EVALUATION OF NAPIER GRASS CULTIVARS FOR RESISTANCE TO NAPIER HEAD SMUT

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Abstract
Napier grass *(pennisetum Purpureum)* is a tall, perennial grass that is indigenous to tropical Africa. Napier grass diseases are rare but napier head smut disease was reported in Kenya in the early 1990s and was reported to cause reduction of biomass up to 46%. The objective of the study was to evaluate for resistant cultivars. Seven napier grass varieties were evaluated for resistance to napier grass smut disease (*Ustilago kameruniensis*) in a greenhouse at KARI Muguga South. The varieties were Kakamega I (resistant control); Kakamega II, Muguga bana and Ex-githunguri and three susceptible controls (clone 13, farmer bana and French Cameroon). The results affirmed the resistance of Kakamega I and clone 13 was resistant. Among the test cultivars, Kakamega II was highly resistant whereas Ex-githunguri and Muguga bana were susceptible (disease rating 7.1% and 3.6% respectively) after 42 weeks. French Cameroon and Farmer bana were highly susceptible (disease rating 18.2% and 50% respectively). French Cameroon was most prolific in tillering with 6.9, 15 and 23.3 mean tillers at 8, 16 and 24 weeks after planting. Ex-Githunguri had the least number of tillers with an average of 3.3, 3.4 and 4.4 tillers for the respective time intervals. Farmer bana had the highest Leaf:stem ratio (6.06) while Kakamega I had the least (1.65) for non-smutted material. For smutted material, Ex-githunguri had the least of 1.01 and French Cameroon the highest of 2.89. The identified resistant cultivars should be disseminated to the farmers to ameliorate the smut problem as more resistant and productive varieties are evaluated to diversify germplasm at farm level as a precautionary step to mitigate potential future infections that are currently not there.

Introduction

In Kenya, napier grass is the dominant fodder crop in zero-grazing systems, even in areas above 2250 m, which may be too cold for its optimal performance (Boonman, 1993). Napier grass contributes up to 40% (McLeod et al. 2001) of the fodder availed to dairy cattle in small holder dairy farms which produce up to 80% of the marketed milk (Omore et al. 1999). However in recent times Napier in the highlands has been affected by head smut, a systemic disease caused by *Ustilago kameruniensis.* This disease was first reported in Kiambu District in Kenya (Farrell 1998). The disease species was first described by Sydow and Sydow (1910) from specimen of *P. purpureum* collected from Cameroon hence the specific name *kameruniensis*. The disease appears to have spread from West Africa, via Uganda (1930), Rwanda (1963) or Tanzania (1975). It is interesting to note that McDonald (1929; 1936) who compiled a comprehensive, host lists of Kenyan fungi, did not record *U. kameruniensis* on *P. purpureum. Ustilago kameruniensis* has not been reported outside Africa (Farrell, 1998). It is not clear how the disease found its way in Kenya. The disease changes the morphology of Napier grass and is characterized by early flowering with the inflorescence having spores. It causes dwarfing and increased tillering perhaps in an effort to counter the pathogen (own observation). Napier head smut reduced biomass yield 25 - 46 % in Kenya (Farrell, 1998). Farrell (1998) made the first attempt to screen for smut resistance and identified a local accession. Kakamega I as resistant while French cameroon , clone 13 and Kitale bana were found susceptible. Efforts have been made to disseminate the Kakamega I to farmers in the smut prone areas of central Kenya but its usage remains low (Mwendia and Mwangi, 2005). In addition, concern has been raised about the low leaf to stem ratio of Kakamega I in comparison with the commonly grown bana variety (Mwangi and Mwendia, 2002). This study was conducted to evaluate Napier grass varieties for smut resistance, and the varieties that may have a better leaf to stem ratio.

Materials and Methods

Planting material and design

The trial was conducted at KARI-Muguga South situated at an altitude of 2095m with mean temperatures between 13.4^{o}C to 17.7^{o}C. The design was a complete Random with seven napier grass varieties, Kakamega II, Ex-githunguri and Muguga bana, three varieties that were considered susceptible to the disease was to be evaluated (Clone 13, French Cameroon and Farmer bana) and one that was highly resistant (Kakamega I) (Farrell, 1998). Farmer bana was suspected to be susceptible because it originated from a farmer's plot that had some diseased stools. Only healthy canes were used as seed material. Thirty canes of each of the varieties were cut at three internodes length. The sheaths were removed to expose the buds at the nodes in all canes.

Inoculum preparation

Inoculum was prepared using *Ustilago kameruniensis* utilospores collected from affected a farmer's field in Muguga Kiambu District. Ten grams of the spores were weighed using an electronic balance and put in a

plastic bucket containing 10 litres of distilled water and stirred using a glass rod until the spores were mixed with water. Utilospore concentration was quantified using a haemocytometer and adjusted to 2.9×10^6 spores per ml using a protocol described by Kinyua (2004). This concentration was within the wide range used by several authors from 5×10^4 to 5×10^6 (Farrell, 1998).

Pathogenecity tests

Thirty canes of each of the varieties were dipped in the prepared inoculum in plastic buckets for a period of three hours. They were removed and incubated under high humidity overnight in polythene bags using a procedure previously described Farrell, (1998). Inoculated canes were planted in plastic pots of 20 cm diameter with a potting mixture and watered. The canes were planted at an angle with one-third of the cane above the soil (Boonman, 1993). Two canes were planted per pot and watered twice per day. After sprouting, plants were examined daily for any disease development. The observed smutted tillers were enclosed with a polythene bag to reduce secondary infection to neighboring canes. The smutted and clean canes were noted. The number of tillers in each pot was counted after every 8 weeks (recommended harvesting interval for Napier grass)

Harvesting

After 24 weeks, the Napier grass was harvested from all the pots and fresh yield per pot recorded. Samples were taken from each pot for dry matter (DM) and leaf to stem ratio analysis. Four samples were taken from each pot in which plants had developed Napier grass head smut disease; two of non-smutted and two of smutted tillers. One sample was for DM analysis and the other leaf to stem ratio assessment. The samples for determining the leaf: stem ratio were manually separated into leaves and stems that were then reweighed separately using an electronic balance. Dry matter was assessed by the method of AOAC (1984). Re-growth after harvesting continued to be monitored for disease development for 18 weeks.

Data analysis

The data was managed in excel software. Proportions of smutted canes were calculated in excel while one way ANOVA procedures of Genstat 5 (Lawes Agricultural Trust, 1995) was done on dry matter yield per established cane and leaf to stem ratio (response variables) for smutted and non-smutted tillers while the variety was the factor.

Results

Establishment and tillering

Clone 13 had 36.7% establishment, French Cameroon 73.3%, Farmer bana 73.3%, Kakamega II 90%, Ex-githunguri 93.3%, Muguga bana 93.3% and Kakamega I 96.7%. Boonman (1979) observed that one of the characteristics of clone 13 is very poor establishment from cane cuttings and this study confirmed this (Table 1). Thin stems are reported to be less viable (Boonman, 1993) and this was the case with clone 13 which had the thinnest stems among five napier varieties observed by Boonman (1979). Ex-githunguri produced significantly ($P< 0.001$) lower number of tillers at 8, 16 and 24 weeks than clone13, French Cameroon and Muguga bana. In addition, at 16 and 24 weeks Farmer bana, Kakamega I and II also produced significantly more tillers than Ex-githunguri.

Table 1–Tillering characteristics of Napier grass

Napier grass variety	No. of canes established	% establishment	Mean number of tillers		
			Week 8	Week 16	Week 24
Clone 13	11	36.7	5.9	16.0	20.4
French Cameroon	22	73.3	6.9	15.0	23.3
Farmer bana	22	73.3	4.3	10.1	15.2
Kakamega II	27	90.0	4.5	7.2	10.8
Ex- githunguri	28	93.3	3.2	3.4	4.4
Muguga Bana	28	93.3	5.9	9.7	14.9
Kakamega I	29	96.7	4.2	7.5	9.5
		s.e.d	1.077*	1.715*	2.109*

* $P< 0.001$

Table 2–Percentage incidences of smutted tillers of various Napier collections at Muguga in Kenya

Week	Kakamega I	Muguga Bana	Ex- Githunguri	Kakamega II	Farmer bana	French Cameroon	Clone 13
Week 9	0	0	0	0	0	4.5	0
Week 10	0	0	0	0	0	9.1	0
Week 11	0	0	0	0	0	9.1	0
Week 12	0	0	0	0	0	9.1	0
Week 13	0	0	0	0	0	9.1	0
Week 14	0	0	0	0	0	9.1	0
Week 15	0	0	0	0	0	13.6	0
Week 16	0	0	0	0	4.5	13.6	0
Week 17	0	0	0	0	4.5	18.2	0
Week 18	0	0	0	0	13.6	18.2	0
Week 19	0	0	3.6	0	13.6	18.2	0
Week 20	0	0	3.6	0	36.4	18.2	0
Week 21	0	0	3.6	0	36.4	18.2	0
Week 22	0	0	3.6	0	36.4	18.2	0
Week 23	0	0	3.6	0	36.4	18.2	0
Week 24	0	0	7.1	0	40.9	18.2	0
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Week 25	0	0	7.1	0	40.9	18.2	0
Week 26	0	0	10.7	0	40.9	18.2	0
Week 27	0	0	10.7	0	40.9	18.2	0
Week 28	0	0	10.7	0	40.9	18.2	0
Week 29	0	0	10.7	0	40.9	18.2	0
Week 30	0	0	10.7	0	45.5	18.2	0
Week 31	0	0	10.7	0	45.5	18.2	0
Week 32	0	0	10.7	0	45.5	18.2	0
Week 33	0	0	10.7	0	45.5	18.2	0
Week 34	0	0	14.3	0	45.5	18.2	0
Week 35	0	0	14.3	0	45.5	18.2	0
Week 36	0	0	14.3	0	45.5	18.2	0
Week 37	0	0	14.3	0	45.5	18.2	0
Week 38	0	0	14.3	0	50.0	18.2	0
Week 39	0	0	14.3	0	50.0	18.2	0
Week 40	0	3.6	14.3	0	50.0	18.2	0
Week 41	0	3.6	14.3	0	50.0	18.2	0
Week 42	0	3.6	14.3	0	50.0	18.2	0

* $P < 0.001$, + means not applicable, # means smutted after harvesting thus was not possible to take sample

Pathogenecity tests

French Cameroon was the first variety to show the disease symptom at the 9th week after inoculation (Table 2). The proportion of affected canes increased gradually to 18.2 % at week 17 up to week 42. Disease symptoms were evident on Farmer bana at week 16. The proportion of infected canes increased at higher rate than that of French Cameroon to 40.9% and 50% by week 24 and 38 respectively. Smut symptoms were observed on Ex-githunguri 19 weeks after inoculation. The proportion of infected canes was 7.1% in week 24. Clone 13 developed disease symptoms by week 14. The napier grass was harvested after 24th week instead of the recommended of about 8 weeks (MLD, 1991), because it was being observed for disease development. After harvesting, the proportion of smutted canes for ex-githunguri increased to 14.3% by 34th week where it remained up to the 42nd week. Muguga bana was symptomatic 40 weeks after inoculation with low disease rating (3.6%).

Leaf to stem ratio and dry matter yields

French Cameroon had the lowest dry matter yield per cane while clone 13 had the highest (P<0.001) (Table 3). Kakamega I and Ex-githunguri had significantly lower (P<0.001) leaf dry matter yield per established cane.

Table 3–Mean dry matter yield (kg) of cane and leaf, and Leaf: stem ratio of smutted and non-smutted Napie grass varieties

Variety	Cane	Leaf	Leaf to stem ratio		
			Non-smutted	Smutted	s.e.d
Ex-githunguri	0.064	0.038	1.66	1.01	ns
Farmer bana	0.102	0.085	6.06	1.97	0.87*
French cameroon	0.058	0.043	3.42	2.89	ns
Clone 13	0.116	0.082	2.51	+	
Muguga bana	0.083	0.066	5.01	#	
Kakamega I	0.064	0.038	1.65	+	
Kakamega II	0.069	0.051	3.41	+	
s.e.d	0.011	0.009	0.785*	ns	

Discussions

The low establishment rate in this study may have reduced the chances of infection initially. More studies should be done to ascertain the status of clone 13. Kakamega I did not show the disease as previously reported. Kakamega II and Clone 13 also did not show the symptoms and could also be classified among the resistant varieties. The Farmer bana had significantly (P<0.001) higher leaf:stem ratio than Ex-githunguri, Kakamega I, French Cameroon, Clone 13 and Kakamega II. The proportion of leaves to the stems is an important attribute in forages as the leaves are usually of higher nutritive value than the stems. According to Tiley (1969) Napier grass leaf blade had a higher crude protein of 6-9 % compared to 3-5 % for stem and sheaths thus the higher the leaf to stem ratio, the better the forage. On the basis of this attribute, the Farmer bana was the best variety. However, it had the highest smut infections and, of the varieties that smutted, the only one with a significant (P<0.001) reduction in leaf to stem ratio as a result of the infection disadvantaging Farmer bana in smut prone areas. The decrease on leaf to stem ratio suggests a decline in dry matter yield. It was not possible to separate canes that were smutted to analyze for their DM yield because not all tillers from one cane succumb to the disease at the same time. In addition the varieties were succumbing to the disease at different times thus at any one time they would be at different severity levels. Muguga bana showed the disease long after harvesting thus it was not possible to collect samples of its smutted material for leaf to stem ratio assessment.

Conclusions

Kakamega I, Kakamega II and Clone 13 are resistant to Napier head smut disease. Muguga bana, Ex-githunguri, French Cameroon and Farmer bana were susceptible to napier smut with susceptibility increasing in that order. Further work need to be done on clone 13 to ascertain its susceptibility.

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