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Effect of Tillage on the Growth and Yield of Cowpea Varieties in Sudan Savanna Agroecology of Northern Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SUE and AYK designed the study. Author SUE wrote the protocol and performed the statistical analysis with input from author UEU. Author UEU wrote the first and the final draft of the manuscript and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Field study was conducted during the rainy seasons (July-November) of 2007, 2008, 2009 and 2010 at the Research Farm of the International Institute of Tropical Agriculture (IITA) Minjibir, Kano State, Nigeria; to compare responses of six cowpea varieties to tillage. The treatments consisted of tillage systems (zero tillage, flat tillage and ridge tillage) as the main plot and cowpea varieties (IT89KD-391, IT90K-277-2, IT97K-461-4, IT97K-499-35, IT98K-131-2, and IT98K-506-1) as the sub-plot. The treatments were arranged as split plot laid out in a randomized complete block design with four replications.

Zero tillage was significantly superior in influencing days to maturity, canopy height, intercepted

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photosynthetic active radiation (IPAR) and leaf area index but not total dry matter and grain yield of cowpea. A positive and significant association was recorded for days to physiological maturity and canopy height across the tillage systems with a correlation coefficient of ≤ 40% for days to maturity and ≥50% for canopy height. Though flat tillage showed a positive correlation with intercepted photosynthetic active radiation (IPAR) and leaf area (LAI), but this association was not significant. However, ridge tillage showed a positive and significant correlation with IPAR and LAI (r =0.378*** and 0.384***). All the tillage systems showed a high and significant positive correlation with cowpea dry matter and fodder yield (r= 0.54*** to 0.77***). Across varieties, grain yield was better with flat tillage than zero and ridge tillage systems, with 10% yield advantage over the two. Zero and ridge tillage were similar in their effects on grain yield. Except for IPAR, LAI and total dry matter (TDM), the interaction effect of cowpea varieties and tillage systems was significant. Our result point to the fact that extensive soil tillage (especially, conventional tillage) may not be necessary for cowpea production in this agro-ecology with a high percentage of sand and a sandy loam as soil textural class. Following our result, we may recommended varieties for the different tillage systems as follows: IT98K-131-2, IT97K-461-4, IT90K-277-2, IT98K-506-1 (grain) and IT89KD-391/IT97K-461-4 (best for fodder) for zero tillage system; IT90K-277-2, IT97K-499-35, IT98K-131-2 and IT98K-506-1(grain) and IT89KD-391/IT97K-499-35 (best for fodder) for flat-tillage; IT98K-131-2, IT90K-277-2, IT98K-506-1 and IT97K-464-4(grain) and IT90K-277-2/ IT89KD-391 (best for fodder) for ridge tillage).

Keywords: Cowpea; fodder; grain yield; canopy height; intercepted photosynthetic active radiation.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp.) is a vital crop to millions of resource-poor people. It is a food and animal feed crop grown in the semi-arid tropics covering Africa, Asia, Europe, United States and Central and South America [1]. In northern Nigeria, depending on location, farmers grow cowpea on zero-tilled and tilled soils with or without ridges. In the humid tropics where most of the farmers are smallholders and chemical fertilizer is scarce and expensive, soil working and tillage methods can be a suitable alternative to enhance nutrient availability to crops [2]. Tillage practices are critical components of soil management systems and it creates an ideal seedbed condition for plant emergence, plant development and unimpeded root growth [3,4]. Inappropriate tillage practices could inhibit crop growth and yield. Selection of an appropriate tillage practice for the production of crops is a step in realizing optimum growth and yield. A good soil management and tillage practices should protect the soil from water and wind erosion, provides a good, weed-free seedbed for planting destroys hardpans or compacted layers that may limit root development and allows maintenance of organic matter [5]. Resource poor smallholder farmers in sub-Saharan Africa produce cowpea (*Vigna unguiculata* (L) Walp) under rain-fed conditions, using different tillage practices. The type of tillage systems employed by these farmers sometime depends on the availability of labour services and input cost implications. Zero tillage crop production can reduce input costs and labour and conserve the soil. The soil, however, suffers from compaction when not tilled which can negatively affect plant growth. When tilled, crops benefit from the improved looseness, oxygen supplies and water intake. However, there is no documented information on how cowpea responds to different tillage practices in northern Nigeria. Therefore, this paper reports the effects of zero tillage, flat tillage and ridge tillage on performance of cowpea in the Sudan savannah ecology of Nigeria.

2. MATERIALS AND METHODS

2.1 Site Description

The experiments were conducted during the rainy seasons (July –November) of 2007, 2008, 2009 and 2010 at the research farm of the International Institute of Tropical Agriculture (IITA), Minjibir (Lat 12º 08'N, Long 08º 32'E, elevation 500 m above sea level), 40 km north-east of Kano. Minjibir is in the Sudan savannah and has an average annual rainfall of 690 mm and a growing period of about 120 days. The characteristics of the soil at the experimental site are presented in Table 1. The soil is classified as typic Utipsamments and is sandy loam [6].

2.2 Cowpea Varieties

Six cowpea varieties (IT89KD-391, IT90K-277-2, IT97K-461-4, IT97K-499-35, IT98K-131-2, IT98K-506-1) developed at IITA (IITA, 2009) were evaluated in this study (Table 2).

Table 1. Selected soil physical and chemical properties at the experimental site (soil layer 0-15 cm)

Soil properties	Value
Sand (%)	84
Silt (%)	8
Clay (%)	8
Organic carbon (%)	0.30
pH(H_2O 1:1)	5.8
Total N (%)	0.019
Ca (cmol/kg)	1.29
Mg (cmol/kg)	0.22
K (cmol/kg)	0.20
Available P (mg/kg)	20.76
Na (cmol/kg)	0.86
Exch. acidity (cmol/kg)	0.08
ECEC (cmol/kg)	2.66
Zn (ppm)	0.83
Cu (ppm)	0.25
Mn (ppm)	41.45
Fe (ppm)	60.65

2.3 Treatments and Experimental Design

The experiment was a split-plot laid out in a randomized complete block design. The treatments were tillage systems (zero tillage, flat tillage and ridge tillage) and the cowpea varieties. Tillage systems were assigned to the main plot and cowpea varieties were assigned to the subplots. The experiment had four replications with a subplot measuring 3.0 m × 5.0 m, containing four ridges, with 75 cm spacing between ridges.

2.4 Cultural Practices

Gramoxone (1:1-dimethyl-4, 4-bipyridinum dichloride, manufactured by Syngenta Crop Protection AG, Basle, Switzerland) at a rate of 1 litre /ha was used to kill the vegetation at the time of land preparation. Zero tillage blocks were left undisturbed. The flat tillage block was harrowed and left without forming ridges. The ridge tillage block was harrowed and ridged. Cowpea seeds were treated with Apron star (20% w/w thiamethoxam, 20% w/w metalaxyl-M and 2% w/w difenoconazole, Syngenta Crop Protection AG, Basle, Switzerland) at a rate of four kilogram to a sachet of 10 g before planting. On 13, 11, 10 and 16 July 2007, 2008, 2009 and 2010 respectively, three seeds of cowpea were planted per hole, 75 cm between rows and 20 cm apart on each ridge. This was thinned to two plants per stand two weeks after planting to obtain a cowpea plant population of 133, 333 plants ha^{-1}. Inorganic fertilizer, NPK 15:15:15 at a rate of 15 kg, ha^{-1} of N, P_2O_5 and $K_2O$and SSP at a rate of 30 kg phosphorus ha^{-1} were applied by side placement at the time of planting, making total 45 kg ha^{-1} phosphorus as P_2O_5. At planting, a mixture of gramoxone (1:1-dimethyl-4, 4-bipyridinum dichloride, manufactured by Syngenta Crop Protection AG, Basle, Switzerland) and Pendilin (500 g/l pendimethalin, manufactured by Meghmani Industries Limited, India) at a rate of 1 l/ha each, was applied as a pre-emergent herbicide. Thereafter, weeds on zero tillage plots were controlled by hand-pulling and those on flat and ridge tillage plots were weeded using hoes just before flowering. During the vegetative, flowering and podding stages, cowpea plants were sprayed with Karate (50 g/l lamda-cyhalothrin, Syngenta Crop Protection AG, Basle, Switzerland), applied at a rate of 1.0 l ha^{-1} as soon as the first few insects were noticed.

2.5 Data Collection

Field data were collected from the net plot (two middle rows leaving the outside rows and a distance of 50 cm at the ends of each middle row to serve as borders) of $6m^2$(1.5m × 4m). Leaf area index and intercepted photosynthetically active radiation (IPAR) were measured simultaneously at full cowpea flowering (7 weeks after planting (WAP) using AccuPAR model LP-80 PAR/LAI Ceptometer (Decagon Devices, Inc., Pullman, USA). Incident PAR was measured in the open without vegetation interception, above the cowpea canopy in each plot. Five above-canopy measurements were taken and the displayed average recorded. Intercepted PAR was measured under the cowpea canopy in each plot. The sensor was placed diagonally across the two middle rows, so that the ends of the sensor coincided with the line of plants in each row. Five measurements were taken and the displayed average recorded. Observations were taken under cloud-free conditions between 12.00 noon and 2.00 pm in the afternoon. The percentage of PAR intercepted by the cowpea canopy was calculated as:

$$IPAR = (1.0-(PARb/PARa)) \times 100$$

Where,

IPAR = intercepted PAR, PARa = PAR, umol

m^2/s, measured above cowpea canopy, PARb = PAR measured below cowpea canopy.

Days from sowing to when 95% of the pods reached maturity were recorded. At pod maturity, mean canopy height taken over six points in a plot was recorded. At this time, pod yield, leaf weight and stem weight from a 6-plant sample harvested along the two middle rows were used to calculate total dry matter. Dry pods from the two middle rows were hand-picked, sun-dried for one week and threshed. Grains were weighed and added up with those from the 6-plant sample. Percentage moisture content of grains was determined using Farmex MT-16 grain moisture tester. Grain yield adjusted to 14% moisture was computed from the grain. Mean 100-seed weight of three lots was recorded for each plot. Fodder from the net plot were rolled up together and left on the plot to sun-dry to a constant weight. Dried fodder was weighed on the field to obtain fodder yield per plot. This was added up with those from the 6-plant sample and calculated as fodder yield in kg ha^{-1}.

2.6 Data Analysis

Combined statistical analysis for the four years was performed on the data using SAS [10]. The combined analysis was done because year, variety and tillage interaction were not significant for the greater numbers and most important of the cowpea attributes measured. The SAS procedure used for the ANOVA was mixed model applying the REML method at 5 % level of probability. Replication was treated as random effect and tillage as fixed effect in determining expected mean square and appropriate *F*-tests in the ANOVA. Differences between treatment means, and interaction effect were compared using Least Significant Difference (LSD) at 5% level of probability. Linear correlation coefficient (r) among combined means of four years of tillage systems and cowpea traits was calculated at 5%.

3. RESULTS

3.1 Cowpea Growth and Yield Responses to Tillage

Tillage significantly ($P<0.05$) influenced all growth parameters measured and yield of cowpea (Table 3). There were significant varietal differences with respect days to maturity and canopy height. Except for total dry matter, there were significant year differences with respect to variety. However, variety response to tillage was not significant for light interception, leaf area index and total dry matter. Tillage and variety interaction was not significantly influenced by year except for days to maturity, canopy height and leaf area index ($P\leq0.05$) (Table 3).

3.2 Days to 95% Pod Maturity in Cowpea

Though there were varietal differences in maturity days with respect to tillage, zero and flat tillage however, had significantly longer maturity days for all the varieties compared with ridge tillage, which had shorter maturity period (Table 4).

3.3 Canopy Height

Cowpea planted in ridge plots had significantly shorter cowpea canopies compared with those that were planted in untilled or flat tilled plots. Zero tillage plots on the other hand, had significant taller cowpea canopy compared to flat tillage ($P\leq0.05$) (Table 5). Irrespective of tillage type, IT89KD-391 had the tallest cowpea canopy while IT98K-506-1 had the shortest cowpea canopy (Table 5). However, tillage significantly influenced variety canopy height.

3.4 Intercepted Photosynthetically Active Radiation (IPAR)

Intercepted PAR followed a similar trend like canopy height, with zero tillage and flat tillage intercepting ≥ 70% of the incident light; while ridge tilled plots intercepted about 50% of the incident light (Table 6). Canopy light interception was greater with IT89KD-391 averaging about 70% while IT98K-506-1 intercepted the lowest amount of light averaging about 60% (Table 6). Tillage however, did not significantly ($P\leq0.05$) improve variety effect on light interception.

3.5 Leaf Area Index (LAI)

Tillage did not significantly influence variety leaf area ($P\geq0.05$) (Table 7). However, leaf area index was significantly higher with zero and flat tillage compared to ridge tilled plots. IT89KD-391 was the only variety that had a significantly higher leaf area index than IT98K-506-1(Table 7).

3.6 Total Dry Matter per Plant

Variety total dry matter was significantly influenced by tillage. However, zero and flat tillage had a significant higher dry matter compared to varieties planted on ridges. The variety IT90K-277-2 had a significant higher total dry matter compared to the rest of the varieties (Table 8). Irrespective of variety, total cowpea dry matter was as follow: flat-tillage (40.5%) and zero tillage (37%) greater than ridge tillage.

3.7 Fodder Yield

Fodder yield was significantly higher with zero and flat tillage plots compared to ridge tilled plots (Table 9). The varieties IT89KD-391 and IT90K-277-2 had significantly higher fodder yield compared with the rest of the varieties, with IT98K-506-1 having the lowest fodder yield (Table 9).

3.8 Grain Yield

Irrespective of tillage system, cowpea varietal yield was in this order of importance IT90K-277-2 > IT98K-131-2 > IT98K-506-1 > IT97K-461-4 > IT97K-499-35 > IT89KD-391 (Table 10). The highest cowpea yield came from the variety IT90K-277-2 (1432 kg ha^{-1}), and followed by IT97K-499-35 (1405 kg ha^{-1}). Both varieties were from flat tilled plots. The lowest yield on the other hand, was recorded in ridge tilled plot with the variety IT97K-499-35. There was a significant tillage and variety interaction effect on cowpea yield, with all varieties planted on flat-tilled plots having a significant higher yield (10%), compared to varieties planted on zero and ridge-tilled plots (Table 10). Irrespective of tillage type, varieties IT90K-277-2 and IT98-131-2 had significantly higher grain yield compared with the other varieties (Table 10). However, yield of IT98K-131-2 was not significantly (P≥0.05) greater than that of IT98K-506-1.

3.9 Relationship of Grain Yield with Other Traits

There was a higher (≥50%) positive correlation between tillage and the following growth parameters, canopy height, total dry matter and fodder yield (Table 11). Day to maturity had a lower positive correlation (≤ 40%) with tillage (Table 11). Except for ridge –tillage which had low positive correlation (≥ 37%), intercepted PAR and LAI had no significant correlation with other forms of tillage.

Table 2. Some of the Characteristics of the cowpea varieties used for the trial

Cowpea variety	Characteristics	Texture
IT89KD-391	Medium maturing (75-80), dual-purpose, medium sized seeds, moderately susceptible to insect pests and diseases, needs 3–4 sprays, very good as a relay with cereals, yields 1300–1700 kg/ha.	Rough
IT90K-277-2	Medium maturing (75–80 days), medium sized seeds, some level of resistance to insects and diseases, needs 2–3 sprays, high grain yield about 1500-2000 kg/ha, high fodder yield.	Rough
IT97K-461-4	Medium maturing (83–87) days), erect, seed size, big and brown. High seed size yield, 1500-2000kg/ha.	Smooth (hairy)
IT97K-499-35	Medium maturing (75–80 days), medium sized seeds, *Striga* and *Alectra* resistant, some level of resistance to insects and diseases, needs 2–3 sprays, high grain yield about 1500-2000 kg/ha, heat and drought tolerant, very good in dry season.	Rough
IT98K-131-2	Medium maturing (75–80) days), erect, seed size, medium and brown. High seed size yield, 1500-2000kg/ha.	Rough
IT98K-506-1	Medium maturing (80–87) days), semi-erect, seed size, moderate and white. High seed size yield, 1500-2000kg/ha.	Smooth

Source: [7, 8, 9]

Table 3. Probability of F values for growth and yield responses of cowpea varieties to tillage at Minjibir in Nigerian Sudan savannah

Effect	Days to maturity	Canopy height	IPAR†	Leaf area index	Total dry matter	Fodder yield	Grain yield
Year (Y)	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Tillage (T)	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.002
Y × T	0.4933	<.0001	0.0142	0.0176	<.0001	<.0001	0.001
Variety (V)	<.0001	<.0001	<.0001	0.0011	0.0001	<.0001	0.0005
Y × V	<.0001	<.0001	0.0051	0.0012	0.0614	<.0001	0.004
T × V	0.0023	<.0001	0.3782	0.0854	0.5683	0.0007	0.004
Y × T × V	0.0001	0.0149	0.1934	0.0031	0.1793	0.0625	0.5727

†IPAR, intercepted photosynthetically active radiation

Table 4. Interactive effects of tillage and variety on days to maturity of cowpea at Minjibir in Nigerian Sudan savannah

Variety	Tillage			Variety means†
	Zero tillage	Flat tillage	Ridge tillage	
IT89KD-391	84.4	79.8	77.4	80.5
IT90K-277-2	76.9	78.1	73.6	76.2
IT97K-461-4	70.0	72.4	66.1	69.5
IT97K-499-35	74.3	74.2	68.5	72.3
IT98K-131-2	79.8	76.4b	74.2	76.8
IT98K-506-1	72.9	72.1	67.8	70.9
Tillage Means†	76.4	75.5	71.2	
$LSD_{0.05}$ Tillage (T)	0.75			
$LSD_{0.05}$ Variety (V)	1.0			
$LSD_{0.05}$ T × V	1.65			

Table 5. Interactive effects of tillage and variety on canopy height in cowpea at Minjibir in Nigerian Sudan savannah

Variety	Tillage			Mean†
	Zero tillage	Flat tillage	Ridge tillage	
	----------------------------Height (cm)---------------------------			
IT89KD-391	63.8.	56.2	50.4	56.8
IT90K-277-2	56.5	53.0	45.1	51.5
IT97K-461-4	55.1	51.1	40.9	49.0
IT97K-499-35	53.8	56.6	43.1	51.2
IT98K-131-2	60.6	53.4	46.3	53.4
IT98K-506-1	48.9	50.1	42.2	47.1
Tillage Mean†	56.5	53.4	44.7	
$LSD_{0.05}$Tillage(T)	1.39			
$LSD_{0.05}$ Variety(V)	1.87			
$LSD_{0.05}$ T × V	3.17			

Table 6. Interactive effects of tillage and variety on percentage intercepted photosynthetically active radiation (IPAR) in cowpea at Minjibir in Nigerian Sudan savannah

Variety	Tillage			Mean†
	Zero tillage	Flat tillage	Ridge tillage	
	----------------------------------(%)--			
IT89KD-391	87.2	78.2	58.6	74.7
IT90K-277-2	75.7	82.7	50.7	69.7
IT97K-461-4	77.6	71.8	48.0	65.8

Table 6 continued…..

IT97K-499-35	78.3	75.7	51.8	68.6
IT98K-131-2	85.7	74.5	53.1	71.1
IT98K-506-1	69.8	70.5	40.3	60.2
Tillage Mean†	79.1	75.6	50.4	
$LSD_{0.05}$Tillage(T)	3.90			
$LSD_{0.05}$ Variety(V)	5.56			
$LSD_{0.05}$ T × V	9.46[ns‡]			

‡ns, not significant at 0.05 level of probability

Table 7. Interactive effects of tillage and variety on leaf area index (LAI) in cowpea at Minjibir in Nigerian Sudan savannah

Variety	Tillage			Mean†
	Zero tillage	Flat tillage	Ridge tillage	
IT89KD-391	3.7	3.2	1.8	2.9
IT90K-277-2	2.8	3.2	1.5	2.5
IT97K-461-4	2.9	2.5	1.5	2.3
IT97K-499-35	3.3	2.9	1.5	2.6
IT98K-131-2	3.7	2.8	1.6	2.7
IT98K-506-1	2.6	2.9	1.2	2.3
Tillage Mean†	3.2	2.9	1.5	
$LSD_{0.05}$Tillage(T)	0.32			
$LSD_{0.05}$ Variety(V)	0.32			
$LSD_{0.05}$ T × V	0.55[ns‡]			

‡ns, not significant at 0.05 level of probability

Table 8. Interactive effects of tillage and variety on total aboveground dry matter of cowpea at Minjibir in Nigerian Sudan savannah

Variety	Tillage			Mean†
	Zero tillage	Flat tillage	Ridge tillage	
	---------------------------------($g\ plant^{-1}$)-------------------------------			
IT89KD-391	88.7	83.4	47.5	73.2
IT90K-277-2	92.3	106.7	71.1	90.1
IT97K-461-4	80.0	79.1	53.4	70.8
IT97K-499-35	74.6	93.0	41.5	69.7
IT98K-131-2	91.0	90.0	56.1	79.0
IT98K-506-1	74.3	78.6	46.3	66.4
Tillage Mean†	83.5	88.4	52.6	
$LSD_{0.05}$ Tillage(T)	7.85			
$LSD_{0.05}$ Variety(V)	10.32			
$LSD_{0.05}$ T × V	17.63[ns‡]			

‡ns, not significant at 0.05 level of probability

Table 9. Interactive effects of tillage and variety on fodder yield in cowpea at Minjibir in Nigerian Sudan savannah

Variety	Tillage			Mean†
	Zero tillage	Flat tillage	Ridge tillage	
	← ($kg\ ha^{-1}$) →			
IT89KD-391	3846.1	3227.6	2196.3	3090.0
IT90K-277-2	3087.2	3096.2	2518.3	2900.6
IT97K-461-4	3350.3	2733.4	2106.8	2730.2
IT97K-499-35	2580.9	3170.7	1641.7	2464.4
IT98K-131-2	3089.5	2853.0	1881.8	2608.1

Table 9 continued…..

IT98K-506-1	2750.9	2663.3	1609.5	2341.2
Tillage Mean†	3117.5	2957.4	1992.4	
$LSD_{0.05}$ Tillage(T)	215.88			
$LSD_{0.05}$ Variety(V)	237.68			
$LSD_{0.05}$ T × V	406.08			

Table 10. Interactive effects of tillage and variety on grain yield in cowpea at Minjibir in Nigerian Sudan savannah

Variety	Tillage			Mean†
	Zero tillage	Flat tillage	Ridge tillage	
	← (kg ha^{-1}) →			
IT89KD-391	1052.0	1129.6	*1055.1*	1078.9
IT90K-277-2	1163.4	1432.3	1293.0	1296.2
IT97K-461-4	1223.7	1076.9	1071.8	1124.1
IT97K-499-35	993.6	1404.9	906.5	1101.7
IT98K-131-2	1308.7	1257.7	1246.2	1270.9
IT98K-506-1	1119.0	1255.2	1151.6	1175.3
Mean†	1143.4	1259.4	1120.7	
$LSD_{0.05}$ T	82.65			
$LSD_{0.05}$ V	117.68			
$LSD_{0.05}$ T × V	201.04			

Table 11. Correlation coefficients of grain yield with other traits under different tillage systems

Trait	Zero tillage	Flat tillage	Ridge tillage
Days to maturity	0.406***	0.413***	0.264**
Canopy height	0.580***	0.517***	0.560***
IPAR†	0.231	0.066	0.378**
Leaf area index	0.232	0.001	0.384***
Total dry matter	0.541***	0.605***	0.682***
Fodder yield	0.716***	0.729***	0.772***

†IPAR, intercepted photosynthetically active radiation
**significant at 0.05 probability level*
***significant at 0.01 probability level*
****significant at 0.001 probability level*

4. DISCUSSION

Days to physiological maturity showed positive correlation across the tillage systems. The association of tillage systems with day to maturity was as follows, Flat-tilled plot (0.41) > zero-tilled (0.40) >ridge tilled (0.26). Tillage had a significant effect on varietal canopy height in this study. Zero tillage had the tallest plants and canopy when compared to both flat and ridge tillage. The effect of zero-tillage on plant canopy height can be attributed to the fact that the soil of the study site has a high percentage of sand (84%) and was characterized as sandy loam. Soil with up to 80% sand is adjudged loose enough to enable crop performance without tilling [11]. Tillage effect on cowpea height has been reported by various authors. This result, agrees with earlier reports that found taller cowpea plants in no tillage plots under ferric luvisol in the rainforest zone of Nigeria [12], but in contrast with another reports that taller plants were found in tilled plots [13]. The higher cowpea canopy height in zero tillage and flat tillage as against ridge tilled may be attributed to better aeration and adequate moisture or differences in soil structure and fertility level [14]. Canopy light interception (Intercepted Photosynthetic Active Radiation (IPAR)) followed a similar trend like canopy height, with zero tillage and flat tillage intercepting about 20 % more of the incident light than ridge tilled plots. However, the interaction effect of tillage systems and variety in terms of light interception was not significant. This may be due the fact that tillage did not influence varietal leaf area significantly. The effect of tillage on leaf area followed the same trend as PAR interception, with zero and flat tillage systems having higher cowpea leaf area than the ridge tillage system. Though zero tillage was superior to flat tillage in terms of leaf area but the difference was not significant. This result is in contrast with other work which reported slightly higher leaf area in tilled plots [15]. A positive correlation was recorded for LAI with the tillage systems, but this was only significant for ridge tillage system (*r*= 0.38***). Flat tillage system was superior to zero tillage in total dry matter yield but the difference was not significant. The lowest dry matter yield was recorded in the ridge tillage. This result agrees with other authors [13], who recorded higher dry matter in tilled plot (flat-tilled), but in disagreement with the authors on the basis of lower dry matter recorded with no-till plots under a ferric Acrisols with a sandy loam textural class [16,17]. In terms of fodder and grainyield the varieties IT90K-277-2 and IT98K-131-2 will be the variety of choice whether or not land is tilled in this ecology, this is because these varieties had the highest total above-ground dry matter and grain yield across the tillage systems. Also these varieties are early to medium maturing, may therefore escape extreme drought in this agro-ecology. In another study, and similar environment these two varieties were also reported to have a higher harvest index and yield per plant among other cowpea varieties studied [18]. The effects of tillage on crop production have therefore been found to be its influence on growth, development and yield [19]. However, where minimum tillage is to be practiced, the varieties of choice will be IT89KD-391 for fodder yield followed by IT90K-277-2, while for grain yield IT90K-277-2 will be followed by IT98K-131-2.

5. CONCLUSION

Averaged over the variety means and tillage systems, zero tillage performed slightly better than the other tillage systems except for total dry matter and grain yield; where flat tillage performed better than the rest of the tillage systems Considering this result, it can be concluded that soil tillage in an area with high percentage of sand in the textural class may not offer any greater advantage for cowpea production, as the soil is already loose and further tillage on this type of soil can lead to soil damage with its implication on crop performance. For fodder and grain yield, irrespective of tillage system, varieties IT89KD-391 and IT90K-277-2 will be recommended. Fodder yield only in minimum or no-till situation IT89KD-391 and IT90K-277-2 will be the variety of choice, while IT90K-277-2 and IT98K-131-2 will be for grain.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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