EFFECTS OF MULCH APPLICATION ON MAIZE YIELD IN THE SEMI ARID AREAS OF KENYA

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ABSTRACT

Experiments on plant nutrient status and yield of maize in relation to mulch nutrient composition were concucted at Katumani, in Machakos from 1987 to 1989. In all the seasons apart from the short rains of 1988, Katumani composite B was sown. During the SR'88, Hybrid 511 was mistakenly planted.

Cassia siamea had been grown as the tree species forming the hedges. Between the hedges, 3 maize rows were sown parallel to the hedges. The hedges were lopped periodically at a height of 50 cm and the loppings fully incorporated into the soil within the hedges (alleys) before the beginning of each season. In the control plots, each hedge row was replaced by a row of maize and therefore no mulch was incorporated in the control plots.

The results indicated that incorporation of mulch improved the nutritional status of maize as evidenced by increased nutrient concentrations in the maize leaves and grains of the treated plots compared to the controls. Decomposition experiments indicated that, approximately 70 - 90% of Cassia siamea mulch dry matter could be lost within 60 days after incorporation into the soil.

It was observed that the most limiting factor to the alley cropping technology in the semi-arid areas is the competition for water and nutrient in the soils. Water and nutritional status of the soil, will therefore determine to a large extent, the success or otherwise of such a system in these areas.

INTRODUCTION

One of the greatest challenges facing Kenya today is the production of adequate food to feed the rapidly increasing population. Two ways of achieving this are stabilizing food production and by opening up new areas for arable farming in marginal and medium agricultural potential areas. Kenya's arid and semi-arid areas cover approximately 80% of the country while the semi-arid areas with marginal to medium agricultural potential comprise about 20% of the country's land area. It is from these areas that one third of the projected increase in agricultural production is expected to come from (Anon. 1983).

Major constraints in the semi-arid areas include low and unreliable rainfall, and very low organic matter in the soils. The repetitive maize/bean intercrops and low agricultural inputs into the soi have led to degradation and improverishment of most soils in these areas resulting in very low crop yields. At times total crop failure, necessitating expensive intervention in the form of famine relief, has been experienced (Mungai, 1987).

In the traditional systems, farmers mainly relied on long fallow period to regenerate the fertility of the land exhausted during the cropping period. The bush fallow - crop production rotation is known to be an ecologically stable system since a long fallow period is feasible. When the fallow period becomes too short, as observed in areas with high population densities, either artificial fertilizers have to be used to be improve soil fertility or other alternatives which are economically attractive to small farmers have to be included in the production system. High costs and/or lack of inorganic fertilizers in many developing countries exclude or limit their use by many small farmers. In addition, low clay Alfisols and related soils which are widely distributed in the tropics are known to be prone to soil acidification due to continuous use of high rates of artificial fertilizers (Kang & van der Heide, 1985).

In order to reduce the dependency on artificial fertilizers and at the same time respond adequately to the problems of food production in the semi-arid areas, a technically feasible and economically viable technology which can sustain crop production and offer other benefits to the farmer needs to be developed. Agroforestry has been proposed as one such alternative in these areas.

Young (1989) has defined agroforestry as a collective term for land use systems in which trees are deliberately grown on the same land management unit as agricultural crops or pastures, and in which there is both an economic and ecological interaction between the tree and non-tree components. Agroforestry can be both a low-input as well as a self-sustaining technology. According to Nair (1984), it has the most apparent potential in "marginal" and in resource-limited small holder systems where monocultural agriculture or forestry may not be most feasible or even desirable.

HEDGEROW INTERCROPPING IN SEMI ARID AREAS OF MACHAKOS DISTRICT, KENYA

One form of low input agroforestry system that has been introduced in the semi arid areas of Kenya is hedgerow intercropping (alley cropping). This low input technology seeks to sustain crop production as well as to offer other benefits for the farmer as fodder, fuelwood, etc (Sang et al 1985 & Sang & Hoekstra, 1986). Hedgerow intercropping is a crop production system whereby food crops are planted in spaces by hedgerows of selected trees or shrubs (Wilson & Kang, 1981). The loppings from the hedgerows supply nutrients and organic materials to the crop and recycle leached nutrients.

Kenya Forestry Research Institute (KEFRI) in conjunction with international and National Development Agencies is carrying out a research project in the hedgerow intercropping in Machakos district involving both the on-station and on-farm experimentation.

THE EXPERIMENTS

The experimental work was carried out at Katumani National Dryland Farming Research Station which is about 7km south-west of Machakos town. The average seasonal rainfall is about 350 mm for each of the two seasons i.e. the long rains (March - May) and the short rains (October - December). The soils of the experimental site are luvisols which are well drained and deep (80 - 120 cm) with friable clay over murram. The top soils have low (<1%) organic matter content (Kibe et al, 1981).

The established experimental layout is a completely randcmised design with two treatments (excluding the control) each replicated 4 times. Cassia siamea had previously been selected as the tree species for the headgerows. Within each plot (except control plots) four hedges were established in November 1983, at between-row spacing of 3.6m and in-row spacing of 0.25m for treatment 1 and 1.0m for treatment 2. Betweer hedgerows, 3 rows of maize were sown parallel to the hedges at a spacing of 90cm by 30cm. In the control plots, each hedgerow was replaced by a row of maize. The established practice is to lopp the Cassia siamea at 50 cm and incorporate the loppings into the soil at the beginning of each season. Maize s planted twice a year in regard to the rainfall pattern of the area.

OVERVIEW OF SOME RESULTS

This paper presents some results of the assessment of the nutrient aspects and decomposition of the loppings of Cassia siamea in relation to maize yield.

Decomposition of the loppings of Cassia siamea which was incorporated into the alleys was more rapid in the first few days and gradully decreased over time for both seasons (Fig. 1). The C/N ratio for the long rains 89 was narrower (9.27) than for the short rains 88 (15.05). This explains why decomposition was faster for the long rains 89 than for the short rains 88.

There is evidence that incorporating mulch into the soil does increase and improve the nutritional value of maize and eventually the total yield as indicated by tables 1, 2 & 3 when the treated plots are compared with the controls, in respect with maize leaves, grains and total yields.

The magnitude of the increase of the yield on per row basis of the treated plots over the controls was approximately 32% and 12% for the long rains and short rains of 1988. The drop during the short rains as compared to the long rains may have been due to the different cultivar (Hybrid 511) planted mistakenly during the short rains 88 as opposed to the Katumani Composite B that is normally planted in Machakos. The hybrid did better than Katumani

Table 1. Means of nutrient composition for maize leaves.

SEASON	N	P	K	Ca	Mg	S	Na
	NUTRIENTS IN %						
LR'88							
Treated	3.72	0.28	1.75	0.98	0.38	0.08	0.32
Control	3.12	0.24	1.25	0.78	0.28	0.07	0.28
% Incr.	19.2	16.7	40.0	25.6	35.7	14.3	14.3
SR'88							
Treated	2.46	0.17	2.02	0.44	0.23	0.05	0.32
Control	2.21	0.14	1.82	0.28	0.17	0.04	0.25
%	11.3	21.4	11.0	57.1	35.3	25.0	28.0

Table 2. Means of nutrient composition for maize grains.

SEASON	N	P	K	Ca	Mg	S	Na
	NUTRIENTS IN %						
LR'88							
Treated	1.47	0.18	0.22	0.18	0.14	0.00	0.06
Control	1.22	0.14	0.17	0.16	0.12	0.00	0.04
% Incr.	20.5	28.6	29.4	12.5	16.7	0.00	50.0
SR'88							
Treated	1.53	0.22	0.23	0.16	0.13	0.01	0.05
Control	1.41	0.19	0.20	0.15	0.11	0.01	0.04
% Incr.	8.5	15.8	15.0	6.7	18.2	0.0	25.0

Table 3. Mean yields (grains) in g/row

SEASON	TREATED PLOTS		CONTROL PLOTS	
	Plot No.	*g/row*	*Plot No.*	*g/row*
LR'88	2	3047.2	1	2281.5
	3	3787.7	5	2099.1
	8	2675.9	7	1794.3
	10	2925.2	12	3272.9
	AVG	3109.0	AVG	2362.0
	% INCR.	32.0		
	2	4589.6	1	4199.9
	3	3486.5	5	3916.2
	8	4563.3	7	3309.4
	10	4531.0	12	3899.9
	AVG	4292.6	AVG	3831.4
	% INCR.	12.0		

NB

LR - Long rains
SR - Short rains
% Incr - % Increase
AVG - Average

Compossite in terms of total yields, but the controls of the hybr d increased more than the treatments when the long rains and the short rains were compared. The hybrid was apparently able to exploit control areas more effectively. Hybrid 511 is a long maturing variety compared to the Katumani variety and is sually grown in the wetter areas. The rainfall received during this season was however, higher (515 mm) than the normal expected average of 350 mm and was well distributed throughout the growing season. This ensured that they hybrid maize grew to maturity and yielded well. It was observed that this cultivar grew taller and had a more increased above ground biomass compared to the Katumani cultivar. If this extra shoot height and biomass could be reflected in a greater root biomass and deeper root system than the Katumani cultivar, then it is possible that the Hybrid maize roots exploited new and deeper mineral reserves which allowed it to perform better (Coulson, et al, 1989). The narrower differences in nutrients between the treated and control plots of the hybrid maize as compared to the Katumani could be explained by the fact than, prior to the SR'88, the experimental plots had always been planted with Katumani maize. It is likely that those successive maize crops had extracted nutrients down to a certain depty of soil, and the soil in that depth had become denuded of nutrients compared to the soil below it. When the deeper rooted hybrid maize was introduced, it is possible that its roots exploited new mineral reserves at lower levels and hence the observed increase in the nutrients and yields. The magnitude of the increase was however, bigger for the controls than treated plots. The reason for this could be that there was competition between the maize and Cassia in the treated plots for both nutrients and water (Fig. 2).

Alley cropping in the semi-arid areas aimed at increasing yields with a degree of sustainability is not as clear cut as in the more humid areas, for rainfall and nutritional status of the soil seem to dictate to a large extent the success of the system. The expectation from the early data from this system was that the yield advatage of growing maize in the alleys would consistently increase with passing seasons. This might appear to be obvious when we consider that the fertility of the control plots would continue to decline while that of the treatment plots would be sustained or improved. The fact that this appealingly simple hypothesis is not supported suggests that under limited rainfall conditions the situation has other facets. From the data obtained so far from these experiments and mungai's data (unpublished) seems to indicate that yield reversals can occur depending on seasonal amount of rainfall. From the preliminary analysis (Coulson et al; 1989) it would seem that above a certain rainfall level (possibly about 160 mm for our system and site) the per row maize yield in the alleys is greater than that of the controls (Fig. 3). As the rainfall increases above this figure the increase of the treatment yield becomes larger than the control. Conversely, as the rainfall decreases below this figure the productivity of maize in the alleys declines more and more below that of the control due to the competition of water with Cassia (see also Fig. 2a). Thus it would appear that the benefits of the added mulch are very much dependent on soil water availability as governed by rainfall and competition.

It is necessary to undertake more trials on multipurpose trees and shrubs for alley cropping systems with different management options in order to improve the net value of alley cropping under semi-arid conditions.

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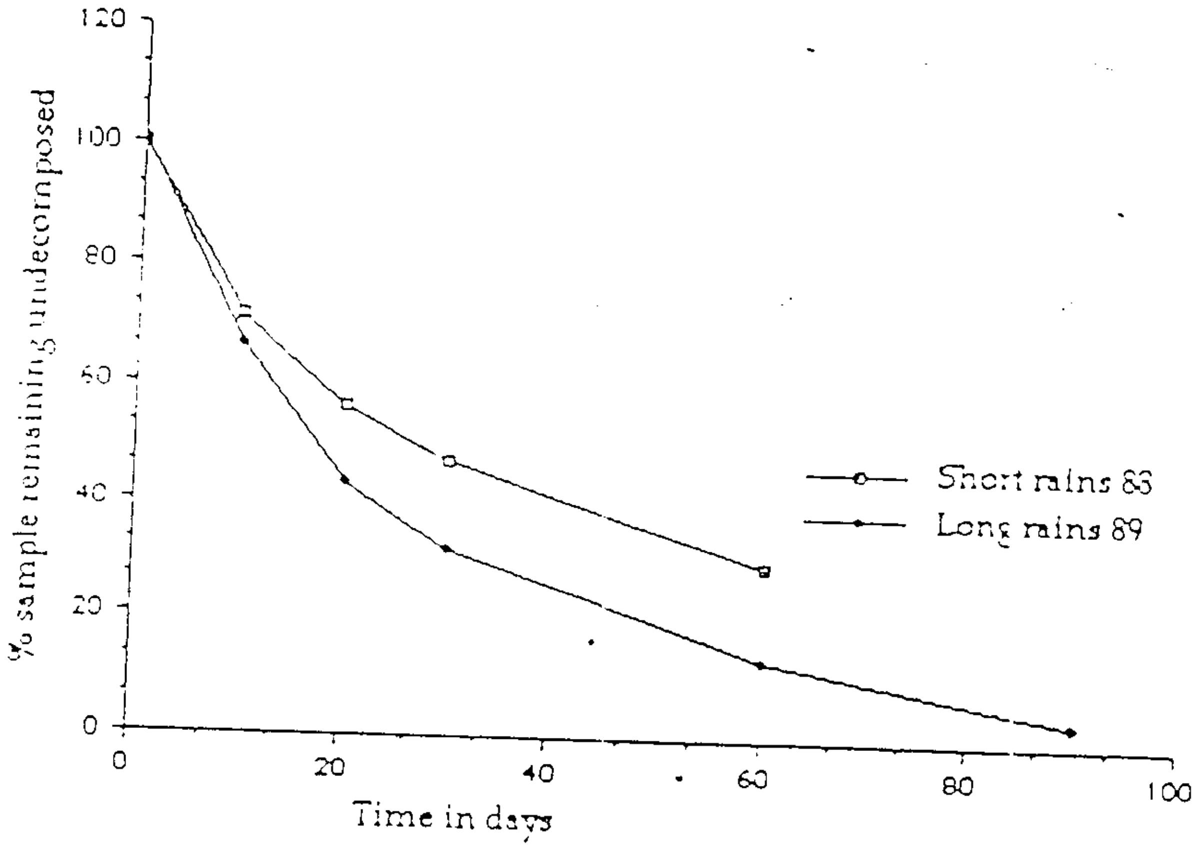
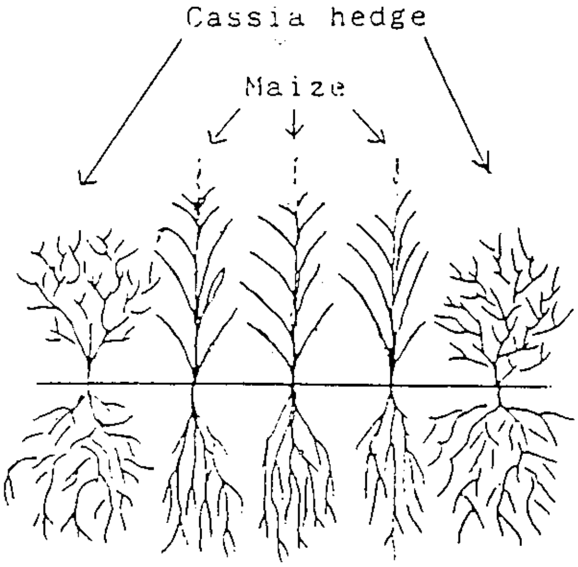


Fig. 1: Decomposition of *C. siamea* short rains 88 versus long rains 89.

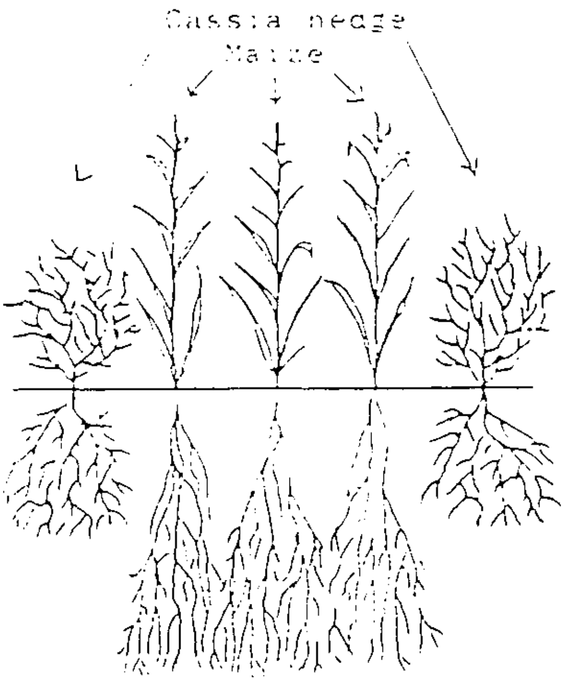
Fig. 2 (a-c). Illustrates the possible nutrient and soil moisture extraction dynamics of the control and treatment plots.

2(a) Treatment.



Because of similar rooting depths, under low rainfall the Cassia hedge successfully competes with the maize (Katumani Comp. B.) for water in the treatment plots (a). This leads to a reduction in maize yield under these conditions. In the controls there is less competition due to the absence of Cassia and compared to the treatment the controls yield higher. The concept implied here is that if the crop and tree components root at different depths then competition for water and nutrients will be ameliorated.

2(b) Treatment



2(c) Control

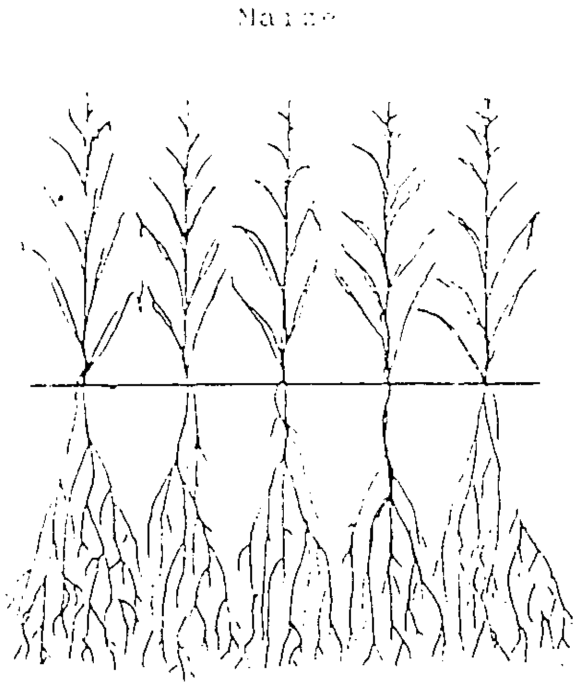


Fig.2 (b) and (c) illustrate a phenotypic difference in maize rooting depth and is, thought to be applicable to the short rains 1988 (515mm). In (b) it is postulated that under this unusually high and well distributed rainfall and with a deeper rooting cultivar extraction of unexploited nutrient reserves occurred. However, under this situation the controls (c) appear to have had relatively more nutrients available due to the absence of competition by the Cassia

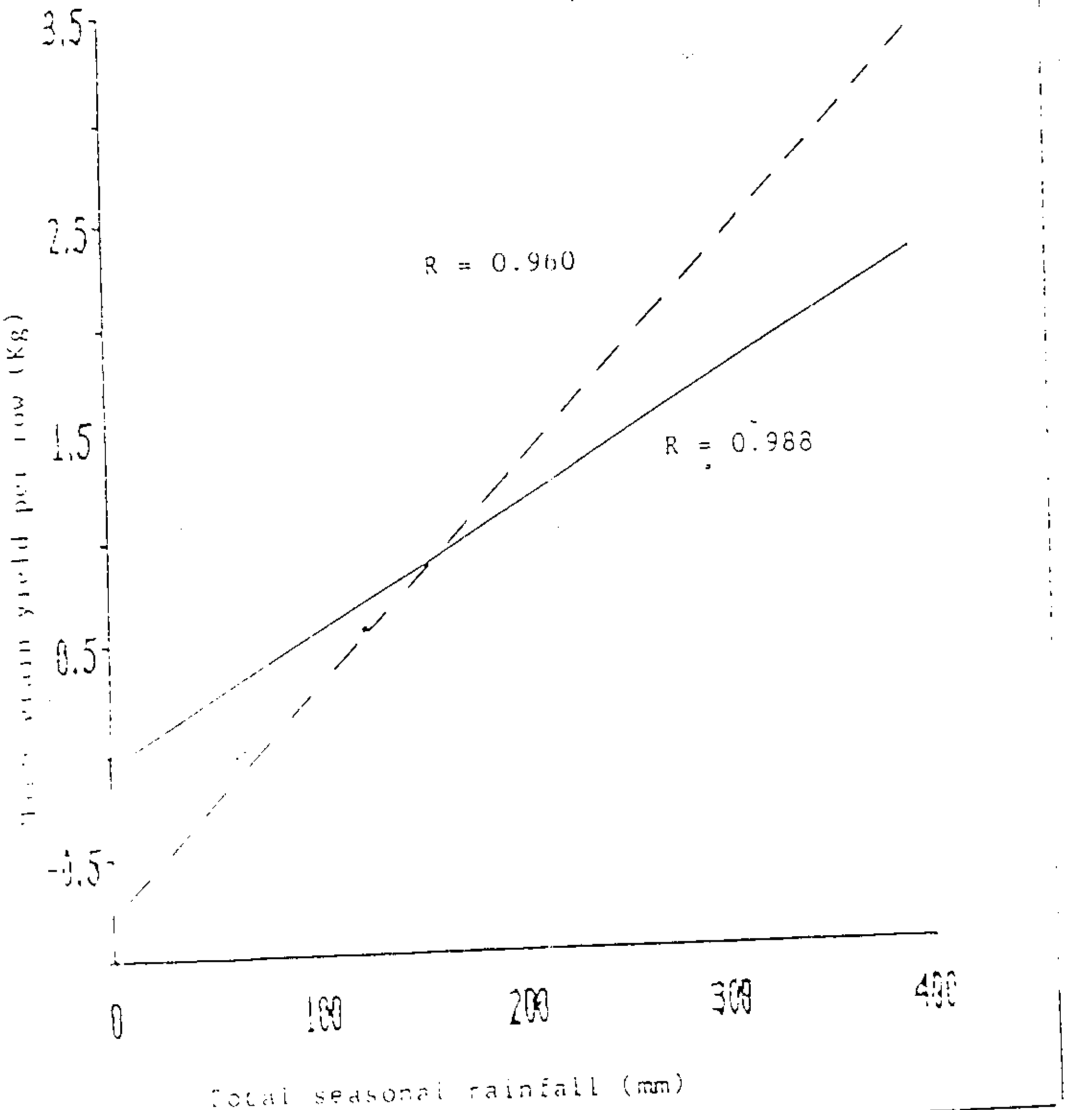


Fig 3. Maize grain yield for four seasons, 1986 - 1988. (Kg/row) for treatment plots (cassia alleys) (-----) and control plots ——— against total seasonal rainfall (mm)