Research Note on Investigation on the Poor Performance of Rainfed Maize (*Zea mays*) at Morogoro Tanzania

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Abstract

A study was undertaken to find out the cause of poor performance of maize in some parts of Morogoro District, Tanzania. Rainfall (R) and Reference crop evapotranspiration (ETo) data were organized on 10-day basis for a period of 20 years from 1974 to 1993. Corresponding values of the two parameters for each 10-day period were then matched and used to determine the duration of rain seasons, appropriate planting dates and to detect the occurrence of dry spells. Findings indicate that, long rains are marked by a period of moisture sufficiency (R>ETo) lasting 60 days beginning March 12th. The average long-term rainfall amount during long rains is 360mm, which is inadequate for optimum yields for late maturing cultivars of maize. Storage of surplus moisture in the profile would extend the period of moisture sufficiency by 20 days during long rains. However, this is unlikely because soils are coarse textured and low in organic matter. Further more, poor agronomic practices encourage the loss of up 30% of rainwater as runoff. Short rains are characterized by a period of general increase in the supply of moisture beginning November 17th reaching a peak in December. During the entire short rain season, rains do not attain a level of sufficiency (R/ETo 1) in any of the ten day periods. Thus, moisture supply for the crop is sufficient during long rains but only to short maturing maize cultivar Kito/Katumani. There is a deficit in the supply of moisture throughout the short rains ruling out a successful production of a maize crop. The current study has however failed to detect the frequently experienced dry spells (during long rains) which adversely affect the maize crop. On the strength of the results obtained, the following can be concluded. During short rains, neither short (Kito/Katumani) nor long maturing (Staha/Ilonga Composite) maize cultivars can be successfully grown. Short maturing Kito/Katumani is recommended for planting during long rains instead of Staha/Ilonga Composite as is currently practiced. Dry planting should be done before March, 10th so as to make full use of the first rains.

Keywords: Rainfed maize, rainfall chacteristics, poor performance

Introduction

Production of rainfed maize in some parts of Morogoro District, Tanzania, has a history of low yields and total crop failure at times due to moisture stress. Inevitably, this has caused food shortages in the area. This problem was noted by Coe and Dumelow (1982) who attributed it to the absence of a clear policy on planting date. Using water balance and rainfall modeling methods, they respectively obtained March 10th and 12th to be dates that give minimum probability of failure during long rains. Observance of the above mentioned planting dates has however not reduced the incidences of crop failure. It is still necessary to replant two to three times to establish a good stand of maize. Frequently, subsequent dry spells interfere with crop development leading to drastic reduction in grain yield, or total crop failure.

A map of Tanzania showing the agroclimatic growing seasons (Gommes and Houssian, 1982), shows most of Morogoro District north of the Uluguru mountains falling into a zone with unreliable rainfall. This, coupled with sandy soils of low storage and available water holding capacities (Hathout, 1983) increase the probability that water stress will occur at some stage during the growing season. A soil survey in the study area by Mpepo (1986), also shows that sand and loamy sand (>83% sand) are the dominant textural classes in the 0-50 cm soil layer. On the other hand, soils with high water holding capacity constitute a very small proportion of the total area and are confined in narrow valley bottoms and along riverbanks. In his evaluation, Mpepo mentioned coarse texture and low available water capacity as the soil physical characteristics most limiting to crop growth in the study area.

The shortage of soil moisture to crops can also be attributed to unsuitable land preparation and management practices. Land preparation for the majority of resource poor farmers in Morogoro and in many parts of Tanzania, is for example limited to merely scratching on the soil surface to kill weeds and other vegetation before planting. The practice is locally called "kuberega". Deep tillage would require high draft power, which can not be achieved using hand hoes on hard dry soil at the end of the dry season. Unloosened soil restricts infiltration and thus encourages water loss through surface run-off. Long term run-off studies at Sokoine University (Shayo-Ngowi and Mtakwa, 1994; Gebremedhin, 1996; and Mkoga, 1998) indicate that as much as 36% of seasonal rainfall is lost as run-off from bare fallow (Table 1). The bare fallow treatment in the quoted studies is almost similar to the "kuberega" system. Thus, 36% run-off losses amount to 168mm equivalent of rainwater basing on the average rainfall of 467mm during long rains from 1994 to 1997 when the study was conducted. In addition, there are other losses of soil water for example through evaporation due to high temperatures and deep percolation in soils with low water holding capacities. The nature of rains can also encourage the loss of limited rainwater as runoff. What could be considered as adequate rainfall, is at times concentrated into a few heavy storms leading to runoff. Mkoga (1998) reported the frequent occurrence of storms in Morogoro and Kilosa Districts. When a dry spell occurs during a growth stage sensitive to water stress such as during flowering, the results can be a complete crop failure. In semi-arid areas, this means that crop yields are often chronically low not due to inadequate total rainfall amounts but rather due to the detrimental effect on crop growth of dry spells (Rockstrom, 2000).

General recommendations from other studies give the total seasonal (3 – 4 months) crop water needs for maize as 500 – 800mm and that for sorghum/ millet as 450 – 650mm (Dorenboos and Kassam, 1979). The average amount of rainfall (467 mm) in the area based on studies by Shayo-Ngowi and Mtakwa (1994); Gebremedhin (1996) and Mkoga (1998), is thus inadequate for maize but just enough for sorghum/ millet. A five-year development plan (1994/85 – 1989/90) for Morogoro region (RDD, 1984), blamed the increased area under maize in what was once predominantly a sorghum growing area as the main cause of frequent food shortages and crop failure. Although the problem of poor performance of maize is known to crop researchers and to most if not all-maize farmers in Morogoro, documented information on the subject is scarce. A study by Mhagama (1995) singled out moisture stress as the major bottleneck to rainfed field experiments at Sokoine University of Agriculture (SUA). Field experiments involving maize as a test crop are frequently disrupted for same reason as given above. Unfortunately, crop failure on experimental sites is usually not studied or reported if at all.

The onset and distribution of rain within the growing season create a difficult management situation in which planting dates and choice of cultivars are critical. High yielding, long maturing "Ilonga Composite or Staha" and low yelding, short maturing "Katumani or Kito" cultivators of maize are planted during long and short rains, respectively. Long rains last from mid-March to mid-May and short rains last from mid-November to mid-January. A study by

Rwehumbiza (1987) has shown that "Katumani" and Ilonga Composite tassel about 40 and 60 days after planting, respectively and harvesting take place 80 and 115 days after planting in the same order.

This present study was initiated to confirm whether or not dry spells occurred in Morogoro during the growing season resulting in water deficit for the maize crop. The study was also aimed at determining the duration of each of the growing season and appropriate planting dates. The findings are discussed in relation to tillage practices, as well as soil and rainfall characteristics in the study area.

Materials and Methods

Climatological data for a period of 20 years viz from 1974 to 1993 were gathered from a Meteorological Station located at the Sokoine University of Agriculture campus, Morogoro (6°51'S latitude and 37°39'E longitude) Tanzania. The period of each year beginning January 1st to December, 26th was divided into 36 ten-day periods and one five-day period from December 27th to 31st when it was averaged over 5-day period. Penman method (Doorenbos and Pruitt, 1977) was used for estimating Reference crop evapotranspiration (ETo) values following the steps outlined by Gommes (1983). Further, the Rainfall (R) and ETo data for each 10-day period were averaged over a period of 20 years (1974-1993) expressing R and ETo in mm/day representing the mean values over that period. Additionally a ratio R/ETo was computed for corresponding mean values of R and ETo obtained above. The ratio was later used to determine planting dates and duration of rain seasons. Similarly, periods of sufficient supply of moisture (R/ETo ≥ 1) and those of moisture deficity (R/ETo < 1) were assessed using the ratio. The study investigated how well the maize cultivars Staha/ Ilonga Composite and Kito/ Katumani fit rainfall distribution by matching corresponding values of R and ETo in each 10-day period.

Results and Discussion

The data on rainfall (R) and Reference crop evapotranspiration (ETo) averaged over a period of twenty years (1974-1993) for each 10-day period in terms of mm/day are presented in Table 1. The data of the ratio R/ETo based on the average values of R and ETo are also given in the same table. Values with plus/minus signs are the standard deviations for the years.

Looking at the data, minimum deviation from the means of ETo is noted. On the other hand, very high deviations from the mean values of R in most cases exceeding the respective means underline the inherent year to year variability in the amount of rainfall received.

A period of moisture sufficiency (R> ETo) lasting 60 days begins March 12th thus confirming earlier findings by Dumelow and Coe (1981) in which 10th and 12th March were given as ideal planting dates during long rains. If an assumption is made that surplus moisture is not lost but stored in the profile, calculations involving carrying forward surplus moisture from one ten day period to the next indicate that the period of moisture sufficiency can be extended by 20 days to May 30th. Usually, when rainfall exceeds crop requirement, the fate of surplus water could be one of the following:

(i) It can be stored into the profile if the soil is unsaturated, deep enough and of high water holding capacity,

(ii) It could percolate beyond the rooting depth if the root zone is already saturated or it can lead to surface ponding or surface run-off depending on the topography of the area. Storage of surplus water in the profile can even out the distribution of soil moisture to the crop especially when rainfall events are few but heavy and far separated in time and space. Unfortunately, soils in the study area are coarse textured, high in bulk density, and low in organic matter content (Mpepo, 1986). The storage of surplus moisture is thus unlikely in such droughty soils.

The short rains are characterized by a period of general increase in the supply of moisture beginning November 17th reaching a peak in December. During the entire short rain season, rains do not attain a level of sufficiency (R/ETo 1) in any of the ten day periods.

Tracing the phenological development of either Katumani/ Kito or Ilonga Composite/ Staha against R/ETo in any of the rainy seasons using the above mentioned planting dates as starting points, one notes the following:

Table 1: Amount of rainwater (mm) lost from runoff plots under different management systems during long rains (March - May, 1994 - 1998) at Morogoro

	Year and Seasonal Rainfall				Run-off as fraction of Rainfall(RO/R x 100). Mean value for four years (1994 - 1997) (%)
Management system (on 4% slope)	1994 (354.2mm)	1995 (589.4 mm)	1996 (520 mm)	1997 (403.6mm)	
	Run-off /season/treatment (mm)				
Ridge cropping across slope (maize)	269.7	14.3	35.2	12.4	22
Flat cropping	268.8	51.4	157	13.0	30
Natural (permanent) grass cover	135.4	5.1	14.4	5.3	11
Bare fallow	298.3	59.2	239.8	21.9	36
Fine Mesh (80% net shading rate)	168.3	12.3	29.7	20	15
Medium mesh (55% net shading rate)	166.5	12.6	38	15.1	15
Coarse mesh (44% net shading rate)	237.7	15.7	75.1	12.3	22

Based on data from run-off plot studies at Sokoine University of Agriculture, Morogoro Tanzania (Shayo -Ngowi and Mtakwa, 1994; Gebremethin, 1996 and Mkoga, 1998).

Table 2: Rainfall (R) and Reference crop Evapotranspiration (Eto) in mm/day and R/ETo raatio for each 10 - day period at Morogoro, Tanzania

Decade	(10 -day) period	Rainfall (R)	ETo Penman	R/ETo
January	1-10	2.88 + 2.71	6.05 + 1.05	0.48
	11-20	2.39 + 3.07	5.18 + 1.39	0.46
	21-30	2.89 + 2.81	5.60 + 0.82	0.52
	31-Feb. 9	2.81 + 4.33	5.98 + 1:13	0.47
February	10 - 19	2.64 + 4.48	6.00 + 1.45	0.44
	20 - March 1	2.51 + 2.11	5.12 + 1:03	0.49
March	2 - 11	2.61 + 1.95	5.77 + 1.43	0.45
	12 - 21	4.94 + 4.50	4.36 + 0.75	1.13
	22-31	5.23 + 3.86	3.46 + 0.79	1.51
April	1-10	6.36 + 3:50	3.42 + 0.71	1.86
	11-20	4.98 + 3.01	3.40 + 0.45	1.46
	21-30	6.15 + 2.92	3.33 + 0.20	1.85
May	1-10	4.63 + 3.53	2.69 + 0.32	1.72
	11 - 20	1.96 + 1.54	3.45 + 0.31	0.57
	21-30	1.91 + 1.97	3.25 + 0.26	0.59
	31 - June 9	1.23 + 2.18	3.37 + 0.37	0.36
June	10 - 19	0.89 + 1.57	3.17 + 0.31	0.28
	20 - 29	0.61 + 0.81	3.87 + 0.51	0.61
	30 -July 8	0.64 + 0.76	4.34 + 0.60	0.15
July	10 - 19	0.70 + 1.01	3.71 + 0.24	0.19
	20 - 29	0.36 + 0.58	4.43 + 0.43	0.08
	30 -Aug 8	0.24 + 0.35	4.74 + 0.48	0.05
August	9 - 18	0.34 + 0.46	4.64 + 1.01	0.07
	19 - 28	0.08 + 0.17	4.95 + 0.79	0.02
	29 - Sept. 7	0.22 + 0.45	5.56 + 0.86	0.04
September	8 - 17	0.26 + 0.36	5.64 + 0.82	0.05
	18 - 27	0.82 + 1.17	5.74 + 1.01	0.14
	28 - Oct 7	0.10 + 0.26	5.78 + 0.92	0.02
October	8 - 17	1.64 + 3.74	6.41 + 1.29	0.26
	18 - 27	0.60 + 0.80	6.64 + 1.28	0.09
	28 - Nov 6	1.43 + 1.90	6.11 + 1.18	0.23
November	7 - 16	1.07 + 1.70	6.72 + 1.41	0.16
	17 - 26	2.97 + 4.68	6.89 + 2.09	0.43
	27 - Dec 6	2.97 + 3.11	6.55 + 1.79	0.45
December	7 - 16	4.97 + 5.25	5.50 + 2.00	0.90
	17 - 26	5.09 + 3.63	5.64 + 1.94	0.90
	27 - 31	4.72 + 7.83	5.53 + 1.12	0.85

Each R, ETo and R/ETo Value is a 20 year average.

During short rains

(i) There is deficit in the supply of moisture throughout the season

(ii)It would be tasselling stage for short maturing Katumani/ Kito when the peak of rains come to an end.

During long rains

(i)Katumani/ Kito would be adequately supplied with moisture to its maturity

(ii)The so called "long rains" are too short for the long maturing Ilonga Composite/ Staha. The crop would be at the tasselling stage when moisture deficit sets in. However, as earlier mentioned above, if surplus moisture is stored in the profile, then the period of moisture sufficiency can be extended by 20 days. The extra twenty days would enable the long maturing Ilonga Composite to reach physiological maturity before moisture stress sets in. The average amount of rainfall received from the proposed planting date (March 12th) to the end of May, is 360 mm. This amount is inadequate compared to the water requirement for maize which range from 500 to 800 mm (Dorenboos and Kassam, 1979). It is also less than the figure of 467mm based on a four-year study reported by Mkoga (1998). As discussed earlier, runoff losses can be as high as 36% of the total rainfall (Shayo-Ngowi and Mtakwa, 1994; Gebremedhin, 1996; and Mkoga, 1998). Based on the above, the amount of rainwater that infiltrates into the soil is therefore much less than the 360 mm value. The inadequacy of rainwater is thus one of the main factors leading to the poor performance of maize in Morogoro.

The current study has however failed to detect the frequently experienced dry spells (during long rains) which adversely affect the maize crop. It is thus strongly felt that these (dry spells) will probably emerge if a similar study is undertaken in which R and ETo are organized using a shorter period of, say, five instead of ten days.

There is little if anything that can be done to control the commencement, intensity, amount, distribution, and the duration of rainfall. It can be argued however that, once rain arrives on the land, it can be managed efficiently to produce crops. Deep tillage to encourage infiltration, incorporation of organic manure to enhance water retention, and contour barriers to prevent runoff are technologies which when adopted, have been shown to significantly increase sorghum grain yield in semi-arid areas (Swai and Rwehumbiza, 1998).

On the strength of the current findings, the following can be concluded. Neither long nor short maturing maize cultivar can be successfully grown during the short rains. Short maturing Katumani or Kito maize cultivars be recommended for planting during long rains instead of Ilonga Composite or Staha as is currently practiced. This strategy would reduce maize crop failure during long rains. Dry planting should be practiced and ideally before March 10th so as to make full use of the first rains.

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