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EFFECT OF DIFFERENT FARMYARD MANURE LEVELS ON SOIL MOISTURE CONTENT, CANOPY TEMPERATURE, GROWTH AND YIELD OF MAIZE – COWPEA INTERCROPS

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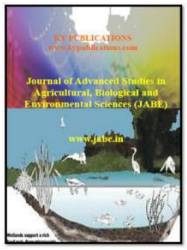

ABSTRACT

The cost of inorganic fertilizers is prohibitively expensive for resource challenged small holder farmers in the coastal lowland Kenya. Use of organic fertilizers has the potential to improve the productivity of maize-cowpea based cropping systems. A study was carried out at Pwani University and Kenya Agricultural and Livestock Research Institute (KALRO) Mtwapa in 2011 and 2012 to determine the effects of farmyard manure levels on soil moisture content, canopy temperature, growth and yield performance of maize-cowpea intercrop. The treatments comprised two cropping systems and three farmyard manure levels. The farmyard manure levels comprised: control (no manure), 2.5 t manure ha^{-1} and 5.0 t manure ha^{-1}. The experiment was laid out in a randomized complete block design, with a factorial arrangement of treatments and replicated three times. Data collected included: soil moisture content, canopy temperature, weed biomass, chlorophyll content, percent ground cover, leaf number, plant height, grain weight and grain yield of maize and cowpea. Cowpea root nodule number, numbers of pods per plant, number of grains per pod, maize ears per plant and stover yield were also determined. Data was analyzed using the general linear model (GLM) procedure for analysis of variance using SAS statistical package. Where the F values were significant, means were compared using the least significant difference (LSD) test, at p = 0.05. Farmyard manure application increased soil moisture content and groundcover, chlorophyll content, growth parameters, yield and yield components of maize plants; however, it reduced canopy temperature and all cowpea plant attributes. DH04-cowpea intercrop outperformed Lamu-cowpea intercrop in most plant attributes. The performance of DH04-cowpea intercrop was significantly higher than Lamu-cowpea intercrop.

Key words: Farmyard, moisture, temperature, maize and cowpea

INTRODUCTION

Maize is the staple food in Kenya, produced by small scale farmers who have limited capacity to produce efficiently (Schroeder et al., 2013). Low soil fertility and moisture stress are the major factors limiting maize productivity in the coastal lowland of Kenya (Wekesa et al., 2003). Adoption of inorganic fertilizers in coastal lowlands is low and this has been attributed to high fertilizer costs (Saha et al., 1993). According to Saleem et al., (2011) the cost of inorganic fertilizers is prohibitively expensive for resource challenged smallholder farmers. Organic manures such as animal manure, compost and green manure cover crops are suggested alternatives (Nandwa, 1995). According to Tennakoon and Bandara, (2003) both plant materials and animal manure have considerable amounts of plant nutrients. Thus continual applications of these organic

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manures can not only supply plant nutrients but also enrich agricultural soils. In addition to being important sources of N for crop production, animal manures and compost are beneficial in soils because they can increase the water holding capacity and the cation exchange capacity (Nandwa, 1995). The responses of crops to manure application has been attributed to quantity of manure N already available to the plants, amount of N that becomes available after mineralization during the season, release and availability of P, K, and micronutrients, and improvement of soil structure and permeability (Bocchi and Tano, 1994).

Majority of farmers in the coastal region neither use organic nor inorganic fertilizers. Among the organic sources, farmyard manure is the most important as it contains all the nutrients needed for crop growth including trace elements, albeit in small quantities (Achieng et al. 2010). Farmyard manure can be used for crop production as a substitute of chemical fertilizers (Khan et al., 2005; Ayoola et al., 2007). The efficiency of manure utilization by a crop is determined by the method of application, time of incorporation and the rate of decomposition in the soil (Achieng et al., 2010). Despite the importance of farmyard manures as sources of nutrients, their use is limited mainly due to their low and variable nutrient composition and the large quantities needed to provide adequate plant nutrients (Nandwa, 1995). The objective of the study was to determine the effects of farmyard manure levels on soil moisture content, canopy temperature, chlorophyll content, growth and yield of maize-cowpea intercrop.

MATERIALS AND METHODS

Study site

The study was carried out at Pwani University and Kenya Agricultural and Livestock Research Organization (KALRO). Pwani University is located 60 km north of Mombasa between latitudes 3^{o} S and 4^{o} S and longitudes 39^{o} E and 40^{o} E. Mean monthly minimum and maximum temperatures of about 22^{0}C and 30^{0}C, respectively, and mean relative humidity of 80% (Jaetzold, et al., 2012). The site is in coastal lowland (CL) Kenya. The region receives an average annual rainfall of 600–1100 mm in two seasons (Sombroek et al., 1982). The long rains are received in March/April through August while the short rains are received in October, November and December. The long rains season is the most important cropping season and 75% of the annual rainfall is usually received during this time (Saha, 2007). The rainfall, temperature and relative humidity at the Kilifi and Mtwapa sites are shown in Table 1. According to Sombroek et al., (1982), the soils in coastal lowland Kenya are mostly ferralsols. They are low in cation exchange capacity, total N organic matter content and essential plant nutrients (such as Calcium, Magnesium, Zinc and Sodium). In addition, they are prone to leaching, and have a pH of 5.6. Soils were analysed for pH, total N, Organic carbon, Phosphorus, potassium, calcium, Magnesium, Manganese, Copper, Iron, Zinc and Sodium.

Experimental design, treatments and crop husbandry

The study evaluated the effect of intercropping maize with cowpea under different farmyard manure levels in the coastal lowland of Kenya. A randomized complete block design with a factorial arrangement of treatments was used and replicated three times. The treatments comprised two cropping systems and three farmyard manure levels. The cropping systems comprised: Dryland Hybrid 04 (DH04) - cowpea intercrop and Lamu - cowpea intercrop. The farmyard manure levels comprised: control (no manure), 2.5 t manure ha^{-1} and 5.0 t manure ha^{-1}. Cowpea variety Nyeupe, which was among the farmer prefereed, drought/insect pest resistant cowpea, was used for intercropping with maize. Plot size was 5 m x 5 m. Maize plant spacing was 100 cm x 50 cm giving a 20,000 plant population per hectare. Cowpea was planted in between the maize rows with spacing of 30 cm within the row, two plants per hill, giving a plant population of about 66,660 plants/ha. All the cowpeas in the two sites were planted four weeks after the maize was planted to reduce competition (Mureithi et al., 1996). Weeding was done by hand at two, four and six weeks, respectively, after planting.

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Data collected

Data collected included: soil moisture content, canopy temperature, weed biomass, chlorophyll content, percent ground cover, leaf number, plant height, grain weight and grain yield of maize and cowpea. Cowpea root nodule number, numbers of pods per plant, number of grains per pod, maize number of ears per plant and stover yield were also determined. Data was collected as described in chapter six.

Data analysis

Collected data were analyzed by the general linear model (GLM) procedure for analysis of variance using SAS statistical package (SAS Institute, 1993). Where the F values were significant, means were compared using the least significant difference (LSD) tests, at p = 0.05.

RESULTS

Soil moisture content

Cropping systems and farmyard manure (FYM) application had significant effect on soil moisture content at 20, 40 and 60 cm soil depths. Interaction between cropping system and FYM had no significant effect on soil moisture content. In most cases, Lamu-cowpea intercrop plots had significantly lower moisture content than DH04-cowpea intercrop plots at all soil depths and maize growth stages (Table 1). Farmyard manure application significantly increased moisture content relative to the control at all stages (Table 2). Application of 2.5 t/ha had significantly higher moisture content than application of 5 t/ha.

TABLE 1: EFFECT OF CROPPING SYSTEM ON SOIL MOISTURE CONTENT (% PER VOLUME) AT 20, 40, 60 AND 80 CM SOIL DEPTH AT ALL GROWTH STAGES

Cropping system	20 cm Soil depth			40 cm soil depth		
	Boot	Silk	Maturity	Boot	Silk	Maturity
Lamu – cowpea	7.43	13.52	9.22	13.25	19.52	13.32
DH04-cowpea	9.12	15.43	9.33	14.83	22.19	14.53
P-value	0.0001	0.0001	0.451	0.0001	0.0001	0.0001
$LSD_{0.05}$	0.37	0.39	0.32	0.34	0.22	0.27
CV (%)	4.22	2.57	3.24	2.34	0.99	1.81
	60 cm Soil depth			80 cm soil depth		
Lamu – cowpea	17.02	22.68	17.84	22.48	25.79	22
DH04-cowpea	20.24	23.87	19.59	23.83	25.9	22.25
P-value	0.0001	0.0001	0.0001	0.0001	0.292	0.137
$LSD_{0.05}$	0.31	0.42	0.323	0.319	NS	NS
CV (%)	1.59	1.72	1.64	1.31	0.80	1.50

Ground cover and canopy temperature

Application of farmyard manure and cropping system had significant effects on ground cover and canopy temperature (Table 3). Application of farmyard manure significantly increased percent ground cover at Mtwapa, but had no effect at Kilifi. DH04 maize variety intercropped with cowpea had a higher percent ground cover than Lamu maize variety intercropped with cowpea at 0 and 5.0 t/ha farmyard manure application. Application of 5 t/ha farmyard manure had a significantly higher percent ground cover than application of 2.5 t/ha farmyard manure. Average percent increase in ground cover with 2.5 t/ha and 5.0 t/ha farmyard manure

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application was 56.0% and 63.2%, respectively. Farmyard manure application, cropping system and their interaction significantly affected the canopy temperature at Kilifi (Table 3). Farmyard manure application reduced canopy temperature in Lamu-cowpea intercrop but had no effect in DH04-cowpea intercrop. Farmyard manure application rates of 2.5 t/ha and 5.0 t/ha were not significantly different in canopy temperature. The canopy temperatures of the two cropping systems were not significantly different at all farmyard manure levels except at 5.0 t/ha where Lamu-cowpea intercrop had lower canopy temperature than DH04-cowpea intercrop.

TABLE 2: EFFECT OF FARMYARD MANURE ON SOIL MOISTURE CONTENT (% PER VOLUME) AT 20, 40, 60 AND 80 CM SOIL DEPTH IN ALL GROWTH STAGES

Farmyard manure	20 cm soil depth			40 cm soil depth		
	Boot	Silk	Maturity	Boot	Silk	Maturity
0 t/ha FYM	7.47	15.47	7.91	13.69	20.02	13.26
2.5 t/ha FYM	8.98	14.45	11.22	14.44	22.57	14.62
5.0 t/ha FYM	8.38	13.51	8.70	13.98	19.98	13.89
P-value	0.0001	0.0001	0.0001	0.0088	0.0001	0.0001
$LSD_{0.05}$	0.45	0.48	0.39	0.42	0.27	0.33
CV (%)	4.22	2.57	3.24	2.33	0.99	1.81
	60 cm soil depth			80 cm soil depth		
0 t/ha FYM	17.32	21.95	17.68	23.31	25.97	22.96
2.5 t/ha FYM	22.05	25.48	22.52	26.54	27.56	24.41
5.0 t/ha FYM	16.52	22.39	15.95	19.61	24.02	19.02
P-value (FYM)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
$LSD_{0.05}$ (FYM)	0.38	0.51	0.40	0.39	0.27	0.43
CV (%)	1.59	1.72	1.64	1.31	0.80	1.50

FYM = Farmyard manure

Chlorophyll contents of cowpea and maize

Application of farmyard manure, cropping system and their interaction significantly affected cowpea chlorophyll content at Kilifi but not at Mtwapa (Table 4). At Kilifi, cowpea chlorophyll content was significantly higher under cowpea intercropped with DHO4 maize than under cowpea intercropped with Lamu maize under control (no farmyard manure) and 5.0 t/ha farmyard manure. At Mtwapa, Lamu-cowpea intercrop had significantly lower canopy temperature than DH04-cowpea intercrop. Application of farmyard manure and the interaction between FYM and cropping system significantly affected maize chlorophyll content at Kilifi (Table 4).

TABLE 3: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON PERCENT GROUND COVER AND CANOPY TEMPERATURE AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASON

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS- mean	F_0	F_1	F_2	CPS- mean
	Percent ground cover							
Lamu - cowpea	89.23	83.47	82.63	86.11	24.43	41.90	41.87	36.07

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DH04 - cowpea	82.93	84.10	82.23	83.09	29.23	41.77	45.70	38.90
Mean-FYM	86.08	83.79	82.43		26.83	41.84	43.79	
P-value (CPS)	0.312				0.035			
P-value (FYM)	0.325				0.0001			
P-value (CPS x FYM)	0.317				0.235			
$LSD_{0.05}$ CPS	Ns				0.87			
$LSD_{0.05}$ FYM	Ns				1.07			
$LSD_{0.05}$ CPS x FYM	Ns				Ns			
CV (%)	4.79				2.14			
					Canopy temperature (^{o}C)			
Lamu - cowpea	24.43	23.43	22.80	23.55	28.39	28.49	27.86	28.25
DH04 - cowpea	23.70	24.03	23.97	23.90	26.76	29.29	27.29	27.78
Mean-FYM	24.07	23.73	23.39		27.58	28.89	27.58	
P-value (CPS)	0.083				0.007			
P-value (FYM)	0.033				0.69			
P-value (CPS x FYM)	0.004				0.45			
$LSD_{0.05}$ CPS	Ns				0.741			
$LSD_{0.05}$ FYM	0.49				Ns			
$LSD_{0.05}$ CPS x FYM	0.90				Ns			
CV (%)	1.60				2.55			

F_0 = No farmyard manure; F_1 = 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure

TABLE 4: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON CHLOROPHYLL CONTENT OF COWPEA AND MAIZE AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASON

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS- mean	F_0	F_1	F_2	CPS- mean
					Cowpea chlorophyll index			
Lamu - cowpea	51.57	48.70	46.60	48.96	52.93	53.07	52.07	52.69
DH04 - cowpea	54.43	49.27	51.53	51.74	54.40	52.53	55.70	54.21
Mean-FYM	53.00	48.99	49.07		53.67	52.80	53.89	
P-value (CPS)	0.0001				0.015			
P-value (FYM)	0.001				0.241			
P-value (CPS x FYM)	0.001				0.025			
$LSD_{0.05}$ CPS	0.74				1.15			
$LSD_{0.05}$ FYM	0.91				Ns			
$LSD_{0.05}$ CPS x FYM	1.58				0.48			
CV (%)	1.40				2.05			

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	Maize chlorophyll index							
Lamu - cowpea	38.60	42.47	45.47	42.18	44.83	43.93	43.73	44.28
DH04 - cowpea	36.40	43.20	44.30	41.30	45.50	43.63	46.37	45.17
Mean-FYM	37.50	42.84	44.89		45.17	43.78	45.05	
P-value (CPS)	0.0001				0.142			
P-value (FYM)	0.0001				0.154			
P-value (CPS x FYM)	Ns				Ns			
$LSD_{0.05}$ CPS	0.08				0.11			
$LSD_{0.05}$ FYM	1.24				Ns			
$LSD_{0.05}$ CPS x FYM	1.86				Ns			
CV (%)	2.32				2.72			

F_0 = No farmyard manure; F_1 = 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure

Farmyard manure treatments had no significant effect on maize chlorophyll content at Mtwapa. Application of FYM significantly increased maize chlorophyll content at Kilifi in both cropping systems. Application of 5.0 t/ha FYM had higher chlorophyll content than application of 2.5 t/ha FYM in Lamu-cowpea intercrop. Cropping systems had no significant effect on maize chlorophyll content at 2.5 t/ha and 5.0 t/ha FYM. Lamu-cowpea intercrop had higher maize chlorophyll content than DH04-cowpea intercrop.

Leaf numbers of cowpea and maize

Application of farmyard manure and the interaction between FYM and cropping system significantly affected cowpea leaf number in both sites (Table 5). Farmyard manure application significantly increased cowpea leaf number in both cropping systems at both sites. Application of 2.5 t/ha FYM increased cowpea leaf number in Kilifi and Mtwapa by 5.2% and 55.9%, respectively. Application of 5.0 t/ha of FYM increased cowpea leaf number in Kilifi and Mtwapa by 52.8% and 73.5% respectively. Application of farmyard manure, cropping system and their interaction significantly affected maize leaf number of both cropping systems in both sites (Table 5). Farmyard manure application significantly increased maize leaf number in both cropping systems and sites. Application of 2.5 t/ha FYM significantly increased maize leaf number in Lamu-cowpea intercrop system in Kilifi. Generally, Lamu maize variety intercropped with cowpea had significantly higher leaf numbers than DH04 maize variety intercropped with cowpea. The average maize leaf number for Mtwapa was 25.7% lower than for Kilifi.

Plant heights of cowpea and maize

Application of farmyard manure, cropping system and their interactions significantly affected cowpea and maize plant height (Table 6). Application of 5.0 t/ha farmyard manure significantly increased cowpea plant height relative to the cereal in both cropping systems at both sites. Application of 2.5 t/ha FYM increased cowpea plant height only in Mtwapa. The average plant height at Mtwapa was 37.0% higher than at Kilifi. Application of farmyard manure significantly increased maize plant height in both cropping systems at both sites (Table 6). Farmyard manure application increased maize plant height at Kilifi and at Mtwapa by 8.7% and 14.3%, respectively.

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TABLE 5: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON LEAF NUMBER OF COWPEA AND MAIZE AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASONN

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS- mean	F_0	F_1	F_2	CPS- mean
	Cowpea leaf number per plant							
Lamu - cowpea	18.37	19.07	29.53	22.32	11.00	23.47	24.37	19.61
DH04 - cowpea	19.07	20.33	27.67	22.36	21.03	26.47	31.23	26.24
Mean-FYM	18.72	19.70	28.60		16.02	24.97	27.80	
P-value (CPS)	0.0001				0.0001			
P-value (FYM)	0.0001				0.0001			
P-value (CPS x FYM)	0.0001				0.0001			
$LSD_{0.05}$ CPS	0.36				0.52			
$LSD_{0.05}$ FYM	0.04				0.64			
$LSD_{0.05}$ CPS x FYM	0.66				0.95			
CV (%)	1.54				2.15			
	Maize leaf number per plant							
Lamu - cowpea	12.27	13.37	14.03	13.22	8.60	8.87	9.67	9.05
DH04 - cowpea	12.33	12.37	13.27	12.66	7.57	7.73	15.30	7.65
Mean-FYM	12.30	12.87	13.65		8.09	8.30	12.49	
P-value (CPS)	0.009				0.0001			
P-value (FYM)	0.002				0.0001			
P-value (CPS x FYM)	0.004				0.0001			
$LSD_{0.05}$ CPS	0.39				0.22			
$LSD_{0.05}$ FYM	0.48				0.27			
$LSD_{0.05}$ CPS x FYM	0.72				0.41			
CV (%)	2.88				2.20			

F_0 = No farmyard manure; F_1 = 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure

TABLE 6: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON PLANT HEIGHT (CM) OF COWPEA AND MAIZE AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASONN

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS- mean	F_0	F_1	F_2	CPS-mean
	Cowpea plant height (cm)							
Lamu - cowpea	18.37	19.07	29.53	22.32	22.67	29.73	33.70	28.70
DH04 - cowpea	19.90	20.33	27.67	22.63	25.67	36.47	36.50	32.88
Mean-FYM	19.14	19.70	28.60		24.17	33.10	35.10	
P-value (CPS)	0.0001				0.0001			

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P-value (FYM)	0.0001				0.0001			
P-value (CPS x FYM)	0.0020				0.0001			
$LSD_{0.05}$ CPS	0.54				0.31			
$LSD_{0.05}$ FYM	0.66				0.38			
$LSD_{0.05}$ CPS x FYM	0.98				0.56			
CV (%)	2.24				0.95			
				Maize plant height (cm)				
Lamu - cowpea	155.63	175.50	177.00	169.38	128.77	144.30	160.87	144.65
DH04 - cowpea	146.83	147.77	151.90	148.83	132.87	137.73	138.10	136.23
Mean-FYM	151.23	161.64	164.45		130.82	141.02	149.49	
P-value (CPS)	0.0001				0.0001			
P-value (FYM)	0.0001				0.0001			
P-value (CPS x FYM)	0.0001				0.0001			
$LSD_{0.05}$ CPS	1.24				2.28			
$LSD_{0.05}$ FYM	1.52				2.79			
$LSD_{0.05}$ CPS x FYM	2.28				4.17			
CV (%)	0.74				1.54			

F_0 = No farmyard manure; $F_{1\,=}$ 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure

Application of farmyard manure levels of 2.5 t/ha and 5.0 t/ha significantly increased maize plant height in Kilifi by 6.9% and 8.7%, respectively. In Kilifi intercropped maize was significantly taller than intercropped maize in Kilifi. Maize plant height average at Mtwapa was 11.7% lower than at Kilifi.

Cowpea root nodule number

Farmyard manure application, cropping system and their interaction had significant effect on cowpea number of root nodules in Mtwapa. In Kilifi, cropping system and farmyard manure application had no effect on number of nodules (Table 7). Application of farmyard manure significantly reduced the number of root nodule of cropping systems at both sites. Farmyard manure application rate of 5.0 t/ha resulted in lower number of nodules per plant than 2.5 t/ha in both cropping system at both sites. Cowpea intercropped with DH04 maize variety had higher number of root nodules than cowpea intercropped with Lamu maize variety. The average number of root nodules at Mtwapa was 34.2% higher than at Kilifi.

TABLE 7: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON NUMBER OF COWPEA ROOT NODULES PER PLANT AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASONN

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS-mean	F_0	F_1	F_2	CPS-mean
Lamu - cowpea	11.07	7.60	7.17	8.61	6.10	4.87	4.40	5.12
DH04 - cowpea	14.27	12.83	8.30	11.80	17.50	4.50	2.97	8.32
FYM-mean	12.67	10.22	7.74		11.80	4.69	3.69	
P-value (CPS)	0.673				0.0001			

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P-value (FYM)	0.0001	0.0001
P-value (CPS x FYM)	0.0001	0.0001
$LSD_{0.05}$ CPS	Ns	0.10
$LSD_{0.05}$ FYM	0.84	0.12
$LSD_{0.05}$ CPS x FYM	1.25	0.54
CV (%)	5.48	1.37

F_0 = No farmyard manure; $F_{1=}$ 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure.

Pods per plant and grain per pod of cowpea

Farmyard manure application, cropping system and their interaction significantly affects the number of cowpea pods per plant and grains per pod in both cropping systems and at both sites (Table 8). Application of 5.0 t/ha FYM had higher number of cowpea pods per plant than application of 2.5 t/ha FYM.

TABLE 8: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON NUMBER PODS PER PLANT AND GRAINS PER POD OF COWPEA AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASONN

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS- mean	F_0	F_1	F_2	CPS- mean
	Cowpea number of pods per plant							
Lamu - cowpea	4.50	6.30	7.63	6.14	1.67	2.37	2.80	2.28
DH04 - cowpea	6.03	6.23	8.13	6.80	2.23	2.33	3.00	2.52
Mean-FYM	5.27	6.27	7.88		1.95	2.35	2.90	
P-value (CPS)	0.011				0.009			
P-value (FYM)	0.0001				0.0001			
P-value (CPS x FYM)	0.033				0.026			
$LSD_{0.05}$ CPS	0.47				0.18			
$LSD_{0.05}$ FYM	0.58				0.22			
$LSD_{0.05}$ CPS x FYM	0.86				0.33			
CV (%)	6.94				7.06			
	Cowpea number of grains per pod							
Lamu - cowpea	13.37	14.07	14.83	14.09	4.87	4.93	5.70	5.17
DH04 - cowpea	12.17	13.43	14.40	13.33	4.70	5.03	5.10	4.94
Mean-FYM	12.77	13.75	14.62		4.79	4.98	5.40	
P-value (CPS)	0.00				0.06			
P-value (FYM)	0.19				0.20			
P-value (CPS x FYM)	0.00				0.00			
$LSD_{0.05}$ CPS	0.36				0.25			
$LSD_{0.05}$ FYM	Ns				Ns			
$LSD_{0.05}$ CPS x FYM	0.66				0.45			
CV (%)	2.49				4.63			

F_0 = No farmyard manure; $F_{1=}$ 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure

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Cowpea intercropped with DH04 maize variety had higher number of cowpea pods per plant than cowpea intercropped with Lamu maize variety at both sites. Farmyard manure application rate of 2.5 t/ha increased the number of cowpea pods per plant at Kilifi and at Mtwapa by 19.0% and 20.5%, respectively, while 5.0 t/ha FYM increased the number of cowpea pods per plant in Kilifi and Mtwapa by 49.8% and 48.7%, respectively. The average numbers of pods per plant in Kilifi was 62.9% higher than in Mtwapa. Farmyard manure application had no significant effect on the number of cowpea grains per pod at both sites. There was however, no significant difference between the numbers of cowpea grains per pod for the two cropping systems in both sites.

Ears per plant and 100-grain weight of maize

Application of farmyard manure, cropping system and their interactions had significant effect on the number of maize ears per plant of both cropping systems and at both sites (Table 9). At Kilifi, application of farmyard manure rates of 2.5 t/ha and 5.0 t/ha increased the number ears per plant at Kilifi by 27.6% and 41.4%, respectively. Application of 2.5 t/ha and 5.0 t/ha farmyard manure levels at Kilifi increased the number of ears per plant by 31.0% and 53.5%, respectively, in Lamu maize intercropped with cowpea. The average number of maize ears per plant in Kilifi was 63.4% higher than in Mtwapa. Farmyard manure application and the interaction between farmyard manure and cropping system significantly affected maize 100-grain weight of both cropping systems at both sites (Table 10). Cropping system significantly affected maize 100-grain weight in Kilifi only. Application of 2.5 t/ha and 5.0 t/ha FYM significantly increased maize 100-grain weight by 7.1% and 12.1%, respectively at Kilifi. The cropping systems were not significantly different. The average 100-grain weight in Kilifi was 1.9% higher than Mtwapa.

TABLE 9: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON NUMBER EARS PER PLANT AND 100-GRAIN WEIGHT (G) OF MAIZE AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASON

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS- mean	F_0	F_1	F_2	CPS- mean
	Maize number of ears per plant							
Lamu - cowpea	0.58	0.76	0.89	0.74	0.21	0.28	0.33	0.27
DH04 - cowpea	0.58	0.71	0.75	0.73	0.23	0.26	0.27	0.25
Mean-FYM	0.58	0.73	0.82		0.22	0.27	0.30	
P-value (CPS)	0.0001				0.0005			
P-value (FYM)	0.0001				0.0001			
P-value (CPS x FYM)	0.0001				0.0001			
$LSD_{0.05}$ CPS	0.01				0.01			
$LSD_{0.05}$ FYM	0.02				0.01			
$LSD_{0.05}$ CPS x FYM	0.03				0.02			
CV (%)	1.7				3.21			
	Maize 100-grain weight (g)							
Lamu - cowpea	28.40	30.20	35.50	31.40	30.57	32.07	32.27	31.64
DH04 - cowpea	30.83	33.30	30.90	31.70	28.40	28.53	33.53	30.14
Mean-FYM	29.62	31.70	33.20		29.49	30.30	32.90	
P-value (CPS)	0.009				0.576			

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P-value (FYM)	0.016	0.002
P-value (CPS x FYM)	0.0002	0.0005
$LSD_{0.05}$ CPS	1.01	Ns
$LSD_{0.05}$ FYM	1.24	1.57
$LSD_{0.05}$ CPS x FYM	1.86	2.35
CV (%)	3.13	3.88

F_0 = No farmyard manure; F_1 = 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure

Cowpea 100-grain weight and grain yield

Farmyard manure application, cropping system and their interaction had significant effects on cowpea 100-grain weight of both cropping systems at Mtwapa but not at Kilifi (Table 10). Application of farmyard manure significantly reduced cowpea 100-grain weight in both cropping systems. However, there was no significant difference between 0 t/ha and 2.5 t/ha of farmyard manure applications. Cowpea intercropped with Lamu maize varieties had higher 100-grain weight than cowpea intercropped with DH04 maize variety.

TABLE 10: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON 100-GRAIN WEIGHT (G) AND GRAIN YIELD (T/HA) OF COWPEA AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASON

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS- mean	F_0	F_1	F_2	CPS- mean
				Cowpea 100-grain yield (g)				
Lamu - cowpea	14.84	14.83	14.00	14.56	5.82	5.55	5.26	5.54
DH04 - cowpea	13.96	13.25	14.52	13.91	5.47	5.28	4.92	5.22
Mean-FYM	14.4	14.04	14.26		5.65	5.42	5.09	
P-value (CPS)	0.156				0.0001			
P-value (FYM)	0.789				0.0001			
P-value (CPS x FYM)	0.169				0.0001			
$LSD_{0.05}$ CPS	Ns				0.02			
$LSD_{0.05}$ FYM	Ns				0.03			
$LSD_{0.05}$ CPS x FYM	Ns				0.04			
CV (%)	6.29				0.39			
				Cowpea grain yield (t/ha)				
Lamu - cowpea	0.36	0.15	0.12	0.21	0.23	0.22	0.13	0.19
DH04 - cowpea	0.15	0.13	0.11	0.13	0.23	0.19	0.19	0.20
Mean-FYM	0.26	0.14	0.12		0.23	0.21	0.16	
P-value (CPS)	0.002				0.0001			
P-value (FYM)	0.0001				0.0001			
P-value (CPS x FYM)	0.195				0.0001			
$LSD_{0.05}$ CPS	0.01				0.01			

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$LSD_{0.05}$ FYM	0.02	0.01
$LSD_{0.05}$ CPS x FYM	Ns	0.02
CV (%)	5.89	7.72

F_0 = No farmyard manure; $F_{1 =}$ 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure

Farmyard manure application, cropping system and their interactions had significant effects on cowpea grain yield of both cropping systems at both sites (Table 8.10). Application of farmyard manure significantly reduced cowpea grain yield in both cropping systems at both sites. Application of 2.5 t/ha and 5.0 t/ha FYM decreased percent cowpea grain yield of cowpea intercropped with Lamu maize by 58.3% and 66.7%, respectively, at Kilifi. Cowpea grain yield at Mtwapa was higher than at Kilifi by 17.7%.

Stover yield and grain yield of maize

Farmyard manure application, cropping system and their interactions significantly affected maize stover yield and grain yield in both cropping systems at both sites (Table 11).

TABLE 11: EFFECTS OF CROPPING SYSTEM AND FARMYARD MANURE APPLICATION ON MAIZE STOVER YIELD (T/HA) AND GRAIN YIELD (T/HA) AT KILIFI AND AT MTWAPA SITES DURING JULY – OCTOBER 2011/2012 SEASON

Cropping system (CPS)	Kilifi				Mtwapa			
	F_0	F_1	F_2	CPS- mean	F_0	F_1	F_2	CPS- mean
	Maize stover yield (t/ha)							
Lamu - cowpea	3.59	4.48	4.61	4.23	1.03	1.55	1.65	1.41
DH04 - cowpea	3.67	4.07	4.24	3.99	0.95	1.05	1.35	1.12
Mean-FYM	3.63	4.28	4.43		0.99	1.30	1.50	
P-value (CPS)	0.0001				0.0001			
P-value (FYM)	0.0001				0.0001			
P-value (CPS x FYM)	0.0003				0.0001			
$LSD_{0.05}$ CPS	0.32				0.04			
$LSD_{0.05}$ FYM	0.39				0.04			
$LSD_{0.05}$ CPS x FYM	0.59				0.06			
CV (%)	0.01				2.68			
	Maize grain yield (t/ha)							
Lamu - cowpea	1.86	2.37	2.90	2.38	0.56	0.73	0.85	0.71
DH04 - cowpea	2.12	2.40	2.86	2.46	0.65	0.83	0.97	0.82
Mean-FYM	1.99	2.39	2.88		0.61	0.78	0.91	
P-value (CPS)	0.0001				0.0001			
P-value (FYM)	0.0001				0.0001			
P-value (CPS x FYM)	0.0020				0.0001			
$LSD_{0.05}$ CPS	0.17				0.02			
$LSD_{0.05}$ FYM	0.28				0.02			
$LSD_{0.05}$ CPS x FYM	0.31				0.03			
CV (%)	6.92				2.19			

F_0 = No farmyard manure; $F_{1 =}$ 2.5 t/ha farmyard manure; and F_2 = 5.0 t/ha farmyard manure

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Application of farmyard manure significantly increased maize stover yield and grain yield in both cropping systems at both sites. Application of 2.5 t/ha and 5.0 t/ha farmyard manure increased maize stover yields in Kilifi by 17.9% and 22.0%, respectively, while in Mtwapa the increase was 31.3% and 51.5%, respectively. The average maize stover yields at Kilifi were 69.3% higher than at Mtwapa. Farmyard manure application rates of 5.0 t/ha had higher grain yield than 2.5 t/ha at both sites. DH04 maize variety intercropped with cowpea had higher maize grain yield than Lamu maize variety intercropped with cowpea under all farmyard manure levels. Application of 2.5 t/ha and 5.0 t/ha farmyard manure increased average maize grain yield by 20.1% and 44.7% respectively in Kilifi. At Mtwapa, application of 2.5 t/ha and 5.0 t/ha farmyard manure increased average maize grain by 27.9% and 37.7%, respectively. The average maize grain yield at Kilifi was 68.2% higher than at Mtwapa.

DISCUSSION

Soil moisture content

Application of 2.5 and 5 t/ha FYM/ha significantly increased the soil moisture content relative to the non-fertilized control at 20, 40 and 60 cm soil depths. Mossaddeghi et al., (2000) reported an increase in soil moisture content due to farmyard manure application. The non-fertilized control plots and 2.5 t FYM /ha plots had higher moisture content than 5 t FYM/ha at 60 and 80 cm soil depths. This could be attributed to the fact that farmyard manure improves penetration and subsequent deep establishment of crop roots (Hati et al., 2006; Li et al., 2010) that helps to help maintain high relative plant water content under soil moisture stress conditions (Hati et al., 2006). Application of 5 t FYM /ha may have caused greater root penetration into the soil thus leading to greater exploitation of moisture at lower soil levels. Further, 5 t FYM/ ha may have provided higher nutrient levelsl thereby enhancing plant growth and water uptake (Rasool et al., 2013). DH04–cowpea intercrop had significantly higher soil moisture content than Lamu-cowpea intercrop at all growth stages at 20, 40 and 60 cm, suggesting that Lamu maize variety used more moisture than DHO4 maize variety.

Chlorophyll contents of cowpea and maize

Application of farmyard manure significantly reduced cowpea chlorophyll content at Kilifi. Shaker-Kooh et al., (2014) reported significant reduction in chlorophyll content of mung-bean intercropped with sorghum under different replacement ratios. The cereal crop had a competitive advantage over the legume. Farmyard manure application resulted in an increase in maize chlorophyll content in both sole crop and intercrop systems at Kilifi. Ghosh et al. (2006) reported increase in chlorophyll content of sorghum intercropped with soybean due to farmyard manure application. The increase in chlorophyll content could be attributed to increased photosynthesis due to nutrient release and soil moisture conservation effect of the farmyard manure which was observed in the current study.

Canopy temperature

Application of farmyard manure resulted in significant reduction in canopy temperature of intercrops in both sites. This observation is in agreement with the study by Naresh et al., (2014) who reported reduction in canopy temperature under maize legume intercrop. This was attributed to the water conservation effect of farmyard manure. According to Jones et al., (2009), the major determinant of leaf temperature is the rate of evaporation or transpiration from the leaf. Water deficit results in stomatal closure, which leads to increased temperature. The significant reduction in canopy temperature observed with farmyard manure application indicates that there was no severe water stress conditions to trigger the closure of stomata to avoid dehydration (Hamidou et al., 2007). In fact, farmyard manure application significantly increased moisture content relative to the control at all stages in this study. Cropping systems had significantly lower canopy

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temperatures in Kilifi than in Mtwapa. This could be attributed to the fact that Kilifi received 43.8 % higher amount of rainfall than Mtwapa.

Cowpea root nodule number

Farmyard manure significantly reduced the number of cowpea root nodules in both cropping systems. This finding is in agreement with the study by Otieno et al., (2007) who reported a reduction in nodulation in several legume species due to nitrogen from the mineralized manure which impacted negatively on nodulation. Organic manures commonly have C:N ratios of less than 30:1 and therefore decompose and often to release N rapidly (Giller, 2001). The nutrients released by farmyard manure could have resulted in increased maize growth parameters at the expense of cowpea growth parameters. Cowpea intercropped with DH04 had significantly higher number of cowpea root nodules than cowpea intercropped with Lamu. This observation could be attributed to the fact that Lamu variety which was taller than DH04 shaded cowpea more than DHO4. Egbe et al. (2013) reported that shading reduced nodule formation in cowpea. The average number of root nodules at Mtwapa was 34.2% lower than at Kilifi. Competition for moisture at Mtwapa could have resulted to the significantly lower number of cowpea root nodules because Kilifi received 43.8 % more rainfall than Mtwapa

Ground cover and growth parameters of cowpea and maize

The study has shown that application of farmyard manure resulted in a significant increase in percent ground cover and growth parameters of cowpea and maize. In studies by Adeoye et al., (2011) and Mohamed et al., (2011) application of farmyard manure increased cowpea leaf number and plant height. According to Adeyemo and Agele (2010), response of various maize growth parameters depended on farmyard manure levels applied. Further, organic manures improve soil-water-plant relations through modifying bulk density, total porosity, soil water retension (Obi and Ebo, 1995). Most of the cowpea growth parameters were higher under DH04 - cowpea intercrop. This could be explained by the fact that Lamu maize variety was taller than DH04 maize variety. The Lamu-cowpea intercrop had significantly lower soil moisture content at booting stage which could have made the cowpea to suffer greater interspecies competition. The increase in growth parameters was higher under 5.0 t/ha farmyard manure application rate than at 2.5 t/ha of farmyard manure. The increase in growth parameters was higher in Kilifi than in Mtwapa partly because Kilifi received higher amount of rainfall than Mtwapa. Most of the maize growth parameters were higher under Lamu-maize intercropped with cowpea than under DH04 maize intercropped with cowpea.

Yield and yield components of cowpea and maize

The study has shown that application of farmyard manure reduced cowpea 100-grain weight and grain yield at both sites. Amujoyegbe and Elemo, (2013) reported that application of farmyard manure significantly reduced grain yield and yield components of intercropped cowpea. This could be attributed to the fact that farmyard manure application significantly increased maize growth, resulting in shading of cowpea intercrop. Eskandari (2012) reported that shading had a significant effect on cowpea under intercropping system because being the shorter component in the intercrop system it could not compete effectively for light resources. Cowpea yield and yield components were higher when cowpea was intercropped with DH04 maize variety than under intercrop with Lamu maize variety at both sites. Lamu maize variety was significantly taller than DH04 maize, hence it could have shaded the cowpea leading to low cowpea grain yield and yield components. Grain yield and yield components were higher at Kilifi than at Mtwapa possibly because Kilifi received 43.8 % more rainfall than Mtwapa.

Farmyard manure application increased the number of ears per plant, 100-grain weight and grain yield of maize. Adeyemo and Ageles (2010) and Agbogidi (2010) reported an increase in maize yield and yield

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components due to manure application. Application of farmyard manure considerably improves soil physical properties and nutrient uptake resulting in increased yield and yield components (Awad et al., (2002). In this study farmyard manure application significantly increased moisture content relative to the control at all stages Application of 5 t FYM/ha had greater yield than 2.5 t FYM/ha possibly due to increased moisture and nutrient uptake. It is worth noting that plots supplied with 5 t FYM/ha had lower moisture content at 60 and 80 cm depths than 2.5 t FYM/ha Maize yield and yield components were significantly higher under Lamu-cowpea intercrop than under DH04-cowpea intercrop. The taller Lamu maize variety could have had an advantage over the shorter DH04 maize since plant height is a major determinant of a plant's ability to compete for light (Falster and Westoby, 2003). Maize yield and yield components were significantly higher in Kilifi than in Mtwapa because Kilifi received 43.8% higher amount of rainfall than Mtwapa.

CONCLUSION

Farmyard manure application significantly increased soil moisture content at all growth stages at 20, 40 and 60 cm soil depths. Application of FYM significantly reduced cowpea growth parameters, yield components and grain yield while the converse was true for maize under maize-cowpea intercropping system. The performance of DH04-cowpea intercrop was significantly higher than Lamu-cowpea intercrop in most plant attributes measured.

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