

Effect of Tillage Practice on Growth and Yield of three Selected Cowpea Varieties (*Vigna unguiculata*) in Turkana County, Kenya

ABSTRACT

Aim: To evaluate the influence of tillage practice on growth and yield of selected cowpea varieties

Study Design: The treatments were laid out in a randomized complete block design (RCBD) with a factorial arrangement and replicated three times.

Place and Duration of Study: Study was carried out at St Theresa demo farm and Nakamane irrigation scheme in Turkana county in November 1914 January 2015.

Methodology: Treatments comprised of 3 tillage practices which were conventional tillage (control), conventional tillage+ mulch and Zero tillage which were tested on, growth and yield of 3 cowpea varieties namely M66, K80 and Kenkunde

Data collected included; plant height, nodule count, total leaf vegetable yield, Pod length, number of pods per plant, number of seeds per pod, grain yield, Hundred-seed weight total biomass and Harvest index.

Results: Both tillage practice and variety had no effect on plant height. while conventional tillage+ mulch increased the number of nodules per plant by 58.9%, zero tillage reduced it by 26.9 %. Tillage increased fresh leaf weight, total grain yield, total biomass and harvest index. Tillage had no significant influence on 100 seed weight at St Theresa Demo farm. However, at Nakamane irrigation scheme Tillage+mulch increased 100 seed weight by 12.6% while zero tillage reduced it by 7.2 %. Nodule count, pod length and hundred seed weight were different among varieties; however, the effects of variety on number of pods per plant, total biomass and harvest index were not significant.

Conclusion: From this study conventional tillage followed by zero tillage enhanced increased grain and fresh leaf weight for varieties that were studied which could be attributed to favorable moisture conditions.

Keywords: Cowpea; varieties; growth; yield; tillage practice.

32 1.0 Introduction

33 Cowpea is widely grown by the resource-poor farmers in the semi-arid parts of Kenya for
 34 subsistence and as a source of income (Macharia, 2004). ~~It has proteins of up to 35% and can~~
 35 ~~therefore validly replace animal protein in the world where plant production is by far more~~
 36 ~~important than animal production~~ (Nelson *et.al* 1997). It flourishes where other crops when
 37 water-stressed, wilt during droughts hence is a crop of choice to fight nutritional and food
 38 insecurity in the country (Jones *et al.*, 2001) Although it is drought tolerant its' performance
 39 depends on the amount of water stored in the soil at critical time when it is needed, (Jalota *et al.*,
 40 2001). However, the available soil moisture is influenced by tillage methods (Fuentes *et al.*,
 41 2003), soil physical properties and climatic factors especially rainfall distribution and reliability
 42 (Foller and Rockstrom, 2001). Although it is being promoted in Turkana its yield remains low.
 43 This has been attributed to several factors including unreliable rainfall within seasons. If this
 44 occurs, growth and yield is greatly affected. However, use of appropriate tillage practices and
 45 variety can increase soil productivity. This technology has not been tried in Turkana on cowpea
 46 hence this study was conducted to establish the influence of different tillage practices and variety
 47 on growth and yield of three selected cowpea varieties.

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2.0 Materials and Methods

2.1 Experimental Site Description

The field experiments were carried out at St Theresa Pastoral Centre demo farm and Nakamane irrigation scheme along river Turkwel in Turkana county North west of Kenya. The field stations fall within an elevation range of 597m to 800m above sea level with an annual rainfall of between 150mm and 500 mm and a temperature range of 24°C to 38°C. The predominant soils in St Theresa Pastoral Centre demo farm site are undifferentiated tertiary volcanic soils, derived from colluvial and alluvial deposits. They are shallow to moderately deep well drained and dark reddish brown/dark greyish brown in colour. The soil along the Turkwel River that is classified as riverine flood plain is riverine alluvium that is pale brown to dark brown in colour. They are deep, non-saline and locally calcareous. The soils are stratified fine sand to loam with a high infiltration rate. The predominant soils of Nakamane are undifferentiated tertiary volcanic soils and derived from colluvial and alluvial deposits. They are shallow to moderately deep well drained and dark reddish brown/dark greyish brown in colour. They are stratified fine sand to clay. Sombroek et al., (1980).

2.3 Experimental Design

The treatments were laid out in a randomized complete block design (RCBD) with a factorial arrangement and replicated three times. Treatments comprised of 3 tillage practices which were conventional tillage (control), conventional tillage+ mulch and Zero tillage which were tested

on , growth and yield of 3 cowpea varieties namely M66, and Kenkunde. The plots were 4x
 3m within the basin and were separated by 0.5m path. There was 1m buffer zone between
 basins. Individual blocks measured 43x3m to give 129m² and were separated from the adjacent
 block by a tertiary canal and 1m buffer zone. The entire experimental plot was 43x 17m to give
 731m². There were two plots each measuring 4 x 3m within the basins and were separated by
 0.5m paths. There was 1m buffer zone between basins. In conventional tillage (**control
 treatment**) land was prepared to a fine tilth before sowing at 50mm (Aikins et al., 2008). In the
 second treatment (**tillage+mulch**) land was prepared to fine tilth before sowing at 50mm and
 mulch applied at the rate of 4tha-1 (Hartsfield et al., 2001) and nama et al., 2005). In the third
 treatment (**zero tillage**) land was cleared off weeds before sowing at 50mm. Water was applied
 at the depth of 40mm at an interval of 7 days using basin irrigation however when it rained
 irrigation was delayed sometimes up to a week. Application of P was done at the rates of 40 kg
 /ha, from Di-ammonium phosphate (18:46:0). Manure was applied at the rate of 5 tons per
 hectare (Madamba et.,al. 2006). Sowing was done at a spacing of 40x20 cm and at the rate of 3
 seeds per hill thinned to two seedlings after 14 days of sowing. First mechanical weed control
 was done at 2 weeks after plant emergence while the second one at 4 weeks during the
 vegetative stage and at 6 weeks close to crop physiological maturity in plots under Conventional
 tillage and conventional +mulch. The Cowpea plants were protected against aphid infestation
 and flower sucking insects through sprays of Duduthrin (Lambda- cyhalotrin 1.75 EC) and
 (Alpha- cypermetrin 10 EC) insecticides at the rate of 20ml/20L .H₂O and 5ml/20L.H₂O.
 Harvesting of fully expanded leaves from two middle rows of each experimental plot started 4
 weeks after germination and repeated after every 14 days as this gave the highest grain yield

(Said et al.,2007). Harvesting ceased when 50% flowering was achieved in all experimental plots as this gave the highest grain yield (Karikari and Molatakgsi, 1999)

2.4 Data Collection

Plant height

Plant height data ~~in~~ was taken using 30 cm ~~ruler~~ one square meter area of plants from the central rows in all the experimental plots from 5 plants in the inner rows once every 10 days after 14 days of emergence and continued for 5 weeks and an average recorded.

Nodule count

Five plants from one square meter area of ~~plants from~~ the central rows in all the experimental plots were uprooted then watered up to saturation point. The root system was washed by keeping them in a bucket containing water. The nodules were ~~then~~ separated and counted to determine nodule number ~~then an~~ average recorded.

Total ~~of vegetable~~ yield (g)

Leaf harvesting was done from one square meter area of ~~plants from~~ the central rows in all the experimental plots. Harvesting of fully expanded leaves was done in each plot at the beginning of the fourth weeks after emergence and every after 14 days interval, ~~as~~ this gave the highest grain yield, (Said et al.,2007). Fresh weight was obtained for each treatment before the leaves were dried in the sun for three days to 5% moisture content to get their dry weight. Harvesting continued in all treatments until 50% flowering was attained.

117 **Number of pods per plant.**

118 Number pods per plant was determined at physiological maturity using the method suggested
 119 by Eghe (2009) where ds count was divided by plants count from one square meter area in
 120 all experimental plots.

$$121 \text{ Number of pods per plant} = \frac{\text{Number of pods on selected plants}}{\text{Number of selected plants}} \dots\dots\dots \text{Equation 1}$$



122 **Length of pods (cm)**

123 Pod length was taken when pods had matured as indicated by change in pod colour. This was
 124 done by selection of 5 plants from one square meter area of the central rows on each
 125 experimental plot and then measuring pod length in ntimetres and an average taken for each
 126 treatment.

127 **Number of seeds per pod**

128 Number of seed per pod was determined by selection of 5 plants from one square meter area of
 129 the central rows for each treatment and counting the number of seeds. The result was converted
 130 to number of **seeds /ha** for each treatment.

131 **Hundred-seed weight (g)**

132 Hundred-seed weight was determined by randomly counting 100-seed from the threshed and sun
 133 dried seeds from each plot. These were weighed to represent the 100 seed weight

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136 **Grain yield (t/ha)**

137 Grain yield was determined at physiological maturity when about 85 % of pods had turned
 138 brown (Dugie *et al.*, 2009) and more than 75 % of leaves had senesced. One square meter area of

139 plants from the central rows on each plot was harvested for the grain yield analysis. The
 140 harvested pods were sun dried to a constant weight. The grains were ~~then~~ removed from the pods
 141 and weighed. Finally, the grains were dried to 13% moisture content. The weights taken per
 142 treatment were ~~then~~ converted to tons per Hectare.

143 **Total biomass**

144 The total dry matter weight was evaluated after harvesting all the plants from one square meter
 145 area of plants from the central rows on each plot. The plants were cut above the ground when
 146 over 75% of the pods were dry. To determine the dry weight, plants were sun dried for 3 days to
 147 constant moisture content and reweighed. The total biomass of each treatment was calculated by
 148 adding the dry weight of fresh leaves and the dry weight of the plant at harvest with the seeds
 149 removed. 

150 **Harvest index**

151 Harvest index was calculated by using the formula suggested by Donald (1963) and expressed as
 152 a percentage

$$153 \quad \text{Harvest Index} = \frac{\text{Economic yield}}{\text{Total biological yield}} \times 100 \quad \text{.....equation 2}$$

154 Where economic yield is seed yield whilst the total biological yield is the summation of total
 155 biomass and seed yield plus pod chaff.

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159 **2.5 Data Analysis**

160 The data collected was subjected to analysis of variance (ANOVA) using the Genstat (2012)
161 software package version 15.1. Significant treatment differences were obtained using Fisher's
162 Protected LSD test. Effects were considered significant in all statistical analysis for P values $\leq$
163 0.05.

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165 3.0 Results

166 3.1: Effect of tillage practice on plant height (cm)

167 Tillage practice, variety and their interaction (**Table 1**) showed no significant ($P \leq 0.05$) effects on
 168 plant height in both sites. However, from observations, Kenkunde and ~~M66~~ recorded the
 169 highest and k80 had the lowest plant height in both experimental sites

170 **Table 1: Effect of tillage practice on plant height (cm)**

171	Theresa				Nakamane			
172	Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde Mean
	Tillage(T)							
	Conventional tillage	30.9	32.3	32.0	31.7	28.5	29.3	35.0 31.00
	Conventional tillage + mulch	28.9	28.3	31.1	29.4	28.1	23.3	28.1 26.5
	Zero tillage	33.5	31.00	31.7	32.0	30.4	26.0	28.4 28.2
	Mean	31.1	30.5	31.6		29.0	26.4	30.5
	LSD _(p<0.05) T	4.064 ^{ns}				4.169 ^{ns}		
	LSD _(p<0.05) V	4.064 ^{ns}				4.169 ^{ns}		
	LSD _(p<0.05) T*V	7.040 ^{ns}				7.221 ^{ns}		
	cv%	13.1				14.6		

173 ns indicates non-significant

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175 **3.2 :Effect of tillage practice on root length (cm)**

176 Tillage practice, variety and their interaction had significant effects on root length at Nakamane
177 irrigation scheme. However, only tillage practice had a significant effect on root length at St.
178 Theresa demo farm.

179 **Table 2: Effect of Tillage Practice and Variety on root length**

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Theresa					Nakamane			
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	14.2	16.4	14.7	15.1	11.8	12.4	18.8	14.5
Conventional tillage + mulch	11.3	15.1	14.6	13.7	17.4	13.2	13.0	14.3
Zero tillage	13.6	12.4	12.4	12.8	8.7	10.4	11.6	10.4
Mean	13.0	14.6	13.9		12.6	12.2	14.5	
LSD _(p<0.05) T	1.491*				1.717**			
LSD _(p<0.05) V	1.491 ^{ns}				1.717*			
LSD _(p<0.05) TXV	2.583 ^{ns} 				2.973**			
%CV	10.8				13.1			

182 * indicate significance at P<0.05, ** indicate significance at P<0.01, ns indicates non-significant

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3.3: Effects of Tillage Practice and Variety on Nodule Count

The effects of soil tillage practice and variety (**Table 3**) on nodulation were significant at St Theresa Demo farm. However, nodulation was not significantly influenced by tillage practice at Nakamane irrigation scheme. Interaction of the treatments under investigation was significant at St Theresa Demo farm. Results revealed that conventional tillage+ mulch increased the number of nodules per plant by 58.9% while zero tillage reduced it by 26.9 % as compared to control. Total number of nodules was significantly influenced by variety in both experimental sites. Kenkunde yielded more mean nodules as compared to both M66 and K 80.

Table 3 Effects of Tillage Practice and Variety on Nodule Count

Theresa					Nakamane			
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	10.33	9.00	16.33	11.89	11.00	7.67	11.67	10.11
Conventional tillage + mulch	10.67	20.33	20.00	17.00	12.00	7.33	16.00	11.78
Zero tillage	10.00	6.33	9.67	8.69	11.00	7.67	8.00	8.89
Mean	10.33	11.89	15.33		11.33	7.56	11.89	
LSD _(p<0.05) T	2.910**				3.407 ^{ns}			
LSD _(p<0.05) V	2.910*				3.407*			
LSD _(p<0.05) TXV	5.041*				5.900 ^{ns}			

CV%

23.3

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* indicate significance at $P < 0.05$, ** indicate significance at $P < 0.01$, ns indicates non-significant

3.4 Effect of Tillage Practice and Variety on Fresh Leaf Weight

Cowpea fresh leaf weight) was significantly ($P < 0.05$) affected by soil tillage practices, ((Table 4). Conventional tillage + mulch had higher fresh leaf weight followed by zero tillage and control was the lowest. Overall, Conventional tillage + mulch had 29.1% and 38.9% higher fresh leaf weight than conventional tillage at St. Teresa and Nakamane sites, respectively. The influence of variety on fresh leaf at St Theresa demo farm was not significant ($P < 0.05$) However at Nakamane irrigation scheme Variety effect on fresh leaf weight was different ($P < 0.05$) Kenkunde had the highest mean yield than both K80 and M66. The interaction of tillage methods and variety was significant in all experimental sites.

Table 4: Effect of tillage practice and variety on fresh leaf weight (gm)

Theresa					Nakamane			
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	1.97	2.48	3.12	2.53	1.54	2.14	3.17	2.28
Conventional tillage + mulch	3.39	3.21	3.18	3.26	3.27	3.16	3.07	3.17
Zero tillage	2.77	2.40	2.99	2.73	2.57	2.53	2.83	2.65

Mean	2.71	2.70	3.09	2.46	2.61	3.02
LSD_{(p≤0.05)(T)}	0.3579*			0.4376*		
LSD_{(p≤0.05) V}	0.3579 ^{ns}			0.4376*		
LSD_{(p≤0.05) T*V}	0.6199*			0.7580*		
CV%	12.6			16.2		

* indicate significance at P<0.05, , ns indicates non-significant

3.5 Effects of Tillage Practice and Variety on Pods Length (cm)

Tillage practice had an effect on pod length at St Theresa. However, tillage practice had no effect on pod length at Nakamane irrigation scheme. Variety had significant influence on pod size at p≤0.05. Kenkunde had the highest mean followed by K80 and M 66 had the lowest mean. While the interaction of tillage methods and variety was not significant at St Theresa demo farm, results showed that at Nakamane irrigation scheme there was interaction of the two treatments under investigation.

Table 5: Effects of Tillage Practice and Variety on Pods length (cm)

Theresa					Nakamane			
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	11.5	13.7	14.5	13.3	10.8	11.03	16.4	12.7

Conventional tillage + mulch	12.4	11.4	12.2	12.0	11.0	11.0	12.6	11.8
Zero tillage	12.4	12.9	13.4	12.9	12.0	11.9	13.5	12.9
Mean	12.1	12.7	13.4		11.2	11.6	14.2	
LSD _(p<0.05) T	0.973*				1.115 ^{ns}			
LSD _(p<0.05) V	0.973*				1.115**			
LSD _(p<0.05) TXV	1.686 ^{ns}				1.932*			
CV%	7.7				8.9			

* Indicate significance ,** indicate highly significant and ns shows non-significant

3.6 Effects of Tillage Practice and Variety on Number of pods per plant.

Tillage practices had significant effect ($p \leq 0.05$) on number of pods per plant at St Theresa demo farm (Table 6). Conventional tillage + mulch recorded the highest mean (15.11) number of pods per plant followed by zero tillage at 13.22 and control was the lowest at 13.00. Tillage practices had ($p \leq 0.05$).no significant effect on number of pods per plant at Nakamane irrigation scheme. However Conventional tillage + mulch mean was higher than both zero tillage and control in both sites. Variety had no significant effects on number of pods in both experimental sites.

Table 6: Effects of Tillage Practice and Variety on Number of pods per plant

Theresa					Nakamane			
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	13.67	12.33	13.00	13.00	14.00	13.33	14.33	13.89
Conventional tillage + mulch	14.67	15.67	15.00	15.11	15.67	12.67	14.00	14.11

Conventional tillage	11.7	9.67	12.7	11.3	10.3	9.0	12.0	13.89
Conventional tillage + mulch	15.3	14.3	15.3	15.0	14.0	13.3	16.00	14.11
Zero tillage	13.00	10.3	14.0	12.4	10.0	12.3	11.7	12.22
Mean	13.3	11.4	14.0		11.4	11.6	13.62	
LSD _(p<0.05) T	1.465* *				2.193*			
LSD _(p<0.05) V	1.465*				2.913 ^{ns}			
LSD _(p<0.05) TXV	2.537 ^{ns}				3.798 ^{ns}			
CV%	11.3				18.2			

* indicates significance , ** indicates highly significance , ns indicates non-significant

3.8 Effects of Tillage Practice and Variety on Total Grain Yield (t/ha)

Tillage practice had significant effects on grain yield ($P<0.05$). Variety had a significant effect on grain yield at St Theresa only. At St Theresa demo farm, conventional tillage+ mulch significantly out-yielded conventional tillage by 27.3%. No difference was noted between the latter and zero tillage. Zero tillage and conventional tillage + mulch out yielded conventional tillage by 52.2 and 60.3% respectively at Nakamane. At St Theresa Demo farm Kenkunde out yielded K80 and M66 by 10.1% and 9.3% respectively. No differences were noted between the latter two varieties.

Table 8: Effects of Tillage Practice and Variety on Total Grain Yield (t/ha)

St Theresa					Nakamane			
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	1.12	1.10	1.48	1.23	0.97	0.89	1.26	1.04
Conventional tillage + mulch	1.49	1.58	1.64	1.57	1.56	1.55	1.64	1.58
Zero tillage	1.22	1.38	1.58	1.39	1.67	1.72	1.70	1.67
Mean	1.27	1.35	1.57		1.40	1.39	1.53	
LSD (p<0.05)T	0.24*				0.30*			
LSD(p<0.05)V	0.24*				ns			
LSD(p<0.05)TXV	Ns				ns			
%CV	17.2				21.0			

* indicates significance and ns indicates non-significant

3.9 Effects of Tillage Practice and Variety on 100 Seed Weight (gm)

While tillage practice had no significant effect ($p \leq 0.05$) on 100 seed weight at St Theresa demo farm (**Table 9**), the effects of tillage practice on 100 seed weight were significant at Nakamane irrigation scheme. Variety effects had no significant influence on 100 seed weight ($p \leq 0.05$) at St Theresa Demo farm however variety had significant influence on 100 grain weight at Nakamane irrigation scheme. The interaction of the effects of both tillage practice and variety were significant in both experimental sites.

Table 9: Effects of Tillage Practice and Variety on 100 Seed Weight (gm)

St Theresa					Nakamane			
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	7.02	10.06	7.72	8.27	9.43	8.60	7.53	8.52
Conventional tillage + mulch	7.96	6.16	9.34	7.82	6.42	11.86	10.55	9.61
Zero tillage	7.11	7.24	8.23	7.53	7.28	6.73	9.69	7.90
Mean	7.36	7.82	8.43		7.71	9.06	9.06	
LSD (p<0.05)T	1.282 ^{ns}				0.877*			
LSD(p<0.05)V	1.282 ^{ns}				0.877*			
LSD(p<0.05)TXV	2.221*				1.519*			
%CV	16.3				10.1			

* indicate significance and ns indicate non-significant

3.10 Effects of Tillage Practice and Variety on Total biomass (gm)

Tillage practice had significant effect on total biomass in the two experimental sites (**Table 10**). Zero tillage had the highest mean influence on total biomass at St Theresa Demo farm followed by conventional tillage+ mulch. However, at Nakamane irrigation scheme conventional tillage+ mulch had more influence on total biomass than zero tillage. Variety ($p \leq 0.05$) had no significant

influence on total biomass. The interaction of tillage practices and variety at $p \leq 0.05$ on total biomass was not significant.

Table 10: Effects of Tillage practice and Variety on Total biomass (gm)

Theresa					Nakamane			
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	6.18	5.55	6.15	5.96	5.39	6.00	5.71	5.70
Conventional tillage + mulch	5.76	6.73	6.39	6.30	6.58	6.45	6.39	6.47
Zero tillage	6.66	7.12	6.66	6.81	4.03	5.10	4.32	4.48 
Mean	6.20	6.47	6.40		5.33	5.85	5.47	
LSD (p<0.05)T	0.634*				0.953*			
LSD(p<0.05)V	0.634 ^{ns}				0.953 ^{ns}			
LSD(p<0.05)TXV	1.098 ^{ns}				1.651 ^{ns}			
%CV	10.0				17.2			

* indicate significance and ns indicates non-significant

3.11 Effects of Tillage Practice and Variety on Harvest Indices (%)

Analysis of variance showed that effect of tillage practice on harvest index ($p \leq 0.05$) was significant in both experimental sites (**Table 11**). Conventional tillage + mulch and zero tillage increased harvest index by 25.4% and 8.5% respectively at the St Theresa demo farm and by 38.6% and 14.39% respectively at Nakamane. Variety effect on cowpea harvest index ($p \leq 0.05$) was not significant. The interaction of tillage practices and variety at $p \leq 0.05$ on harvest index was **not significant**. 

Table 11: Effects of Tillage Practice and Variety on Harvest Indices (%)

Theresa	Nakamane							
Variety (V)	M66	K 80	Ken	Mean	M 66	K 80	Kenkunde	Mean
Tillage(T)								
Conventional tillage	19.9	17.6	19.64	19.02	19.86	20.06	17.79	19.24
Conventional tillage + mulch	26.6	22.49	24.48	24.52	25.97	28.24	25.79	26.67
Zero tillage	20.40	20.14	21.38	20.64	23.50	19.46	23.43	22.01
Mean	22.28	20.07	21.84		23.11	22.46	22.34	
LSD ($p < 0.05$)T	2.55**				4.261*			
LSD($p < 0.05$)V	2.554 ^{ns}				4.261 ^{ns}			
LSD($p < 0.05$)TXV	4.424 ^{ns}				7.380 ^{ns}			
%CV	11.9				5.8			

* indicate significance ,** indicate highly significance and ns indicate non-significant

325 4.0 Discussion

326 No significant increase in plant height was observed for both tillage practice and variety. While
 327 tillage + mulch and zero tillage improved soil condition for plant growth, plants growing under
 328 conventional tillage grew taller in an effort to scramble for below and above ground growth
 329 resources. Narrow genetic variability among the varieties could be attributed to the lack of
 330 significance for plant height. Conventional tillage+ mulch increased the number of nodules per
 331 plant by 58.9% compared to control. St Theresa de ~~the effect could be due to~~ soil
 332 moisture which increased rhizobia activity. ~~the effect could be due to~~ tillage reduced it by 26.9%. This was not
 333 supported by Ferreira et al., (2000) and Zhang et al., (2012) who confirmed that rhizobia isolates
 334 due to zero tillage conditions fixed more atmospheric nitrogen as a result of minimal
 335 disturbance of soil and high rhizobia population. However, the influence of tillage practice on
 336 nodulation was not significant at Nakamane. This could be attributed phosphorous deficiency
 337 under clayey conditions due general leaching or fixation in microbial cells which reduced
 338 nutrient and water uptake necessary for nodule development. Variety had positive influence on
 339 cowpea Kenkunde had the highest nodule count than M66 and K80 in both experimental sites.
 340 This could be attributed to ' long root length and stability under all tillage practices. As
 341 reported by Kurdali et al. (2005), cowpea nodule count is dependent on its genetic potential and
 342 also, to some extent, depends on the availability of essential nutrients and moisture. This
 343 observation was also congruent with the earlier reports by Fuhrman and Vasilas (1994), who
 344 concluded that varieties respond differently to various environmental factors, and this
 345 differential response is primarily driven by their genetic makeup and their adaptive capabilities
 346 The difference in nodule count among cowpea varieties could have been due to differences in

347 genetic composition and moisture within their plots which probably enhanced activity of
348 rhizobia

349 Significant increase in fresh leaf weight was recorded for both tillage practice and variety. The
350 positive influence of tillage practice as found out by (Hummel McKay 2006), (Erdem 2007) and
351 (Abidoye, 2004 and Kerbaui, 2004) was due high water infiltration through tillage and low soil
352 temperature due to mulching. While Tillage + mulch and zero tillage increased grain yield at
353 Nakamane only tillage + mulch was significant at St Theresa meaning that environmental
354 fluctuations could affect total grain yield. Tillage + mulch and zero tillage increased cowpea
355 biomass in both experimental sites. Similar results were observed by Erenstein (2002). This is
356 also in line with the submissions of (Seghatoleslami et al., 2008, and Payero *et al.*, 2009) who
357 reported that drought stress can significantly affect the total biomass produced by the crop and
358 that water stress can reduce crop yield by affecting CO₂ assimilation area and leaf number and
359 total leaf area. Conventional tillage + mulch and zero tillage enhanced cowpea biomass through
360 creating obstacles to external evaporability and energy supply to evaporating site by cutting solar
361 radiation falling on the earth surface. Tillage + mulch may have extended the period of moisture
362 availability which resulted in a higher dry matter accumulation. Variety had no effect on total
363 biomass. This was due to narrow range of variability among varieties in absorbing nutrients and
364 water from the soil and conversion into photosynthates under the difference tillage practices.
365 ~~Variety had no effect on total biomass which implied that there was narrow genetic variation~~
366 ~~among varieties on this yield attribute.~~ Conventional tillage + mulch and zero tillage increased
367 harvest index in both experimental sites. A similar observation was made by Faisal and
368 Abdelshakoor (2010) who reported that harvest index was less under conventional tillage due to
369 water stress conditions and which resulted in reduction of assimilates. High harvest index in

plots under conventional tillage + mulch and zero tillage implies more moisture was available which went into partitioning of photosynthates, translocation and accumulation as sinks. This means there was more grain filling at the expense of vegetative growth thus giving compensatory influence on the observed higher harvest index. This indicates that harvest index or grain yield is maximized when cowpea is established under tillage +mulch and zero tillage as compared to control. In both experimental sites variety had no influence on harvest index meaning that there exists little variability among varieties on this yield attribute.

Conclusion

Tillage +mulch followed by zero tillage enhanced cowpea productivity as shown in the increase of yield attributes. Leaf and Grain yield between tillage methods and among varieties was significantly different in all the sites. It can be concluded that tillage +mulch was the best tillage method for each site and Kenkunde was the best adapted cowpea variety for high yields in Turkana county.

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