randomized complete block design (RCBD) with three replications. The pooled mean analysis of variance revealed that higher yield and yield components of maize were achieved from conservation tillage over conventional tillage. Under conventional tillage and conservation tillage, the intercropped treatment yielded a 27.70% to 28.30% relative yield advantage over solitary cropping, indicating that productivity of maize and haricot bean intercropping was superior in resource use efficiency than sole cropping. According to the findings, conservation tillage combined with maize-haricot bean intercropping should be recommended to produce better and sustainable maize yields in semi-arid locations.

Keywords: Conservation tillage; Cropping systems; Crop residue; Intercropping; Relative yield

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Introduction

Low productivity is a feature of Ethiopian agriculture, which can be ascribed to soil deterioration and inadequate water utilization. Even in years of abundant rainfall, the country's soil and water resource usage inefficiency are so severe that it is unable to produce enough grain to feed its population [1]. Despite the existence of potentially productive resources for food self-sufficiency and even surplus production, domestic grain production is expected to satisfy only about 70% of the total food requirement, and 4 to 6 million people require food aid each year [2]. Almost all of the country's crop cultivation is done by smallholder farmers who use traditional ploughing methods.

Conventional tillage (CT) is a frequently used tillage method, which primarily improves the soil's physical properties [3]. However, CT has the potential to reduce soil organic matter due to enhanced decomposition rate and hence, negatively affect long-term crop productivity, nutrient uptake, and soil health [4]. The previous study also confirmed that organic matter mineralization is enhanced through conventional tillage [5, 6].Under conventional tillage soil organic matter is lost easily [7]. Inversion of the topsoil speeds up the breakdown of organic matter (oxidation) resulting in nutrient losses [8]. Soil erosion depletes soil productivity resulting in adverse physical, chemical and biological soil properties affecting crop yields [9]. In an experiment carried out in Kenya, soil erosion was found to cause a loss of 42 t/ha of topsoil with a run-off of 98,750, litres/ha in 12 months [10].

Tillage systems being developed and studied to address these concerns can broadly be termed conservation tillage. Conservation agricultural activities, which were first pushed by the FAO, were one of the measures launched in Ethiopian agricultural systems to reduce soil and water resource degradation. Conservation agriculture, according to FAO (2001), attempts to make better use of agricultural resources by integrating the management of available soil, water, and biological resources with fewer external inputs. Conservation tillage is defined by three principles that are mutually reinforcing: 1) continuous no- or minimal mechanical soil disturbance (i.e., direct sowing or broadcasting of crop seeds, and direct placement of planting material in the soil); 2) permanent organic-matter soil cover, especially by crop residues and cover crops; 3) diversified crop rotations in the case of annual crops or plant associations in case of perennial crops, including legumes. Conservation tillage with crop residue cover reduces soil manipulation, saves on labour requirement, improves soil productivity by minimizing compaction and improves soil moisture storage within the plough layer thus reducing soil and water losses [11].

Conservation tillage with cover crops protects the soil from splashing rains where they reduce raindrop impact leading to reduced surface run-offs. They improve soil's physical, chemical, and biological properties (Triomphe and Sain, 2004).Cover crops break soil hardpans resulting in high infiltration of rain and irrigation water [12]. They reduce weeds and increase soil organic matter content thus improving soil fertility [13]. Crop residue mulches protect surface soil aggregates from breakdown and dispersal. Consequently, surface sealing or crusting, water runoff, and soil erosion are reduced [14].

Agriculture production in Ethiopia is low and declining, and natural resource degradation is widespread. Soil erosion costs the country 30,000 hectares of land, or one billion tons of topsoil, 30 kilos of nitrogen, and 15-20 kilograms of phosphorous each hectare [15]. Crop yields have decreased as a result of severe soil degradation, and the effectiveness of fertilizer application in increasing farm production has decreased [16]. Continued soil deterioration is jeopardizing global food security and the livelihoods of millions of rural families. The main causes are not only intensive soil preparation by hoeing or plowing, but also deforestation, crop residue removal or burning, poor rangeland management, and insufficient crop rotations that do not maintain vegetative cover or allow for adequate restitution of organic matter and plant nutrients. The soil is exposed to climatic dangers such as wind, rain, and sun as a result of these operations. In certain climate zones, the extensive and ongoing use of the plow has thus been shown to be unsustainable (Govaerts, 2009). There is an ever-increasing concern that it is becoming more and more difficult to achieve and sustain agricultural productivity and food security through conventional tillage and extensive farming system since there is land degradation, soil erosion, and limited opportunities for area expansion.

Shalla is among maize and haricot been producing Woreda under conventional tillage system. Although most of the mid and low-altitude areas of the woreda are suitable for maize and haricot bean production, the productivity of maize-haricot bean intercropping under conservational tillage and conventional tillage are limited mainly due to a lack of information on suitable and appropriate cropping systems and tillage systems. There was no research conducted in the area on cropping systems (sole and intercropping) and tillage systems (conservational tillage and conventional tillage). It has been very difficult to address the increasing demand for food security by producing adequate grain yield in quality and quantity due to high soil erosion by rain and winds. In view of this, the present investigation was conducted to(1) evaluate the growth and yield performance of maize in the sole and intercropping under conservation tillage and conventional tillage, (2) determine economic benefits and land-use efficiency of maize-haricot bean intercropped under conservation tillage and conventional tillage.

Materials and Methods

Description of the Study Area

The field experiment was conducted for four consecutive cropping seasons (2014-2017) in a permanent plot at Shallaworeda, Awara Gama Kebele of West Arsi zone, Oromiya Region. The experimental site is located at $7^0$16'55" N latitude and $38^0$27'27.8" East longitude with at an altitude of 1696 meters above sea level is found 282 km south of Addis Ababa. The long-term average annual rainfall of 750 mm with a mean temperature of 18.5^0C. The major crops grown around the experimental area include maize, haricot bean, teff, finger millet, sorghum and potatoes. Maize is the most dominant food crop grown by farmers in the area. Maize and haricot bean are grown mainly as cash crops.

Treatments and Design

The experiment was factorial with two factors: two tillage systems (conservational tillage with crop residue cover and conventional tillage), and two cropping systems (sole and intercropping). The treatments were arranged in a randomized complete block design (RCBD) with three replications. The land was prepared to be designed for both conventional tillage and conservation tillage, and then it was planted following the field layout.The experimental treatment combination, sole maize under conservation tillage with crop residue cover, sole haricot bean under conservation tillage with crop residue cover, sole maize under convention tillage, sole haricot bean under conventional tillage, maize-haricot bean intercropped under conservation tillage with crop residue cover and maize-haricot bean intercrop under convention tillage were evaluated as in 7.5m length x 6.40m width = 48m^2 for each plot.

The paths between blocks and plots were 2.5m and 2m, respectively. Each block contained all four treatments randomly assigned to each plot. The spacing for sole and inter cropped maize was 80 cm inter–row spacing and 25cm intra-row spacing accommodating eight maize rows, each row of maize consisted of 30 plants. The inter-cropped haricot bean was planted as pair of rows having 40 cm space between them,10cm between plants and 20 cm far from each maize row. Only the central six rows of maize were subjected for data collection. Grain yield was taken from the central four rows of maize and ten rows of haricot bean by excluding first rows for border effects in each side of the plots.

In conventional cultivation, the land was prepared by oxen ploughing three times before planting. In conservation tillage furrow was opened using a narrow slot (5-10cm wide) in the soil for seed placement without mechanical or secondary tillage operation and crop residue covered the surface area as a mulching at the rate of 4 tha^{-1} to reduce erosion and to control weeds. In maize and haricot bean where conservation tillage was used, weeds were controlled by using Round up 4Lha^{-1} applied 15 days before planting. The maize and haricot bean were planted on May 18 and June 19, 2016 respectively, in rows and two seeds per hill were planted to assure germination and good stand after which the seedlings were thinned to a single plant per hill. All plots received a 100 kg ha^{-1} basal treatment of Di-ammonium Phosphate (DAP) (18 percent N, 46 percent P_2O_5) at the time of planting. Nitrogen was applied to all plots in the form of Urea (46 percent N) at a rate of 100 kg ha^{-1} in a split application, with the first half treated at the knee-height stage of maize and the second half applied immediately before tasseling.

Data Collected

Parameters for maize component

Plant height was measured in (cm) as the height from ground level to the base of the tassel by taking ten randomly selected plants per plot using measuring stick. Ear heightwas measured (in cm) as the height from ground levels to the base of the lower most ears from ten randomly taken plants per plot using measuring stick. Leaf area at 50% silking was taken by measuring the leaf length and maximum leaf width and was adjusted by a correction factor (0.75 i.e. 0.75 x leaf length x maximum leaf width). Leaf area index was calculated as the ratio of total leaf area per ground area occupied by the plant [17]. The ground area was calculated for both sole and intercrop as 80 cm x 25 cm=2000 cm^2.

Cob length was measured (in cm) from base level to the tip along the length of the cob from ten randomly selected cobs per plot with ruler and the average were recorded.Above ground, biomass was determined after the crop was harvested. The stalk from the net plot was oven dried at 70^0c until constant weight was achieved, before weighing and converting it to per ha basis. Number of kernels per cob was counted as product of number of rows per ear and number of kernels per row of randomly selected ten cobs per plot during harvesting. Grain yield per ha was obtained from the central four rows of maize, and then the yield was measured after the seeds are picked and shelled by hand. The grain yield was adjusted to 12.5% moisture level and then converted to tha^{-1}.Seeds were counted using an electronic seed counter from a bulk of threshed seed and weighed using a sensitive balance from a plot during harvest, adjusting to 12.5% moisture content. The harvest index was derived by multiplying the ratio of grain yield to above-ground biomass by 100.

Inter cropping efficiency

In evaluating inter cropping efficiency; several procedures are developed by various Workers [18]. An assessment of land return is made from the yield of pure stands and from each separate crop within the mixture. The calculated figure is called the Land Equivalent Ratio, where intercrop yields are divided by the pure stand yields for each crop in the intercropping system and the two figures added together [19] and [20].

$$LER(CA) = \frac{Intercop\ Maize\ under\ CA}{Sole\ maize\ under\ CA} + \frac{Intecrop\ haricotbean\ under\ CA}{Sole\ haricot\ bean\ under\ CA}$$

$$LER\ (CT) = \frac{Intercop\ Maize\ under\ CT}{Sole\ maize\ under\ CT} + \frac{Intecrop\ haricotbean\ under\ CT}{Sole\ haricot\ bean\ under\ CT}$$

Where:

LER_{CA} = Land equivalent ratio under conservation tillage condition

$LER_{CT=}$ land equivalent ratio under conventional tillage condition.

For each crop a ratio is calculated to determine the partial LER for that crop, and then the partial LERs are summed to give the total LER for the intercrop [21].

Data Analysis

he data collected on different parameters was statistically analyzed according to [22] by using SAS statistical software (SAS, 2000) with a general linear model procedure. After performing Analysis of Variance (ANOVA) the differences were compared using the least significance difference ($LSD_{5\%}$).

Results and Discussion

The initial soil properties of the experimental area

The analytical results of particle Soil samples taken at different soil depths from 0-20 cm, 20-40cm and 40-60 cm showed that, the textural class of the experimental soil was sand clay loam (Table 1). Percentage of clay soil varied from 28.33 to 31.50 % for soil depth of 20-40cm and 0-20 cm, respectively. The soil organic carbon and organic matter content of the top soil (0 to20 cm) was 1.74% and 3.00%, respectively, which is in the medium range, according to [23] the soil organic matter content ranges 1-2, 2-4, and 4-6% are rated as low, medium and high, respectively. The result of soil analysis from 0-20 cm depth also shows that total Nitrogen of 0.34%, available phosphorus about 7.40 parts per million (ppm) and pH of 6.54. Usually, maize prefer soil pH ranges from 6.0 to 7.0 [24], indicating that soil pH of the experimental area was suitable for maize production. In general, soil particles distribution was decreased uniformly with soil depth increases except for Silt.

Soil properties	Soil depth		
	0-20 cm	20-40cm	40-60cm
Particle distribution			
Sandy (%)	31.50	28.33	28.00
Clay (%)	22.50	22.33	22.00
Silty (%)	46.00	49.34	50.00
Chemical properties			
pH	6.54	6.70	7.29
Available phosphorus mg kg-1	7.40	6.77	4.31
Organic Carbon (%)	1.74	1.71	1.60
Organic matter (%)	3.00	2.95	2.76
Total nitrogen (%)	0.34	0.29	0.19

Table 1: Particle size distribution and selected chemical properties of the soil of the study area prior treatment application

Phenological parameters of maize

Days to 50 percent anthesis, 50 percent silking, and 95 percent physiological maturities did not affect by tillage and cropping systems except 95% of physiological maturities was affected by tillage systems (Table 2). Days to anthesis ranging from 65.11 days for intercropped maize to 65.89 days for sole maize, days to 50% silking ranging from 67.62 days for intercropped maize to 68.93 days for sole maize, while days to maturity ranging from 118.00 days for intercropped maize to 118.60 days for sole maize. Days to 50 percent anthesis ranged from 64.99 days for maize grown under conventional tillage to 66.02 days for maize grown under conservation tillage. Days to 50% silking ranged from 67.60 days for conventional tillage to 68.95 for maize grown under conservation tillage. Days to 95 percent physiological maturity ranged from 116.10 days for maize grown under conventional tillage to 120.50 days for maize in conservation tillage. However, days to anthesis, silking and physiological maturity in this study did not show significant effect by the interaction between cropping system and tillage system. This might be because of more efficient use of soil moisture by intercropped as described by Morris and Garrity (1993), claiming that water use efficiency by intercrops greatly exceeds the sole crops, often by more than 18% and even by as much as 99%.

Growth parameters of maize

Plant height, ear height, cob length, leaf area and leaf area index were not significantly affected due to varied cropping systems (Table 3). Although non-significant effects revealed in all growth parameters, the maximum values were observed in sole cropping system over that of intercropped. However, tillage practices had significant effects on plant height, ear height and cob length. Despite non-significant effects of tillage practices on leaf area and leaf area index

Treatments	Days to50% anthesis	Days to50% silking	Days to 95% Phenological maturity
Cropping system			
Sole	65.89	68.93	118.0
Inter cropping	65.11	67.62	118.6
LSD	1.70ns	1.75ns	1.74ns
Tillage system			
CA	66.02	68.95	120.50a
CT	64.99	67.60	116.10b
LSD	1.70 ns	1.75 ns	1.74
CV (%)	1.84	1.81	1.04

Table 2: Phenological parameters of Maize grown in sole and intercropping under conservational tillage and conventional tillage in 2017.

Means in the same column followed by the same letters are not significantly different (p<0.005).

observed, conservation tillage tended to give positive influences in all parameters, compared to conventional tillage.These findings could be explained by the residue's surface placement, which lowered N mobilization at the beginning when compared to straw integrated into the soil. Because of higher changes in surface temperature and moisture, as well as reduced nutritional availability to bacteria, [25] reported similar results [26, 27]. Soil-incorporated residues tend to decompose faster than surface residues and have a higher potential for N immobilization [28]. The fast growth rate obtained at the middle age of crop in conservation tillage than conventional tillage might have been due to N fertilizer applied at middle age of maize in the form of Urea. The nitrogen fertilizer might have accelerated the decomposition rate of mulch, which helped the plant to get additional nutrient and resulted in increased growth rate. Similar results were reported by [29] where residue added to soil with manure or nitrogen fertilizer led to residue decomposition rates that were two times greater than when no amendments were added.

Treatments	PH	EH	CL	LA (m2)	LAI
	cm				
Cropping system					
Sole	213.50	108.17	19.13	5274	2.64
Inter cropping	208.50	105.67	17.85	4515	2.26
LSD	24.92ns	11.25ns	1.48ns	1419ns	0.71ns
Tillage system					
CA	230.30a	116.33a	20.81a	5437	2.72
CT	191.70b	97.50b	16.18b	4352	2.18
LSD	24.92	11.25	1.48	1419.3ns	0.71ns
CV (%)	8.36	6.75	2.62	20.53	20.53

Table 3: Growth parameters of maize grown in sole and inter cropping under conservation tillage and conventional tillage

Means in the same column followed by the same letters are not significantly different (p<0.05), CA- conservational tillage, CT- conventional tillage.

Yield, yield components and harvest index

Pooled mean analysis of variance revealed that cropping systems were significantly ($P < 0.05$) affected 100-seed weight, grain yield ha^{-1}, and total biomass. Sole cropping system outperformed over intercropping, possibly due to lessresources competition for growth in sole system than intercropping, particularly for soil moisture. The mean seed number cob^{-1}, seeds per plant, 100-seed weight, grain yield ha^{-1}, and total biomass rangedfrom 498g, 194.20g, 38.63g, 3.58 t ha^{-1}, and 11.48tha^{-1}for inter cropped maize to 510.20g, 216.60, 41.52g, 3.93 t/ha, and 13.45 tha^{-1}for solemaize, respectively (Table 4).The number of seeds per cob did not differ significantly ($P < 0.05$) depending on the cropping system. However, cropping system had a substantial ($P < 0.05$) impact on harvest index. The maximum harvest index was achieved from the intercropped treatment. This was possibly due to better availability of soil moisture, since intercropping can improve canopy cover and thus protect soil surface evaporation [30].

Like cropping systems, tillage methods had significant effects on seed number per cob, 100-kernel weight, grain yield, total biomass, and harvest index (Table 4). The higher values of seed number per cob, 100-kernel weight, grain yield, total biomass was achieved in conservation tillage system. Seed number per cob, seed plant^{-1}, 100-kernel weight, grain yield ha^{-1}, and total biomass, decreased under conservation tillage were increased by 6.41, 10.95, 11.70, 9.62, and 15.6%, respectively when compared to conventional tillage. These results are in line with [31]. Similarly, [32] and [33] reported better soil moisture contents under conservation tillage compared to conventional tillage, this phenomenon increased water infiltration rates and reduced evaporation from the soil surface. According to other authors, yields with no-till are usually comparable to those from conventional methods in years with a consistent rainfall pattern, with higher yields in dry years and lower yields in rainy years [34-37]. However, greater harvest index was recorded in conventional tillage, compared to conservation tillage. Correspondingly, Ahadiyat and Ranamiukhaarac-hchi (2008) reported that conventionally tilled plots gave a higher harvest index.

Treatments	NSPC	100-seed weight (g)	Grain yield (t/ha)	Total biomass (t/ha)	Harvest index (%)
Cropping system					
Sole	510.20	41.52a	3.93a	13.45a	29.67b
Inter cropping	498.00	38.63b	3.58b	11.48b	31.18a
LSD	14.81	2.57	0.31	1.93	2.92
Tillage system					
CA	520.80a	42.56a	3.95a	13.48a	29.67b
CT	487.40b	37.58b	3.57b	11.45b	31.46a
LSD	14.81	2.57	0.31	1.93	2.92
CV (%)	2.10	4.54	5.88	10.94	6.80

Table 4: Yield and yield component of maize grown in sole and intercropping under conservational tillage versus conventional tillage.

Means in the same column followed by the same letters are not significantly different (p<0.05), CA-Conservational tillage, CT-conventional tillage.

Efficiency of intercropping of maize and haricot bean-grown under conservation tillage and conventional tillage

The partial land equivalent ratio (PLER) of maize and haricot bean, as well as the total land equivalent ratio (TLER), did not change significantly between conservation and conventional tillage (TLER) (Table 5). Slightly higher (0.92) PLER was obtained maize grown under conventional tillage comparing to maize grown under conservation tillage (0.89). Slightly higher partial LER of haricot bean (0.39) was obtained when haricot bean was intercropped with maize under conservation tillage. The lowest partial LER (0.36) was obtained when haricot bean was inter cropped with maize under conventional tillage. The partial LER of component crops i.e., maize and haricot bean were calculated as 0.89 and 0.39 respectively for maize grown under conservation tillage, with a total LER of 1.283. The partial LER of maize and haricot been grown under conventional tillage was 0.92 and 0.36, respectively with total LER of 1.277. The total LER for all intercropping treatments were greater than one, indicating that all the treatments had an advantage in land use.

Land equivalent ratio (LER) analysis indicatedthat 27.70% to 28.30% relative yield advantage was obtained by the intercrop over the sole cropping under conventional tillage and conservation tillage respectively. This implies that the productivity of intercropped maize with haricot bean was greater in resource use efficiency as compared to sole cropping in both conservation tillage and conventional tillage.

Treatments	Yield of maize (t ha-1)	Yield of haricot bean (t ha-1)	Partial LER of maize	Partial LER of haricot bean	Total LER
Sole	3.93a	2.602a	-	-	-
Inter cropping	3.58b	0.968b	-	-	-
LSD(0.05)	0.312	0.47	-	-	-
Conservation	3.95a	1.80	0.89	0.39	1.283
Conventional	3.57b	1.77	0.92	0.36	1.277
LSD(0.05)	0.312	0.18 ns	0.34 ns	0.16 ns	0.37 ns
CV (%)	5.88	7.09	10.65	12.18	0.31

Table 5: Efficiency of inter cropping of maize and haricot bean grown under conservation tillage and conventional tillage

Means in the same column followed by the same letters are not significantly different ($p<0.05$) (5%), CA= Conservational tillage, CT=conventional tillage, LER=land equivalent ratio.

Conclusion

In general, high yield was obtained under conservation tillage than conventional one. This may be due to conservation tillage reducing surface crusting and high fluctuation in soil temperature, crop residue protecting soil from excess solar radiation, absorbing the kinetic energy of raindrops, forestalling water evaporation and holding more moisture, reducing runoff and soil erosion,increase soil organic matter content thus improving soil fertility, suppress weed growthand reducing the population of weeds, which compete with crops for water, nutrients and sun light. This suggests the potentials for buildup of cumulative effects to result in significant on crop growth, yield and yield components under conservation tillage. Land equivalent ratio (LER) analysis indicatedthat 27.70% to 28.30% relative yield advantage was obtained from the intercropped treatment over the sole cropping under conventional tillage and conservation tillage, respectively indicated that productivity of intercropping maize and haricot bean was greater in resource use efficiency as compared to sole cropping. From the results, it can be concluded that conservation tillage with maize-haricot bean intercropping give high maize yields in semi-arid areas. It is therefore, recommended to use this combination in order to get high maize yields in semi-aridareas.

References

1. Kassa H (2003) Livestock and Livelihood Security in the Harar Highlands of Ethiopia: Implications for Research and Development, PhD Thesis, Swedish University of Agricultural Sciences, Uppsala.
2. EEA (Ethiopian Economic Association) (2006) Evaluation of the Ethiopian Agricultural Extension with Particular Emphasis on Participatory Demonstration and training Extension System (PADETS) Ethiopian Economic Association/ Ethiopian Economic Policy Research Institute, Addis Ababa, Ethiopia.
3. Wang X, Zhou B, Sun X, Yue Y, Ma W, et al (2015) Soil Tillage Management Affects Maize Grain Yield by Regulating Spatial Distribution Coordination of Roots, Soil Moisture and Nitrogen Status.
4. Zuber SM, Behnke GD, Nafziger ED, Villamil MB (2015) Crop rotation and tillage effects on soil physical and chemical properties in Illinois, Agronomy Journal, 107:971-978.
5. Panettieri M, Knicker H, Berns AE, Murillo JM, Madejón E (2013) Moldboard plowing effects on soil aggregation and soil organic matter quality were assessed by 13C CPMAS NMR and biochemical analyses, Agriculture, Ecosystems and Environment 177: 48-57.
6. Rusinamhodzi L, Corbeels M, Zingore S, Nyamangara J, Giller KE (2013) Pushing the envelope? Maize production intensification and the role of cattle manure in the recovery of degraded soils in smallholder farming areas of Zimbabwe, Field Crop Res, 147:40–53.
7. Tenywa MM (2000) Pre-green revolution to white revolution. Improving land productivity through tillage, water harvesting, irrigation and drainage technologies. A paper in the proceedings of the 18th Conference and end of the Millennium Celebrations, Soil Science Society of East Africa 4th – 8th December, 238 – 239.
8. Jonsson LO, Singicha MA, Mbise SME (2000) Dryland farming in Tanzania: Experiences from the land management programme. Conservation Tillage for Dry Farming RELMA-Workshop Report No 3 Katumani, Machakos, Kenya, 108 -109.
9. Bancy MM, Kithinji M (2002) Integrated soil fertility and management assessment of the KUSA profile, Lake Victoria Basin, final Report, RELMA, 36.
10. Nzabi AW, Tana P, Masinde A, Gesare M, Ngoti B, et al. (1997) On-farm soil erosion control experiment using exotic and any locally available materials in Nyamonyo and Kamingusavillages southwest Kenya Participatory Technology Development for Soil Management by small holders in Kenya. A compilation of selected papers presented at the soil Management and Legume Research Network Projects Conference: Kanamai 24th –26th March, 4.
11. Kaumbutho PG (2000) Overview of conservation tillage practices in Eastern and Souther Africa the case of Kenya, Conservation Tillage for Dryland Farming, RELMA workshop Report No 3.
12. Deborah J (2001) Water harvesting and soil moisture retention A study guide for farmer field school, 18-19.
13. Tisdale SL, Warner LN (1975) Cropping System and Soil Management Soil Fertility and Fertilizers 3rd Edition, 555.
14. Russelle MP, Hargrove WL (1989) Cropping systems: Ecology and management 21:277-317.
15. CIMMYT (2008) Monitoring and Impact Assessment Research Report No 4.
16. World Bank (2007) Ethiopia: Thematic papers on land degradation on Ethiopia MOARD and World Bank, Ethiopia, Mimeo.
17. Diwaker B, Oswalt DL (1992) Research planning and data handling ICRISAT, Andra Pradesh, India, 89.
18. Pal M, Singh KA, Ahlawat IPS, (1985) Cropping systems research: Indices and assessments, Nat symp Indian Soc Agro CSSRI Karnal, 23-45.

19. Mead R, Willey RW, (1980) The concept of 'land equivalent ratio' and advantages in yield from intercropping Exp Agric 16:217-228.

20. Sullivan P, (2003) Intercrop Principle and practices (Agronomy Systems Guide) ATTRA- National Sustainable Agriculture Information Service, 1-22.

21. Willey RW (1979) Intercropping-its importance and research needs, Part 1: Competition and yield advantages, Field Crops Abstr, 32:1-10.

22. Gomez KA, Gomez AA (1984) Statistical Procedures for Agricultural Research (2th Ed.) Johan wilky and Sons InC Newyork.

23. Landon JR (1991) Booker Tropical soil manual Booker Agricultural Institute, Longman, New York, USA.

24. Martine Van Woltswinker (2002) Intercropping of annual food crops. Agronomies foundation, 4:1-2.

25. Rennie DA, Heimo (1984) Soil and fertilizer-N transformations under simulated zero till: effect of temperature regimes, Canadian Journal of Soil Science, 64:1-8.

26. Douglas CL, Allmaras RR, Rasmussen PE, Ramig RE, Roager NC (1980) Wheat straw composition and placement effects on decomposition in dryland agriculture of the Pacific Northwest, Soil Sci Soc Am J, 44:833-837.

27. Schomberg HH, Steiner JL, Unger PW (1994) Decomposition and nitrogen dynamics of crop residues: Residue quality and water effects, Soil Sci Soc Am J, 58:372-381.

28. Brown PL, Dickey DD (1970) Losses of wheat straw residue under simulated field conditions, Soil Sci Soc Am Proc, 34:118-121.

29. Schnürer J, Clarholm M, Rosswall T (1985) Microbial biomass and activity in an agricultural soil with different organic matter contents, Soil Biol Biochem 17:611-618.

30. Walker S, Ogindo HO (2002) The Water Budget of Rain fed Maize and Bean Intercrops 3rd water–net/warfs symposium 'Water demand management for sustainable development', Dar es Salaam.

31. Temesgen A, Dadefo T, Birhanu T, Kifle GS, Degefa, et al. (2011) On farm and on station 'Best Bet' maize-legume cropping systems evaluation under CA and Conventional practice in mid altitude sub humid of Western Ethiopia Bako Agricultural Research Center.

32. Michieka RW (1982) Effect of plant residue on water holding capacity of the soil in no-tillage systems. Soil and Water Conservation in Kenya. Proceedings of the Second National Workshop, IDS University of Nairobi 333–337.

33. Njuge K (1992) Conservation between conservation tillage systems for seedbed preparation in Kabete Unpublished project report Department of Agricultural Engineering, University of Nairobi.

34. Wang XB, Cai DX, Perdok UD, Hoogmoed WB, Oenema O (2006) Conservation tillage in rainfed regions of northern China Soil Tillage Research (in press).

35. Aina PO, Lal R, Taylor GS (1976) Soil and crop management in relation to soil erosion in the rainforest of Western Nigeria In: Soil Erosion: Prediction and Control Soil Conservation Society of America, Washington DC SCSA, 75-84.

36. Angers DA, Mehuys GR (1989) Effects of cropping on carbohydrate content and water stable aggregation of a clay soil Can J Soil Sci 69:373-380.

37. Walkely A, Black IA (1934) An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chromic acid titration method Soil science 37:29-38.

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