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Influence of Tillage Practice and Cropping System on Growth Attributes and Grain Yield of Maize [*Zea mays* L.] in the Forest Agro-ecological Zone of Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RNI and FN designed the study and wrote the protocol. Author RNI wrote the first draft of the manuscript. Authors RNI, MMB and ED managed the literature searches and analyses of the study. Authors RNI, FN and HO managed the experimental process. All authors read and approved the final manuscript.

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ABSTRACT

Tillage is one of the most important practices in agricultural production due to its influence on the physical, chemical, and biological properties of the soil environment. Field experiments were conducted to find out the effects of tillage practice and cropping system on the growth attributes and grain yield of maize within the Forest agro-ecological zone of Ghana from 2011 to 2014. The experimental design was a randomized complete block, arranged in a split plot with four replications. Minimum tillage [MT] and Full tillage [FT] were the main treatments. Maize intercropped with mucuna [Maize/M]; maize intercropped with pigeon pea [Maize/Pp]; maize intercropped with cowpea [Maize/C]; sole maize with recommended rate of mineral fertilizer [Maize/F] and sole maize with minimum mineral fertilizer application [Maize] were the subplot treatments. In the first year all the treatments received 30-20-20 kg N-P_2O_5-K_2Oha^{-1} [F1] except Maize/F which received 60-40-40 kg N-P_2O_5-K_2Oha^{-1} [F2]. Interaction between tillage and cropping

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system showed a similar pattern of plant growth during the first and second years. However, grain yield for the second year was at least 50% less than the first year even though plant growth and grain yield were similar for most of the interactions. In the third year grain yield, Maize/Pp + F1 [3.34 t/ha] under MT produced significantly higher grain yield than most other treatment combinations except Maize/M + F1 [3.12 tha^{-1}] and Maize/Pp + F1 [3.31 tha^{-1}] both under FT. In the fourth year grain yield for Maize/Pp + F1 [3.41 tha^{-1}] under MT and Maize/Pp + F1 [3.45 tha^{-1}] under FT were similar but significantly higher than all the other treatment combinations. All other combinations recorded grain yields below 2.50 tha^{-1}. From this study, Maize intercropped with Pigeon pea showed the highest potential under both minimum and full tillage practices. For increased and sustainable maize production within the forest agro-ecology in Ghana, this system is therefore recommended for maize farmers, particularly the poorly resourced farmers.

Keywords: Intercropping; legumes; maize; tillage; grain yield; yield components.

1. INTRODUCTION

Maize [*Zea mays*, L.] is the most important cereal crop in Ghana and is grown across all the agro-ecological zones in the country according to the Ministry of Food and Agriculture [1]. The crop is eaten by most Ghanaians with varying food preferences and socioeconomic backgrounds [2]. A number of factors, however, constrain the production of the crop in the country. These include declining soil fertility, inadequate or non-application of mineral and organic fertilizers and erratic rainfall. The average yield of 1.7 tha^{-1} as against an achievable yield of 6.5 tha^{-1} [1] attest to the poor production methods of the crop in the country. Mean yield of most cereal crops have been observed to be normally less than 30% of their potential [even when rainfall is sufficient- 1].

Improper soil and crop management practices cause degradation in soil health [depletion of organic matter and other nutrients] as well as decline in crop productivity [3]. Minimizing soil disturbance through reduced tillage, influences several physical [4], chemical [5,6] and biological [7] properties of the soil. Many researchers have studied maize performance under different tillage treatments [8-13]. In all these studies, significant differences in growth and yield of maize between no – till and conventional tillage was reported. However, [13-15] noted non-significant effects of tillage treatments on the growth and yield of maize.

In Ghana most maize farmers are poorly resource and therefore unable to purchase enough mineral fertilizers for the crop due to high price of the commodity. Hence, the use of biological methods to improve and sustain the productivity of the soil is an option that needs to be explored. Leguminous fallows have resulted in the improvement of soil chemical and physical properties and ultimately increased maize yield [16,17]. The authors observed that nitrogen fixed by the leguminous plants and biomass produced by such plants is the sources for soil improvement resulting ultimately in increased maize yield in the Savannah agro-ecological zones of the country. In the forest zone, however, there is scarcity of information on tillage methods under intercropping. This is due to the complexity of their interaction effects on crops which tends to discourage researchers and thus leading to loss of basic research information on the benefit of intercropping. This study, therefore seeks to fill this information gap by evaluating the performance of maize using five cropping systems under both conventional and minimum tillage practices.

2. MATERIALS AND METHODS

2.1 Location and Climate

Field experiments were conducted at the CSIR-Soil Research Institute [SRI] Experimental fields in Kumasi in the Forest agro-ecological zone of Ghana from 2011 to 2014. The site lies on Latitude 6° 40’ 40” and Longitude 1° 0’6”. The Forest agro-ecological zone is characterized by relatively high rainfall averaging between 1250 and 1500 mm per year, distributed in a bimodal pattern [Fig. 1]. The major season occurs from March to mid-July with a peak in May to June. This is followed by a short dry spell from mid-July to mid-August. The minor season then starts from mid-August to about the end of November with a peak in October. A long dry period is experienced from December to February with possibilities of occasional rains. The mean monthly temperature ranges from 25℃ in July/August to 28℃ in March/April. The experiments were conducted during the major seasons of each year.

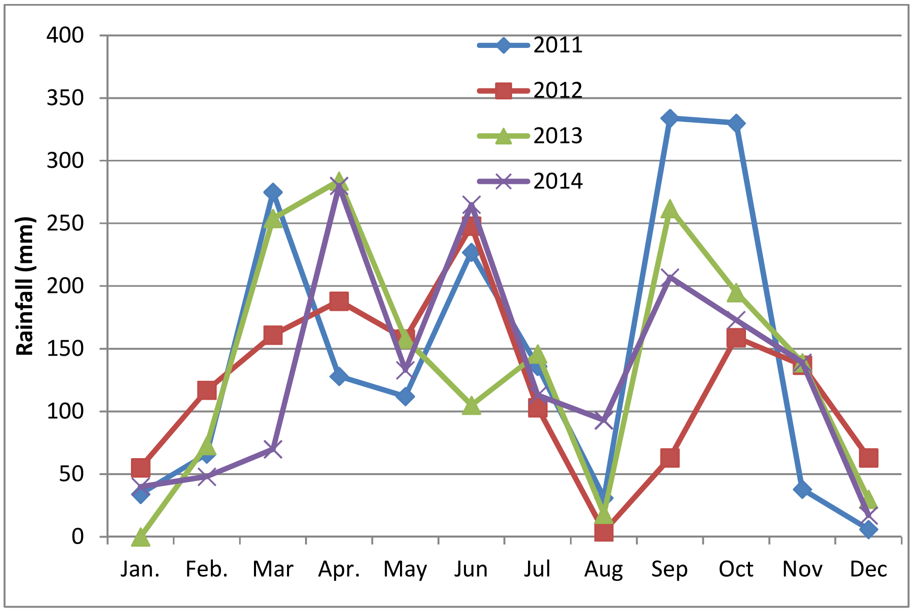

Fig. 1. Monthly rainfall distribution for the four years at Kwadaso

2.2 Experimental Design and Treatments

The experimental design was a randomized complete block arranged in a split plot with four replications. The experimental area was sprayed with a herbicide [glyphosate EC]. For minimum tillage [MT], planting was done directly without any surface disturbance. Subsequently, a cutlass was used to slash weeds off the surface when weeding was necessary. For full tillage [FT], a hoe was used to till the surface to about 10 cm depth after herbicide application. Subsequently, a hoe was used for weeding where the surface of the soil was disturbed to a depth of about 10 cm. Tillage practice formed the main treatments. Maize, intercropped with mucuna *[Mucuna pruriens]* [Maize/M]; Maize intercropped with pigeon pea *[Cajanus cajan]* [Maize/Pp]; maize intercropped with cowpea *[Vigna unguiculata]* [Maize/C]; sole maize with recommended rate of mineral fertilizer [Maize/F] and sole maize with minimum fertilizer application [normal practice of most peasant farmers] formed the sub treatments. During the first year all sub-treatments received 30-20-20 kg N-P_2O_5-K_2Oha^{-1} except Maize/F which received 60-40-40 kg N-P_2O_5-K_2Oha^{-1}. During the second year, all the treatments received30-20-20 kg N-P_2O_5-K_2Oha^{-1} except Maize/F which received 60-40-40 kg N-P_2O_5-K_2Oha^{-1} and sole Maize [farmers practice] which was not fertilized. During the third and fourth years, all the treatments received 30-20-20 kg N-P_2O_5-K_2Oha^{-1}. The leguminous crops were planted two weeks after the maize was planted. Pruning of mucuna and pigeon pea were done when the mucuna started climbing the maize plants and when the pigeon pea was at the same height with the maize plant. The Maize variety used was *Obatampa* [local name]. Plot size was 4.8 m x 4.0 m and maize was spaced at 80 cm x 40 cm planted at two seeds per hill. Where applicable basal fertilization was done two weeks after planting the maize and top-dressed five weeks. Initial soil samples were taken before treatment application.

2.3 Soil Analysis

Soil samples were air-dried, ground and passed through a 2mm sieve. Soil pH was measured at 1:2.5 of soil: distilled water ratio with a pH meter [with a glass electrode] according to the method of [18]. Total N and total C were determined by dry combustion method using NC analyzer Sumigraph NC-220 [Sumika Chemical Analysis Service, Ltd., Japan], based on the principle described by [19] for dry combusting using Perkin-Elmer 240. Exchangeable bases [K, Ca, Mg, and Na] were extracted by 1.0 M ammonium acetate [20] and the concentrations were determined by Inductively Couple Plasma Spectrometer [ICPE-9000, SHIMADZU]. Available P was extracted by Bray 1 solution and P concentration was determined by the ascorbic-molybdenum blue method [21]. Effective Cation Exchange Capacity [eCEC] was calculated as sum of exchangeable cations and acidity. Soil analysis was done in the laboratories of Japan International Research Centre for Agricultural Sciences [JIRCAS], Japan.

2.4 Plant Growth Characteristics

Soil and plant analysis development [SPAD] values were measured monthly and at 60 days after planting. SPAD value was measured using a chlorophyll meter [SPAD-502, Konica Minolta Sensing Inc., Osaka, Japan]. The uppermost fully expanded leaf was used to measure the SPAD value. Plant height and girth were recorded at maturity.

2.5 Dry Matter and Grain Yield

At maturity, an area of 7.68 m^2per treatment was demarcated and harvested. Yield components [cob weight, grain weight and stover weight] were measured and yield per hectare estimated. The statistical software, Statistics 8, was used for data analysis. Standard error was used as the mean separator.

3. RESULTS AND DISCUSSION

The experimental site has a bimodal rainfall pattern as shown in Fig. 1. The soil is a *Ferric Endoskelectic Lixisol* [22], *local name* - Nzema series, a sandy loam with low to moderate levels of soil nutrients. The organic and chemical [0-20 cm] properties of the soil are as follows; organic carbon [16.2 gkg^{-1}], total nitrogen [1.54 gkg^{-1}], available phosphorus [Bray 1; 73.0 $mgkg^{-1}$], exchangeable Potassium [0.63 cmol (+)kg^{-1}] and effective Cation Exchange Capacity [eCEC] [10.7 cmol (+)kg^{-1}]. Soil clay content was very low [4.5 gkg^{-1}]. The very high level of available phosphorus may be largely due to accumulation with little losses since the site was under fallow for over five years.

3.1 Effect of Tillage Practice on Maize Growth and Yield Components

Effect of tillage on maize performance during the four years of cultivation is presented in Table 1. Within each year no significant difference was observed between FT and MT practices throughout the four years. This supports the findings of [13-15] who noted non-significant effects of tillage treatments on the growth and yield of maize. While maize growth [SPAD value, plant girth and height] was similar throughout the four years, grain yield decreased sharply in 2012 and slightly in 2013. The over five years fallow probably supported the high grain yield observed in the first year but declined sharply during the subsequent years.

3.2 Effect of Cropping System on Maize Growth and Yield Components

Table 2 shows the effect of cropping system on the growth and yield components of maize. During the first year, grain yield was high and similar for all the cropping systems probably due to initial moderate soil fertility levels. Maize followed by maize with no fertilizer application, gave significantly lower grain yield than maize followed by mucuna with fertilizer [Maize/M+F1] and maize followed by pigeon pea with fertilizer [Maize/Pp+F1]. Nutrient addition from n-fixation and decomposing biomass of mucuna and pigeon pea may partly explain the observed results.

In the third year, Maize/Pp+F1 gave significantly higher grain yield [3.33t ha^{-1}] than all the cropping systems, followed closely by Maize/M+F1 [2.74t ha^{-1}]. In the fourth year, Maize+F1 recorded the lowest yield of 1.01 tha^{-1} which was significantly lower than all the cropping systems intercropped with a legume. Maize/Pp+F1 cropping system recorded the highest grain yield of 3.43 tha^{-1} which was significantly higher than all the other cropping systems. Nutrient addition from decomposing biomass of pigeon pea may largely explain the observed trend.

3.3 Interaction of Tillage and Cropping System

Results on the interactions between tillage and cropping system are presented in Table 3[a, b, c &d]. In the first year [2011], all the treatment combinations performed similarly [Table 3a]. The plants showed similarity in all the growth parameters resulting in similar grain yield which was relatively very high compared with the country's average yield of 1.7 tha^{-1} [1]. The site was under fallow for over five years probably leading to some nutrient build up and/or accumulation. Hence, the good growth attributes exhibited and high grain yields observed.

Table 1. Effect of tillage practice on maize growth and grain yield during four years of cultivation in the forest agro-ecological zone of Ghana

Tillage practice	SPAD value 60 DAP	Plant girth (cm)	Plant height (cm)	Stover yield (tha^{-1})	Cobs weight (tha^{-1})	Grain yield (tha^{-1})
2011						
MT	39a	7.4a	250a	9.3 a	8.7a	5.0a
FT	36a	7.2a	245a	11.7a	10.1a	5.8a
2012						
MT	47a	7.7a	255a	5.1a	3.8a	2.6a
FT	48a	7.8a	268a	4.9a	3.8a	2.6a
2013						
MT	50a	7.37a	250a	7.70b	5.58b	2.19a
FT	49a	7.70a	262a	9.62a	6.83a	2.51a
2014						
MT	38a	7.83a	254a	6.74a	5.09a	2.11a
FT	40a	7.29b	252b	6.67a	5.44a	2.18a

MT: Minimum Tillage; FT: Full Tillage; DAP: Days after planting
Within a column numbers followed by similar letters are not significant at LSD 5%

Table 2. Effect of cropping system on the growth and grain yield of maize during four years of cultivation in the forest agro-ecological zone of Ghana

Intercrop	SPAD value 60 DAP	Plant girth (cm)	Plant height (cm)	Stover yield (tha^{-1})	Cobs weight (tha^{-1})	Grain yield (tha^{-1})
2011						
Maize/M+F1	40a	7.3b	248a	11.1ab	10.1a	5.8a
Maize/Pp+F1	39a	7.3b	245a	10.9ab	10.0a	5.8a
Maize/C+F1	39ab	7.1b	248a	12.3a	10.0a	5.6a
Maize/F + F2	35bc	7.3b	248a	9.7ab	8.6a	5.0a
Maize + F1	34c	7.4b	247a	8.6b	8.4a	4.8a
2012						
Maize/M+F1	48a	7.7a	256ab	5.1a	5.0a	2.9a
Maize/Pp+F1	46a	7.8a	275a	5.2a	4.9a	2.8a
Maize/C +F1	48a	7.8a	254b	4.9a	4.3ab	2.5ab
Maize/F + F2	48a	7.7a	252b	4.9a	4.4ab	2.5ab
Maize	46a	7.6a	258a	4.8a	4.1b	2.2b
2013						
Maize/M+F1	49a	7.56a	262ab	7.78bc	6.53b	2.74ab
Maize/Pp+F1	51a	7.90a	271a	9.93a	8.12a	3.33a
Maize/C +F1	48a	7.63a	256b	9.23ab	5.99b	2.17b
Maize/F + F1	51a	7.89a	261ab	9.31ab	6.04b	2.08cd
Maize +F1	50a	6.70b	228c	7.08c	4.33c	1.44d
2014						
Maize/M+F1	39b	7.68a	256a	6.81a	5.62b	2.19b
Maize/Pp+F1	49a	8.00a	263a	7.49a	7.08a	3.43a
Maize/C +F1	38bc	7.75a	263a	6.72a	5.24b	1.99b
Maize/F + F1	39b	7.71	258a	7.12a	5.30b	2.10b
Maize +F1	32c	6.64b	228b	5.36b	3.07c	1.01c

M: Mucuna; Pp: Pigeon pea, C: Cowpea. F1:30-20-20 kg $N\text{-}P_2O_5\text{-}K_2Oha^{-1}$, F2:60-40-40 kg $N\text{-}P_2O_5\text{-}K_2Oha^{-1}$.
DAP: Days after planting
Within a column numbers followed by similar letters are not significant at LSD 5%

In the second year [2012], all treatment combinations showed similar crop growth but significant differences were observed for weight of cobs and grain yield [Table 3b], as the relatively good and similar crop growth did not translate to good grain yield. Maize/M +F1 under MT recorded grain yield that was similar to most of the other treatment combinations but significantly higher than Maize +F1 under MT. In general, grain and cob yields for the second year was about 50% that of the first year. The huge biomass and grain produced in the first year could have exhausted the soil of most of its nutrients. This, coupled with low input used [the amount of mineral fertilizer applied was less than the general recommended rate], partly explains the low grain yield observed.

Crop growth parameters and grain yield during the third year [2013] are presented in Table 3c. Maize +F1 under MT had significantly smaller plants [shorter plants with smaller girth] than all the other combinations resulting in significantly lower cob yield. Maize/Pp + F1 under FT had plants that were significantly bigger than most other treatments except Maize/M + F1 under FT, Maize/Pp + F1 and Maize/F + F1 under MT. The bigger and more vigorous growing plants observed for above mentioned treatments resulted in significantly higher grain yield. Maize + F1 under both MT and FT and maize/F + F1 recorded the lowest yields which were significantly lower than all other treatments. These observations support the findings of [23] who obtained significantly higher maize grain yield for maize-pigeon pea intercrop than sole maize or maize-cowpea intercrop. Comparatively, stover yield, cobs weight and grain yields were higher in 2013 than in 2012 [Tables 3b and 3c]. Gradual improvement of soil productivity through the addition of maize, pigeon pea, mucuna and cowpea biomass and a possible fixation of nitrogen by the leguminous plants resulted in improved grain yield during the third year for some of the treatments. The significantly higher grain yield for the maize pigeon pea and partly maize mucuna intercropped may be largely due to the huge biomass produced by these legumes. The cowpea used as intercrop [data not reported] performed poorly due to shading by the maize crop.

Growth and yield parameters during 2014 are presented in Table 3d. Maize/Pp+ F1 under both tillage practices had plants which showed vigorous growth [significantly high SPAD value] and bigger plants than all other cropping systems. This ultimately resulted in significantly higher grain yield than all the other treatments. The huge biomass produced by pigeon pea [data not reported] largely explains these observations. Maize + F1 gave the lowest grain yield of 0.48 t ha^{-1} due to gradual decline in soil nutrients resulting from continuous cropping of maize and higher weed competition.

Fig. 2 shows temporal changes in maize grain yield from 2012 to 2014. Maize grain yield for Maize/Pp+F1 under both MT and FT was similar to Maize/M+F1 under MT and almost similar with all the other cropping systems under FT in 2012. In 2013 grain yield for Maize/Pp+F1 increased significantly under both MT and FT. This increase was sustained in 2014. Maize grain yield for Maize/M+F1 did not show any consistency in terms of temporal changes in grain yield. While maize grain yield for Maize/F+F1 was consistent for both MT and FT in years 2013 and 2014, grain yield for Maize + F1 declined sharply in 2013 under MT which further decreased in 2014.

Table 3a. Effect of interaction of tillage and cropping system on the growth and grain yield of maize in the forest agro-ecological zone of Ghana in 2011

Tillage practice	Cropping System	SPAD value 60 DAP	Plant girth (cm)	Plant height (cm)	Stover yield (tha^{-1})	Cobs weight (tha^{-1})	Grain yield (tha^{-1})
MT	Maize/M+F1	32a	7.88a	255a	9.23a	8.98a	5.05a
MT	Maize/Pp+F1	32a	8.06a	256a	8.33a	7.43a	4.36a
MT	Maize/C+F1	30a	8.23a	256a	11.83a	10.68a	6.18a
MT	Maize/F + F2	29a	7.99a	258a	8.93a	8.43a	4.84a
MT	Maize	33a	8.00a	249a	8.23a	7.95a	4.65a
FT	Maize/M+F1	34a	8.13a	257a	12.93a	11.25a	6.58a
FT	Maize/Pp+F1	32a	8.03a	295a	13.40a	12.48a	6.88a
FT	Maize/C+F1	31a	7.00a	252a	12.68a	9.30a	5.32a
FT	Maize/F + F2	32a	7.84a	258a	10.38a	8.45a	5.33a
FT	Maize	32a	7.81a	255a	9.00a	7.95a	4.85a

MT: Minimum Tillage; FT:-Full Tillage; M: Mucuna; Pp: Pigeon pea, C: Cowpea. F1:30-20-20 kg $N-P_2O_5-K_2Oha^{-1}$, F2: 60-40-40 kg $N-P_2O_5-K_2Oha^{-1}$. DAP: Days after planting

Within a column numbers followed by similar letters are not significant at LSD 5%

Table 3b. Effect of interaction of tillage and cropping system on the growth and grain yield of maize in 2012

Tillage practice	Cropping System	SPAD value 60 DAP	Plant height (cm)	Plant girth (cm)	Stover yield (tha^{-1})	Cobs weight (tha^{-1})	Grain yield ($tha^{-1)}$)
MT	Maize/M+F1	46a	7.66a	255a	4.90a	4.40abc	3.23a
MT	Maize/Pp+F1	46a	7.71a	256a	5.00a	4.83abc	2.88ab
MT	Maize/C+F1	48a	7.67a	256a	5.08a	4.53abc	2.38ab
MT	Maize/F + F2	49a	7.80a	249a	5.15a	4.73abc	2.35ab
MT	Maize + F1	45a	7.49a	258a	4.90a	4.28abc	2.15b
FT	Maize/M+F1	50a	7.83a	257a	5.33a	5.53a	2.48ab
FT	Maize/Pp+F1	47a	7.90a	295a	5.15a	5.00ab	2.80ab
FT	Maize/C+F1	48a	7.83a	252a	4.75a	4.13bc	2.58ab
FT	Maize/F + F2	47a	7.65a	255a	4.60a	4.15bc	2.68ab
FT	Maize + F1	47a	7.49a	258a	4.70a	3.83c	2.28ab

MT: Minimum Tillage; FT:-Full Tillage; M: Mucuna; Pp: Pigeon pea, C: Cowpea. F1:30-20-20 kg N-P_2O_5-K_2Oha^{-1}, F2: 60-40-40 kg N-P_2O_5-K_2Oha^{-1}. DAP: Days after planting
Within a column numbers followed by similar letters are not significant at LSD 5%

Table 3c. Effect of interaction of tillage and cropping system on the growth and grain yield of maize in 2013

Tillage practice	Cropping System	SPAD value 60 DAP	Plant girth (cm)	Plant height (cm)	Stover yield (tha^{-1})	Cobs weight (tha^{-1})	Grain yield (tha^{-1})
MT	Maize/M+F1	50ab	7.30ab	257b	7.03bc	5.96bcd	2.36bcd
MT	Maize/Pp+F1	52a	7.86ab	269ab	9.34ab	7.75ab	3.34a
MT	Maize/C+F1	46b	7.52ab	250bc	8.24ab	6.06bcd	2.21cd
MT	Maize/F + F1	54a	7.90ab	261ab	9.05ab	5.15d	1.97de
MT	Maize + F1	51ab	6.26c	212d	4.82c	2.97e	1.09e
FT	Maize/M+F1	48ab	7.82ab	267ab	8.53ab	7.10abc	3.12abc
FT	Maize/Pp+F1	50ab	7.94a	273a	10.48a	8.50a	3.31ab
FT	Maize/C+F1	50ab	7.73ab	262b	10.22a	5.93bcd	2.21cd
FT	Maize/F + F1	49ab	7.88ab	261b	9.57a	6.93abcd	2.20cd
FT	Maize + F1	49ab	7.14b	245c	9.34a	5.70cd	1.80de

MT: Minimum Tillage; FT:-Full Tillage; M: Mucuna; Pp: Pigeon pea, C: Cowpea. F1:30-20-20 kg N-P_2O_5-K_2Oha^{-1},
Within a column numbers followed by similar letters are not significant at LSD 5%

Table 3d. Effect of interaction of tillage and cropping system on the growth and grain yield of maize in 2014

Tillage practice	Cropping System	SPAD value 60 DAP	Plant girth (cm)	Plant height (cm)	Stover yield (tha^{-1})	Cobs weight (tha^{-1})	Grain yield (tha^{-1})
MT	Maize/M+F1	39bc	7.93abc	261a	7.43a	5.89ab	2.30b
MT	Maize/Pp+F1	48bc	8.30a	269a	7.25a	6.93a	3.41a
MT	Maize/C+F1	39bc	8.38a	266a	6.98a	5.63b	2.25b
MT	Maize/F + F1	37c	8.08ab	267a	7.60a	1.67c	2.09b
MT	Maize + F1	26d	6.78f	210a	4.45b	5.32ab	0.48c
FT	Maize/M+F1	37c	7.42bcde	251a	6.19ab	5.35b	2.08b
FT	Maize/Pp+F1	50a	7.73abcd	258a	7.73a	7.23a	3.45a
FT	Maize/C+F1	36cd	7.13def	259a	6.46ab	4.86b	1.74b
FT	Maize/F + F1	40bc	7.35cde	249a	6.65ab	5.28b	2.11b
FT	Maize + F1	38bc	6.80ef	245a	6.26ab	4.47b	1.54b

MT: Minimum Tillage; FT:-Full Tillage; M: Mucuna; Pp: Pigeon pea, C: Cowpea. F1:30-20-20 kg N-P_2O_5-K_2Oha^{-1},
Within a column numbers followed by similar letters are not significant at LSD 5%

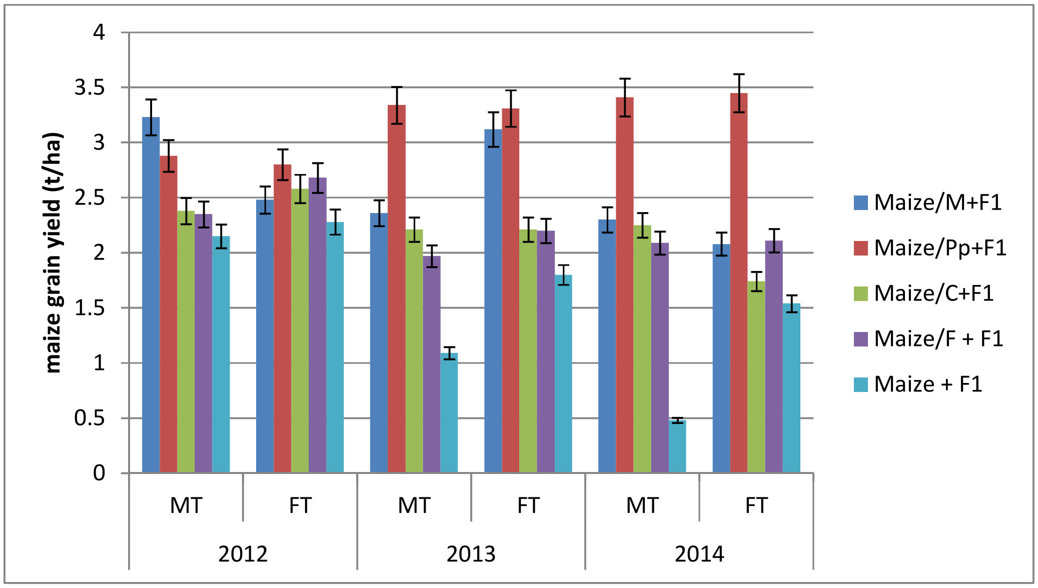

Fig. 2. Changes in maize grain yield under tillage and cropping systems from 2012 to 2014

Nutrient inputs through fixation of nitrogen and mineralization of the large amount of biomass from pigeon pea explains the improvement of maize performance when intercropped with pigeon pea. [24] observed better yield when maize was intercropped with groundnut under both no till and conversional tillage than sole maize. According to the author, no tillage and intercropping proved to be a better management option for soil and water conservation in the zone. The increasing trend of maize yield under Maize/Pp+F1 may progress to higher yields if the practice is maintained for a longer period.

4. CONCLUSION AND RECOMMENDATION

Results from the four year study clearly showed that maize pigeon pea intercropping is promising and a better option for conservation agriculture. It however, performs better under minimum tillage than full tillage.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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