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Effect of weather on organic cropping systems in Kenya

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Abstract

Rainfall is the single most important factor affecting yield and biomass accumulation by crops as well as residue decomposition in the tropics. The ability to capture this resource in organic systems calls for appropriate techniques. Kenya experiences bimodal type of rainfall with two rainfall peaks; the long (730 mm) and the short (376 mm) rains. Rainfall fluctuations in both seasons are becoming more common in the recent years with a likelihood of crop failure in one out of five years. The question addressed was how to utilize the short rains for food and biomass production. Lablab (Dolichos lablab), a N-fixing legume was sown in the short rains and the seeds harvested. The effect of lablab biomass incorporation on organic maize and potatoes planted in the long rains was evaluated in comparison with farmyard manure application. The 3-year trial showed that dry matter biomass (1.95 t/ha) and grain yield (0.5 t/ha) of lablab was a factor of the amount of rainfall. The amount of lablab biomass applied was proportional to maize grain and potato tuber yields. Similarly, amount of yield and biomass in the long rains was species specific and were a factor of both rainfall amounts and distribution.

Introduction

Climate change is being felt in most regions of Africa. Rainfall patterns within seasons have changed. Cases where drought occurs at critical crop growth stages and heavy rainfall at crop maturity when water is least required are becoming common. Often, the short rains are unreliable such that farmers rarely utilize it to grow a crop.

In the wake of climate change, appropriate agricultural techniques have to be fronted to curb vulnerability of farmers who depend on agriculture for livelihood. The incorporation of organic materials to boost water retention is one major step through which organic farming has addressed the problem of moisture availability, however, more needs to be done to identify appropriate crop species, biomass production and management approaches. The general aim of the study was to evaluate the potential of utilizing the short, unpredictable rains by growing lablab (*Dolichos lablab*) which can both provide food through its grains and plant nutrients through incorporation of its biomass into the soil. Lablab, a short duration nitrogen-fixing legumes has been shown to be a potential pre-crop that can be grown in the short rains in Western Kenya (Lelei, 2004). The specific objectives were (1) to asses the effect of precipitation on lablab grown in the short rains and main crops grown in the long

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rains, and (2) to test the effect of biomass management in the short rains on the performance of main crops grown in the long rains.

Materials and methods

The field experiments were carried out at the Egerton University field station, Kenya (0^0 13'S, $35^0$30'E; 2200 m above sea level) with an average annual temperature of 17.5^{0}C and annual rainfall of 1017 mm/annum. The region experiences bimodal type of rainfall with two rainfall peaks; the long rains (April to October) and the short rains (November to March the following year).

Starting from November 2003, the trial consisted of field experiments in the long and the short rains and lasted for three years. Lablab seeds were inoculated with Rhizobium-specific bacteria and uniformly planted in all the plots. At the end of March, 2004, the grains were harvested and the remaining plant material weighted and either incorporated into the respective plots or removed and replaced with farmyard manure at a rate of 5 t DM matter ha^{-1} (72kg N, 25 kg P, 60 kg K). Following a relay cropping system, maize and potatoes were planted as main crops two weeks after incorporation. Three legumes namely; garden pea, lima bean and soybean were planted as intercrops within the main crops. Rock phosphate (16% P_2O_5) was applied in all plots at a rate of 46 kg P_2O_5/ha. The experiment was replicated 4 times in a randomized complete block design. All data were subjected to analysis of variance (ANOVA) using SPSS and means were separated by the Tukey test.

Results

Influence of amounts and distribution of rainfall on lablab

Rainfall in the long and the short rainy seasons has been dropping progressively since 2003 to 2006. However, a high level of rainfall was received from November 2006 to March 2007 (see Table 1). The amount of rainfall received was proportional to the amount of biomass and grain yield of lablab obtained (see Table 1). In the short rains of 2005/06 (November 2005 to March 2006), only 164mm of rain was received, 55% of which occurred in the month of March when the crop was maturing and could not benefit much from the water. Observations made by Lelei (2004) on the same site, one season prior to this experiment (2002/03) have been included in the second column of Table 1 for comparison purposes. Correlations using the 5-seasons data showed the grain yield of lablab to be closely related to the amount of rainfall received in the month of January, 12 weeks after sowing ($r = 0.978^{**}$; n = 5).

Table 1: Lablab grain and biomass yield (t ha^{-1}) in the short rains

Traits of lablab	2002/03	2003/04	2004/05	2005/06	2006/07
Lablab dry matter biomass	5.70	0.80	0.78	0.04	2.42
Lablab grain[a] yield	0.98	0.32	0.33	0.01	0.93
Lablab yield (grain +biomass)	6.68	1.12	1.11	0.05	3.35
Rainfall (mm)	391	351	248	164	744
Rainfall:tot. yield ratio (mm t^{-1})	59	313	223	3280	222

[a]Lablab grains at 15% moisture content

Influence of rainfall amounts and patterns on crops in the long rains

Fluctuations in total amounts and monthly distribution of rainfall in the long rains from 2004 to 2006 had profound effects on the performance of long-season crops (Table 2). Whereas the potato tuber yields were directly proportional to the amount of rainfall received, the yields of maize were more sensitive to monthly distributions and could not only be explained by the total rainfall during this period. The amount of rain in the month of September (21 – 25 weeks after sowing), which coincided with pollination and grain filling stages in maize, was directly proportional to the maize grain yield (r = 0.999*, n = 3).

Table 1: Grain yield and dry matter biomass (t ha^{-1}) for all crops with lablab biomass (LAB) and farmyard manure (FYM) applications in the long rains

	2004			2005			2006		
Traits of crops	LAB	FYM		LAB	FYM		LAB	FYM	
Maize DM yield	4.65	5.67	*	9.13	10.3	*	8.36	9.79	***
Maize grain[a] yield	3.78	4.22	ns	5.90	6.85	*	2.94	2.89	ns
Potato DM yield	1.38	1.46	ns	1.14	1.53	*	0.83	0.84	ns
Potato dry tuber yield	5.88	6.61	*	5.14	5.81	*	2.05	2.10	ns
Leg. DM yield	1.31	1.40	ns	1.66	1.94	ns	0.74	0.73	Ns
Leg. grain[b] yield	0.48	0.49	ns	0.58	0.45	ns	0.15	0.14	ns
Total yield of all crops	17.5	19.9		23.6	26.9		15.1	16.5	
Rainfall in long rains (mm)	780	780		639	639		490	490	
Rainfall:tot. yield ratio (mm t^{-1})	44.6	30.6		27.1	23.8		31.6	29.7	

* significant for P<0.05 ; *** significant for P<0.001

DM: dry matter biomass; Leg.: legume

[a]Maize grains at 13% moisture content; [b]Legume grains at 15% moisture content

Influence of lablab biomass incorporation on long-season crops

In 2005 lablab incorporation gave on average 10% less maize grain yield ($P < 0.05$), maize dry matter biomass ($P < 0.05$) and potato dry tuber yield ($P < 0.05$) compared to FYM. However, in the long rains of 2006 when an average of 0.04 t/ha lablab dry matter was applied against 5 t/ha dry FYM, a significant variation was observed only in maize dry matter yield and not in maize grain yield nor potato tuber yield. This implies a likelihood of drought to limit crop response to soil amendments or to reduce decomposition and nutrient release from organic sources. Correlation analysis within plots which received lablab biomass showed a positive relationship between the dry matter of lablab harvested and grain yield of maize (r = 0.696**, n = 16) in 2004, potato tuber yield (r = 0.522**n = 16) and legume grain yield (r = 0.455*; n = 24) in 2005.

Discussion

Rainfall seems to be the single most important factor for the development of crops in the short and long rains. There was a direct relationship between total rainfall received and grain and biomass yield of lablab in the short rains. The significant relationship between lablab grain yield and rainfall received in January (9-12 WAS) confirm the critical need for water at flowering and podding (Thomas, 1997). Similarly, the strong positive relationship between maize grain yield and the amount of rainfall received at grain filling stage (21-25 WAS) affirm the crucial role of moisture availability at the reproductive phase for cereals, a relationship that was also observed by Bergamaschi et al. (2007).

In organic systems, the management of on-farm materials accruing from the previous seasons is pertinent. Lablab biomass produced at Egerton soils has a nutrient composition of 3.2 % N, 0.21 % P and 1.57 % K (Lelei, 2004). Its N concentration is above 2.5%, a critical threshold for net mineralization, thus nutrients from lablab residues are readily released for uptake by long-season crops. However, variation in biomass production that ranged from 0.04 to 5.7 t/ha implies the need to supplement lablab biomass with other organic fertilizer sources whenever on-site biomass yield is low. A low response of crops to FYM application during the drier long rain season of 2006 demonstrated the role of soil moisture on nutrient mineralization, a relationship that has been reported by Hagedorn et al. (1997).

Conclusions

1. Crop species grown in the short and long rains respond differently to total as well as monthly rainfall received. Lablab and maize grain yields are more sensitive to rainfall received at flowering/podding and grain filling stages respectively. With increasingly unpredictable weather, early maturing maize varieties can be used.

2. The amount of lablab biomass harvested in the short rains was proportional to the performance of subsequent crops. When less on-farm biomass is obtained, additional off-farm biomass may be added to support subsequent crops.

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