International Journal of Agricultural Sciences ISSN: 2167-0447 Vol. 2 (6), pp. 178-185, June, 2012. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Influence of drought stress on growth, yield and yield components of selected maize genotypes in coastal lowland Kenya

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Received March 07, 2012; Accepted June 10, 2012

The risk of drought is high in the coastal lowland Kenya because rainfall in the region is unpredictable in quantity and distribution. Despite the availability of improved maize varieties farmers still grow local coastal maize landraces (LCML). The research was to study LCML in an effort to understand why farmers in the region prefer to grow them in spite of released improved maize open pollinated varieties (OPVs) and hybrid. The objective was to screen for drought tolerance in 25 LCMLs and 5 improved checks. The genotypes were evaluated for tolerance to terminal water deficit before flowering. The design was randomized complete block design (RCBD) with split plot arrangement of treatments. The screening was carried out at Kenya Agricultural Research Institute (KARI) Kiboko, genotypes were grown in water stress and well watered regimes. The traits measured were leaf rolling (LR), leaf senescence (LS), anthesis to silking interval (ASI), ears per plant (EPP), and grain yield (GY). Drought stress reduced grain yield by 28% from 0.96 t ha^{-1} in well watered environments to 0.69 t ha^{-1}, in the severe stress environment. Drought at flowering results in bareness. Ears per plant (EPP) were also reduced by 55% from 1.01 ears in the well watered environment to 0.45 ears in the severe stress environment. Water deficit significantly reduced growth, grain yield and yield components of the maize genotypes. In stressed maize the pollen begins to shed but silks emergence is delayed by 3 or 4 days. In fact pollination shedding may stop before all the silk have emerged and a blank ear will result. Local coastal maize landraces like entries: 3 (Mdzihana), 11 (Kanjerenjere), 16 (Mungindo) all from Kilifi County and entries: 9 (044454) and 17 (Gonjora) all from Lamu County of the coast region of Kenya are drought tolerant and can be used by the resource poor farmers to stabilize maize grain yield in the coastal lowland of Kenya, where recurrent drought threatens grain production. They can also serve as sources of drought tolerance for the developing and improvement of new drought tolerant maize genotypes.

Key words: Assimilates, climate, irrigation, morphological, physiological, and tropical

INTRODUCTION

Drought stress is a major climatic factor limiting the productivity of maize in developing countries (Sallah, et al., 2002). Maize is particularly very sensitive to moisture stress at flowering time, when it is clearly too late for farmers to adjust management practices (Westgate and Bassetti,1990). Maize crop in the tropics

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is continually exposed to drought stress and the incidence may increase, particularly due to global climate changes, partly to the displacement of maize to more difficulty production environments by high value corps, and partly to declines in soil organic matter, reducing soil fertility and water holding capacity (Banziger, et al., 2000).

A characteristic of maize under moisture stress is a delay in silking and increase in anthesis-silking interval (ASI) (Westgate and Bassetti, 1990). Under water stress conditions, plants may increase water use efficiency, by reducing water loss at critical times of the day when the vapour pressure deficits are large, and allow photosynthesis to continue in the early morning or late afternoon when vapour pressure deficits are less severe. This may be accomplished by midday stomatal closure, leaf wilting, leaf rolling (Turner, 1986). However, factors which postpone dehydration by reducing water loss, such as decreasing stomatal conductance, leaf rolling and decrease in leaf area are all processes that decrease productivity (Turner, 1979). Reduction in photosynthesis and water use early in life of the plant may enable a greater grain yield to be achieved by conserving water for the period of anthesis (Passioura, 1977). Plants that have physiological mechanisms that reduce transpiration during drought stress end up being drought tolerant.

Crop biomass is reduced by water deficit, mainly because of reduced radiation use efficiency (RUE) and reduced total radiation interception (RI) particularly when deficit come early in life (Stone et al, 2001). A depletion of the water storage (plant water stress) will decrease leaf gas exchange and a reduction of available water for growth in the above ground parts of plants will modify carbon partitioning to favour growth of supporting organs (Schulze, 1986). The partitioning of carbon into leaves is one of the main processes, which determines growth of individual plants subjected to drought (Nagarajah and Schulze, 1983). A direct signal from the root to the stomata appears to regulate leaf conductance as the soil dries prior to leaf wilting. It is possible that this signal also affects CO_2 assimilation, but the effect on photosynthesis appears to be pre-treatment and species dependent (Schulze, 1986). The potential yield of a crop is determined by how many seeds it sets. Drought may affect this number in two distinct ways. First, the number of seeds set is generally proportional to the amount of dry matter produced by the time of flowering, at least in determinate crops (Fischer 1979) and drought can greatly influence this amount of dry matter. Second, low water status at flowering may lead to infertility, floral abortion, and zygote abortion (Westgate and Boyer, 1986). Drought induced abortion may be modified through lack of assimilates for flower and grain growth if photosynthesis is inhibited by low leaf water potential (Schessler and Westgate, 1991). Drought induced infertility may in part be mediated through hormones (Saini and Aspinall, 1982). According to Morgan and Kings (1984) the filling of the seed that has been set depend partly on current photosynthesis and partly on the transfer of assimilate accumulated before flowering. To a first approximation, the amount of photosynthesis after flowering depends on the efficiency with which the plants can use their limited water during seed filling (Passioura, 1994). Water limited plants may translocate considerable amounts of pre-anthesis assimilates to the grain (Ludlow and Muchow, 1990). The proportion of the grain weight that comes from this source varies widely with species and environment, and depends strongly on the pattern of drought, with the proportion increasing with decreasing supply of water after anthesis (Richards and Townley-Smith, 1987).

The maize growing environment in the Coast Province of Kenya is characterized by low and erratic rainfall (900 – 1000 mm) resulting into recurrent crop failure, that leads to famine and malnutrition. The average maize grain yield in the region is still low (0.5 to 1.0 t ha^{-1}) when the potential for the area is 3.0 t ha^{-1}. Most of the resource poor farmers (70%) grow local coastal maize landraces (LCML) despite the improved varieties that have been released for growing in the region (Wekesa et al., 2003). It is for this reason the work was carried out to evaluate the effect of drought stress on the growth, yield and yield components of LCMLs in an effort to stabilize grain yield production with persistent crop failures due to drought stress.

MATERIALS AND METHODS

Experimental Site

The screening was carried out at Kenya Agricultural Research Institute (KARI) Kiboko, Kenya. This is located at longitude 37.75^{o}E and latitude 2.15^{o}S, at an elevation of 975 meters above the sea level (ASL), receives 530 mm annual rainfall, maximum temperature were 35.1^{o}C while minimum temperatures were 14.3 ^{o}C and has predominantly sandy clay soils (Jaetzold and Schmidt, 1983).

Experimental design

The randomized complete block design (RCBD) was used with three replications. Each had the 30 genotypes that included 25 local coastal maize landraces from the National Gene bank of Kenya.

These collections were from Kilifi, Kwale, Taita Taveta and Lamu counties of the Coastal region of Kenya. Five checks included were Pwani hybrid 4, Coast Composite, Coastal Lowland Composite1, and Coastal Lowland Synthetic 3, all recommended for the Coast and the Katumani Dryland Variety (KDV- 3), the drought tolerant check from KARI Katumani. Maize was planted at a spacing of 75 cm x 25 cm giving a planting density of 53,000 plants ha-1 in plots of 1.5 m x 1.5 m. Two seeds were sowed per hill and later thinned down to one. Planting was synchronized to make sure the entire 30 genotypes flower at the same time. Due to limitations imposed by irrigation, two separate but adjacent fields were planted (40 m apart), each for a severe stress and a well watered treatment. Irrigation was applied by overhead sprinklers. The water stressed was imposed 10 days to anthesis.

Data Collected

Data collected include leaf rolling (LR) (scale of 1 – 5, where 1 is no rolling and 5 is completely rolled), leaf senescence (LS) (scale of 1 – 10, where 1 is 10% of the leaf are senesced, a scale of 10 would mean 100% of the leaf area senesced) and ears per plant (EPP). Anthesis to silking interval (ASI) and grain yield (GY) were computed.

Data Analysis

Analysis of variance for the traits was performed using general linear model (GLM) SAS computer package version 9.1. The means were separated using Duncan's multiple range tests at 5% level of significance (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Leaf rolling and leaf senescence

There were significant differences observed for leaf rolling and leaf senescence evaluated for drought tolerance among Kenya Coastal maize landraces. The mean for leaf rolling was 2.59 while for leaf senescence was 6.32 (Appendix 1). The germplasms whose entry means for leaf rolling are less than 2.59 are drought tolerant because leaf rolling under drought is an indication of leaf water status and may be used to identify plants with inadequacies in water uptake or tugor maintenance (Sobrado, 1987). While, all the germplasms whose leaf senescence means were less than 6.32 are drought tolerant because drought stress is known to accelerate leaf senescence (Bolanos and Edmeades, 1993), so selection for stay green increases interception radiation and hence grain yields (Banziger, et al., 2000). Entries: 3 (Mdzihana), 11 (Kanjerenjere), 16 (Mungindo) all from Kilifi County and entries: 9 (044454) and 17 (Gonjora) all from Lamu County were as good as the drought tolerant KDV 3 check.

Tassel size

This was evaluated under well watered conditions only. This is the only trait that can be measured under well watered conditions but is indicative of drought tolerance at flowering. In maize, tassel morphology has an effect on grain yield as it intercepts available light to the canopy (leaves) and diverts available resources away from the developing grain (Banziger, et al, 2000). In a study by Hunter, et al, (1969) the negative effect of the tassels on yield was demonstrated when detasseled plants yielded 19% more than plants that had not been detasseled or had tassels removed and then rejoined. The mean for tassel size was 3.6 and entries 5 (32423), 6 (34619), 21 (47639) and 25 (47644) had lowest mean of 2.33 indicating that they are capable of yielding more than the other varieties.

Anthesis – silking interval (ASI)

Genotypes responded to water stress by increasing ASI as indicated by the mean of well watered being 3.92 while that of water stress being 6.96 (Appendix 2). The trend in breeding programme is to select against the increase in ASI with water deficit. Anthesis – silking interval is associated with low grain yield (Bolanos and Edmeades, 1996); Ribaut, et al., 2004). Germplasm with ASI means less or equal to 3 are drought tolerant. Entries: 3 (Mdzihana), 11 (Kanjerenjere), 16 (Mungindo) all from Kilifi County and entries: 9 (044454) and 17 (Gonjora) all from Lamu County were as good as the drought tolerant KDV 3 check.

Ears per plant

The ears per plant reduced by 55% from a mean of 1.01 in the well watered environment to 0.45 in the severe stress environment (Appendix 3). In stressed maize pollen begins to shed but silk emergence is delayed by 3 or 4 days.

Pollination shedding may stop before all the silks have emerged, and a blank ear will result (Robert and Twidwel, 2002) Entries: 3 (Mdzihana), 11 (Kanjerenjere), 16 (Mungindo) all from Kilifi County and entries: 9 (044454) and 17 (Gonjora) all from Lamu County were as good as the drought tolerant KDV 3 check.

Appendix 1 : Entry mean performance for leaf rolling (LR) and leaf senescence under water stress (ws) and tassel size (TS) under well watered (ww) conditions of 30 germplasm at KARI Kiboko during June – October 2006 season.

Entry	Accession no./code	District	Local variety name	Leaf rolling (LR) (1 - 5)	Leaf senescence (LS) (1 - 10)	Tassel size (TS) (1 - 5)
1	32329	Kwale	Matsere	2.67 bac	6.00 ebdc	2.67 bc
2	32372	Kilifi	Matsere	3.00 ba	6.00 ebdc	5.00 a
3	32379	Kilifi	Mdzihana	2.33 bdc	7.33 ba	3.33 bac
4	32404	Kilifi	Mingawa	2.67 bac	6.00 ebdc	4.00 bac
5	32423	Kilifi	Tela	2.67 bac	5.33 ed	2.33 c
6	34619	T/Taveta	T/Taveta	2.67 bac	5.67 edc	2.33 c
7	34660	T/Taveta	-	2.67 bac	6.67 bdac	4.33 ba
8	34661	T/Taveta	-	2.67 bac	6.33 ebdac	3.33 bac
9	44454	Lamu	-	2.33 bdc	5.33 ed	5.00 a
10	44458	Lamu	-	2.67 bac	7.00 bac	3.67 bac
11	46360	Kilifi	Kanjerenjere	2.67 bac	6.00 ebdc	4.00 bac
12	47624	Kilifi	Mengawa	3.00 ba	6.33 ebdac	5.00 a
13	47625	Kilifi	Mdzihana	2.67 bac	6.33 ebdac	3.33 bac
14	47628	Kilifi	Chinga cha mosi	3.00 ba	6.00 ebdc	4.00 bac
15	47629	Kilifi	Mwangongo	2.33 bdc	6.67 bdac	3.33 bac
16	47631	Kilifi	Mungindo	2.33 bdc	7.67 a	2.67 bc
17	47632	Lamu	Gonjora	2.33 bdc	7.00 bac	3.33 bac
18	47635	Kwale	Kienyeji	3.00 ba	7.67 a	4.00 bac
19	47636	Kwale	Chitweka	3.00 ba	6.67 bdac	4.33 ba
20	47638	Kwale	-	2.67 bac	6.33 ebdac	3.33 bac
21	47639	Kwale	-	3.67 a	5.67 edc	2.33 c
22	47641	Kwale	Kanjerenjere	2.67 bac	5.33 ed	5.00 a
23	47642	Kwale	-	3.00 ba	6.00 ebdc	4.33 ba
24	47643	Kwale	-	2.67 bac	5.33 ed	3.33 bac
25	47644	Kwale	-	2.67 bac	6.00 ebdc	2.33 c
26	CCM	Kilifi	Coast composite	2.00 bdc	6.33 ebdac	3.33 bac
27	PH 4	Kilifi	Pwani hybrid 4	1.33 d	5.00 e	3.33 bac
28	CLC-1	Kilifi	Coastal lowland comp 1	3.00 ba	6.33 ebdac	3.33 bac
29	CLS-3	Kilifi	Coastal lowland synth 3	1.67 dc	7.67 a	4.00 bac
30	KDV-3	Makueni	-	1.67 dc	7.67 a	3.33 bac
			Mean	2.59	6.32	3.6
			CV	20.36	11.1	26.04
			DMRT	0.86	1.15	1.47

Means followed by the same letter are not significantly different (P<0.05) using DMRT.

Grain yield

The genotypes responded to water stress by reducing yield as indicated by yield loss calculated by subtracting yield under well watered from water stress environment. (Appendix 4) Drought stress reduced grain yield by 80% from a mean of 0.96 t ha^{-1}in well watered environment to 0.64 t ha^{-1}in the severe stress environment. Drought at flowering results in barrenness, which is caused by reduction in the influx of assimilate to the developing ear below some threshold level necessary to sustain grain formation and growth (Schussler and Westgate,

Appendix 2: Entry means performance for days to anthesis (AD) of 30 germplasm under well watered (ww) and water stress (ws) conditions at KARI Kiboko during June – October 2006 season.

Entry	Accession no./code	District	Local variety name	Days to anthesis (AD)			
				ww	ws	ww – ws	AD loss %
1	32329	Kwale	Matsere	73 h	72.3 gfih	0.7	0.96
2	32372	Kilifi	Matsere	70.7 kj	71.3 gih	-0.6	-0.85
3	32379	Kilifi	Mdzihana	75.3 gf	73.3 gfeih	2	2.66
4	32404	Kilifi	Mingawa	71 ikj	70 ih	1	1.41
5	32423	Kilifi	Tela	72.3 ih	77 fedc	-4.70*	-6.5
6	34619	T/Taveta	T/Taveta	71 ikj	69.7 ih	1.3	1.83
7	34660	T/Taveta	-	81.3 d	80 bac	1.3	1.6
8	34661	T/Taveta	-	73.3 h	69.3 ih	4.00*	5.46
9	44454	Lamu	-	83.7 c	83 ba	0.7	0.84
10	44458	Lamu	-	73 h	73.3 gfeih	-0.3	-0.41
11	46360	Kilifi	Kanjerenjere	85.7 b	**84.7 a**	1	1.17
12	47624	Kilifi	Mengawa	81 d	83 ba	-2	-2.47
13	47625	Kilifi	Mdzihana	70.3 k	69.7 ih	0.6	0.85
14	47628	Kilifi	Chinga cha mosi	73 h	74.7 gfedh	-1.7	-2.33
15	47629	Kilifi	Mwangongo	75 g	78.3 bedc	-3.30*	-4.4
16	47631	Kilifi	Mungindo	73.3 h	72 gfih	1.3	1.77
17	47632	Lamu	Gonjora	76.7 f	76 gfedc	0.7	0.91
18	47635	Kwale	Kienyeji	75.7 gf	76.3 gfedc	-0.6	-0.79
19	47636	Kwale	Chitweka	72.7 h	73.7 gfej	-1	-1.38
20	47638	Kwale	-	79.3 e	79 bdc	0.3	0.38
21	47639	Kwale	-	75 g	76 gfedc	-1	-1.33
22	47641	Kwale	Kanjerenjere	73 h	74 gfedh	-1	-1.37
23	47642	Kwale	-	72 ihj	72.3 gfih	-0.3	-0.42
24	47643	Kwale	-	72 ihj	71.3 gih	0.7	0.97
25	47644	Kwale	-	68.3 i	68 i	0.3	0.44
26	CCM	Kilifi	Coast composite	73 h	73.3 gfeih	-0.3	-0.41
27	PH 4	Kilifi	Pwani hybrid 4	**89 a**	**84 a**	5.00*	5.62
28	CLC-1	Kilifi	Coastal lowland comp 1	76 gf	77 fedc	-1	-1.32
29	CLS-3	Kilifi	Coastal lowland synth 3	80.7 d	73 gfih	7.70*	9.54
30	KDV-3	Makueni	-	**59 m**	58 j	1	1.69
			Mean	74.78	74.5	0.34	0.45
			CV	3.43	3.65		
			DMRT	4.19	4.44		

Means followed by the same letter are not significantly different (P<0.05) using DMRT, * Significant

1995). Entries: 3 (Mdzihana), 11 (Kanjerenjere), 16 (Mungindo) all from Kilifi County and entries: 9 (044454) and 17 (Gonjora) all from Lamu County were as good as the drought tolerant KDV 3 check.

Appendix 3: Entry means performance for anthesis – silking interval (ASI) of 30 germplasm under well watered (ww) and water stress (ws) conditions at KARI Kiboko during June – October 2006 season.

Entry	Accession no./code	District	Local variety name	Anthesis - silking interval (ASI)			
				ww	ws	ww – ws	ASI loss %
1	32329	Kwale	Matsere	2.7 ebdc	3.5 bdc	-0.8	-29.63
2	32372	Kilifi	Matsere	3 ebdc	5.5 bdac	-2.5	-83.33
3	32379	Kilifi	Mdzihana	2 edc	4.7 bdc	-2.7	-135
4	32404	Kilifi	Mingawa	2.3ebdc	8.0 bdac	-5.7	-247.83
5	32423	Kilifi	Tela	6.3 a	11.0 ba	-4.7	-74.6
6	34619	T/Taveta	T/Taveta	4.7 bac	8.5 bdac	-3.8	-80.85
7	34660	T/Taveta	-	4.3 bac	7.0 bdac	-2.7	-62.79
8	34661	T/Taveta	-	3.7 ebdac	**13.0 a**	-9.3	-251.35
9	44454	Lamu	-	5.0 ba	2.5 dc	2.5	50
10	44458	Lamu	-	**6.0 a**	11.0 ba	-4.7	-74.6
11	46360	Kilifi	Kanjerenjere	3.0 ebdc	3.0 bdc	0	0
12	47624	Kilifi	Mengawa	**6.0 a**	6.0 bdac	0	-10
13	47625	Kilifi	Mdzihana	**6.0 a**	10.3 bac	-5.3	-106
14	47628	Kilifi	Chinga cha mosi	**6.0 a**	11.0 ba	-4	-57.14
15	47629	Kilifi	Mwangongo	3.7 ebdac	4.0 bdc	-0.3	-8.11
16	47631	Kilifi	Mungindo	4.0 bdac	7.0 bdac	-3	-75
17	47632	Lamu	Gonjora	4.3 bac	10.7 bac	-6.7	-167.5
18	47635	Kwale	Kienyeji	6.3 a	10.5 bac	-4.2	-66.67
19	47636	Kwale	Chitweka	4.3 bac	4.7 bdc	-0.4	-9.3
20	47638	Kwale	-	2.7 ebdc	7.0 bdac	-4.3	-159.26
21	47639	Kwale	-	4.0 bdac	**1.0 d**	3	75
22	47641	Kwale	Kanjerenjere	4.7 bac	**13.0 a**	-8.3	-176.6
23	47642	Kwale	-	4.3 bac	7.7 bdac	4.3	100
24	47643	Kwale	-	2.3 ebdc	3.5 bdc	-1.2	-52.17
25	47644	Kwale	-	5.0 ba	10.0 bac	-5	-100
26	CCM	Kilifi	Coast composite	3.7 ebdac	7.3 bdac	-3.6	-97.3
27	PH 4	Kilifi	Pwani hybrid 4	2.0 edc	3.0 bdc	-1	-50
28	CLC-1	Kilifi	Coastal lowland comp 1	3.0 ebdc	6.0 bdac	-3	-100
29	CLS-3	Kilifi	Coastal lowland synth 3	1.3 ed	3.7 bdc	-2.4	-184.62
30	KDV-3	Makueni	-	**1.0 e**	3.0 bdc	-2	-200
			Mean	3.92	6.5		
			CV	36.34	49.96		
			DRRT	2.33	6.96		

Means followed by the same letter are not significantly different (p=0.05), - No name given to entry

CONCLUSION

Drought stress at flowering significantly affects leaf rolling and leaf senescence which in turn causes reduction in the influx of assimilates to the developing ear below some threshold level necessary to sustain growth and grain formation. It causes barrenness in that pollination shedding may stop even before silk emergen

Appendix 4: Entry means for ears per plant (EPP) of 30 germplasm under well watered (ww) and water stress (ws) conditions at Kiboko during June – October 2006 season.

Entry	Accession no./code	District	Local variety name	Ears per plant (EPP)			
				ww	ws	ww - ws	EPP loss %
1	32329	Kwale	Matsere	0.9 cb	0.5 dc	0.40*	44.44
2	32372	Kilifi	Matsere	1.0 cb	0.4 dc	0.60*	60
3	32379	Kilifi	Mdzihana	0.8 cb	0.6 bc	0.2	25
4	32404	Kilifi	Mingawa	1.2 b	0.3 dc	0.90*	75
5	32423	Kilifi	Tela	1.0 cb	0.3 dc	0.70*	70
6	34619	T/Taveta	T/Taveta	1.0 cb	0.3 dc	0.70*	70
7	34660	T/Taveta	-	1.1 cb	0.3 dc	0.80*	72.73
8	34661	T/Taveta	-	1.0 cb	0.5 dc	0.50*	50
9	44454	Lamu	-	1.1 cb	0.6 bc	0.50*	45.45
10	44458	Lamu	-	1.0 cb	0.3 dc	0.70*	70
11	46360	Kilifi	Kanjerenjere	1.0 cb	0.5 dc	0.50*	50
12	47624	Kilifi	Mengawa	1.0 cb	**0.1 d**	0.90*	90
13	47625	Kilifi	Mdzihana	1.0 cb	0.5 dc	0.50*	50
14	47628	Kilifi	Chinga cha mosi	1.0 cb	0.3 dc	0.70*	70
15	47629	Kilifi	Mwangongo	1.1 cb	0.6 c	0.50*	45.45
16	47631	Kilifi	Mungindo	1.1 cb	0.3 dc	0.80*	72.73
17	47632	Lamu	Gonjora	1.0 cb	0.3 dc	0.70*	70
18	47635	Kwale	Kienyeji	1.0 cb	0.3 dc	0.70*	70
19	47636	Kwale	Chitweka	1.0 cb	0.4 dc	0.60*	60
20	47638	Kwale	-	1.0 cb	0.3 dc	0.70*	70
21	47639	Kwale	-	1.1 cb	0.4 dc	0.70*	63.64
22	47641	Kwale	Kanjerenjere	1.0 cb	0.5 dc	0.50*	50
23	47642	Kwale	-	1.0 cb	0.3 dc	0.70*	70
24	47643	Kwale	-	1.1 cb	0.5 dc	0.60*	54.55
25	47644	Kwale	-	1.0 cb	0.4 dc	0.60*	60
26	CCM	Kilifi	Coast composite	1.1 cb	0.6 bc	0.50*	45.45
27	PH 4	Kilifi	Pwani hybrid 4	1.3 b	**1.3 a**	0	0
28	CLC-1	Kilifi	Coastal lowland comp 1	0.9 cb	0.3 dc	0.60*	66.67
29	CLS-3	Kilifi	Coastal lowland synth 3	**1.7 a**	1.0 ba	0.70*	41.18
30	KDV-3	Makueni	-	**0.70 c**	0.6 bc	0.1	14.29
			Mean	1.01	0.45		
			CV	21	50		
			LSD	0.35	0.37		

Means followed by the same letter are not significantly different (p=0.05) - No name given to entry * Significant

cy. The ears per plant reduced by 55% from a mean of 1.01 in the well watered environment to 0.45 in the severe stress environment. Drought stress reduced grain yield by 28% from a mean of 0.96 t ha^{-1} in well

Appendix 5: Entry mean for grain yield (GY) of 30 germplasm under well watered (ww) and water stress (ws) conditions at KARI Kiboko during June – October 2006 season.

Entry	Accession no./code	District	Local variety name	Grain yield (GY)			
				ww	ws	ww – ws	GYloss %
1	32329	Kwale	Matsere	0.87 edghf	0.63 bdac	0.24	27.59
2	32372	Kilifi	Matsere	1.37 bac	0.60 bdc	0.77	56.2
3	32379	Kilifi	Mdzihana	0.87 edghcf	0.80 ba	0.07	8.05
4	32404	Kilifi	Mingawa	1.2 ebdacf	0.63 bdac	0.57	47.5
5	32423	Kilifi	Tela	0.83 eghf	0.77 bac	0.06	7.23
6	34619	T/Taveta	T/Taveta	0.87 edghcf	0.70 bdac	0.17	19.54
7	34660	T/Taveta	-	0.8 ghf	0.60 bdc	0.2	25
8	34661	T/Taveta	-	0.77 ghf	0.63 bdac	0.14	18.18
9	44454	Lamu	-	0.93 edghcf	0.77 bac	0.16	17.2
10	44458	Lamu	-	1.03 ebdghcf	0.73 bac	0.3	29.13
11	46360	Kilifi	Kanjerenjere	0.70 h	0.80 ba	-0.1	-14.29
12	47624	Kilifi	Mengawa	0.97 edghcf	0,50 d	0.47	48.45
13	47625	Kilifi	Mdzihana	0.83 eghf	0.77 bac	0.06	7.23
14	47628	Kilifi	Chinga cha mosi	1.43 ba	0.57 dc	0.86	60.14
15	47629	Kilifi	Mwangongo	0.9 edghf	0.80 ba	0.1	11.11
16	47631	Kilifi	Mungindo	1.3 bdac	0.77 bac	0.53	40.77
17	47632	Lamu	Gonjora	1.13 ebdghcf	0.70 bdac	0.43	38.05
18	47635	Kwale	Kienyeji	0.73 ghf	0.70 bdac	0.03	4.11
19	47636	Kwale	Chitweka	0.77 ghf	0.70 bdac	0.07	9.09
20	47638	Kwale	-	**1.60 a**	0.63 bdac	0.97	60.63
21	47639	Kwale	-	1.0 edghcf	0.60 bdc	0.4	40
22	47641	Kwale	Kanjerenjere	1.43 ba	0.67 bdac	0.76	53.15
23	47642	Kwale	-	1.03 ebdghcf	0.70 bdac	0.33	32.04
24	47643	Kwale	-	1.27 ebdac	0.73 bac	0.54	42.52
25	47644	Kwale	-	0.93 edghcf	0.73 bac	0.2	21.51
26	CCM	Kilifi	Coast composite	0.83 eghf	0.83 a	0	0
27	PH 4	Kilifi	Pwani hybrid 4	0.27 ebdgcf	0.67 bdac	-0.4	-148.15
28	CLC-1	Kilifi	Coastal lowland comp 1	1.17ebdghcf	0.60 bdc	0.57	48.72
29	CLS-3	Kilifi	Coastal lowland synth 3	**0.2 i**	0.57 dc	-0.37	-185
30	KDV-3	Makueni	-	0.7 h	0.77 bac	-0.07	-10
			Mean	0.96	0.69		
			CV	23.25	16.02		
			LSD	0.36	0.18		

Means followed by the same letter are not significantly different (p=0.05), - No name given to entry

watered environment to 0.69 t ha^{-1}in the severe stress environment. There are sixteen genotypes which have grain yield more than 0.44 t ha^{-1} under drought stress which were as good as the drought tolerant check (KDV 3). This could be one of the reasons why most (70%) farmers in the region grow LCMLs instead of the recommended varieties in the region. Local coastal maize landraces like entries: 3 (Mdzihana), 11 (Kanjerenjere), 16 (Mungindo) all from Kilifi County and entries: 9 (044454) and 17 (Gonjora) all from Lamu County are drought tolerant and can be used by the resource poor farmers to stabilize maize grain yield in the coastal lowland of Kenya, where recurrent drought threatens grain production. They can also serve as sources of drought tolerance for the developing and improvement of new drought tolerant maize genotypes.

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