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Differential Response of Sweet Potato *(Ipomoea batata)* to Green Manuring with Elephant Grass (*Pennisetum purpureum*) and Spear Grass (*Imperata cylindrica*) on a Ferralitic Soil in Sierra Leone

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Abstract

Key Words: Sweet potato, elephant grass, spear grass, green manure, phytotoxicity, C:N

Two separate field studies were conducted to evaluate the response of sweet potato to green manuring with elephant grass (*Pennisetum purpureum*) and spear grass (*Imperata cylindrica*).

The yield and yield components of sweet potato increased consistently with increasing quantities of elephant grass before levelling up between 20, and 30 t ha^{-1}. This suggests the suitability of elephant grass as green manure in sweet potato production.

Yield and yield components of sweet potato increased with green manure rates of spear grass up to 10 t ha^{-1} but progressively declined beyond this rate. This may be due to low N availability resulting from high C:N and consequent poor mineralization. Moreover phytotoxicity of spear grass at higher rates of application beyond 10 t ha^{-1} could be responssible for the low yield. Thus for higher yield, manure rates of spear grass above 10 t ha^{-1} can not be recommended. Further studies to separate phytotoxic effects of decomposing speargrass residues from poor minerilzation effects are needed.

1 Introduction

A large part of upland soils in the humid and sub-humid African tropics is susceptible to nutrient depletion with intensive farming because of their low buffering capacity (BALASUBRAMANIAN and NNADI, 1980). The use of chemical fertilizer to maintain soil fertility has not been practical in the region because of its high costs and enviromental concerns (TIAN et al. 1993).

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The positive effects of organic residues as alternatives to chemical fertilizer has been extensively documented (WADE AND SANCHEZ 1983, MEELU et al. 1992, KANG et al. 1981,). These residues can provide nutrients to the growing crop and improve soil physical properties.

The farmers in Sierra Leone normally incorporate plant materials as in-situ green manure for the cultivation of sweet potato. Because of the continuous cropping of sweet potato, this practice is very common. Spear grass (*Imperata cylindrica*) and elephant grass (*Pennisetum purpureum*) are among the dominant grasses that have successfully invaded arable land in Sierra Leone. Because of their aggressive growth habit, they are very difficult to eradicate. They are as a result most of the times part of the plant materials incorporated into the soil during ridging for sweet potato cultivation.

However, under certain conditions, the growth of crops in close proximity to decomposing plant material can be inhibited by phytotoxic substances (PURVIS 1990). The degree of inhibition appears to be dependent on such factors as the species and variety of both the residue and test plants, quantity, placement and weathering of residues, nutrient status of the soil, microbial activity and other soil parameters (MANSON-SEDUN et al. 1985).

Due to the wide spread practice of the incorporation of plant materials during ridging for sweet potato cultivation, there is a need for the determination of the effect of green manuring on the productivity of sweet potato. The present study was conducted as part of a research program to evaluate the ecological importance of some grassy weed species in the uplands of Sierra Leone. The objective of this study was to determine the effects of spear grass (*Imperata cylindrica*) and elephant grass (*Pennisetum purpureum*) as green manures on the yield and yield components of sweet potato.

2 Materials and Methods

Two experiments, one involving seven rates (0, 5, 10, 15, 20, 25 and 30 t ha-1) of elephant gras green manure and the other involving the same rates of spear grass, were conducted side by side on the Njala upland gravelly soils at the Institute of Agricultural Research Experimental Farm (08° 12'N Lat, 12° 12'W Long, 87m above sea level) in the rainy season of 1994. The climate is humid tropical with pronounced wet and dry seasons and mean annual temperature of 27°C and annual rainfall of 2700mm. The rainy season lasts from May to November and the dry season from December to April. The soils classified as orthoxic pelehumult (ODELL et al. 1974) are acidic and low in available plant nutrients. Prior to planting the topsoil (0-20 cm depth) had a pH (H_20) of 4.9, 3.18 organic C, 0.24 N, 7.0 ppm of available P (Bray 1) and 0.57 meq/100g soil exchangeable K.

The site has previously been cropped with sweet potato for two growing seasons and then left to fallow for about nine months prior to the initiation of the experiment. The dominant vegetation was spear grass.

A randomized complete block design was used with three replications. The area for each experiment (28m X 12.8m) was cleared and ploughed. The green manures which were harvested from adjacent areas were applied to the plots by lining them up and constructing ridges over them. Plot size was 4m X 3.6m with four ridges each 3.6m long and spaced 1m apart.

Twelve apical vine cuttings of sweet potato variety *Njala White* were planted on each ridge 30 cm apart, one week after applying the green manure. The plots were entirely rainfed and were hand weeded at 30 and 60 days after planting. The experiments were terminated 105 days after planting. The sampling unit consisted of the two middle ridges of each plot excluding the end plants. At harvest, the number and fresh weight of tubers and vine weight were recorded for each plot.

3 Results and Discussion

The yield and yield components of sweet potato progressively increased with increasing rates of elephant grass green manure. There were significant increases with rates of 15, 20, 25 and 30 t ha^{-1} respectively over the control (Table1). Compared with the control, there were increases in tuber yields of 4, 23, 43, 72, 81 and 82% with manure rates of 5, 10, 15, 20, 25 and 30 t ha^{-1} respectively. The trend in tuber yield was similar to that found with vine production (Table 1). Fresh weight per tuber was, however, not significant. This finding is consistent with results of studies with rice (MANGUIAT et al. 1992) which indicate that green manures could increase both rice grain and straw yields. Ruhigwa (1993) found plantain to perform best with elephant grass as a green manure as compared to in-situ mulches of *Alchornea cordifolia, Dactyladenia barteri, Gmelina arborea*, and *Senna siamea.* He attributed this performance to the high nutrient contributions from the elephant grass mulch material applied, which particularly improved available phosphorus and exchangeable cations (Ca, Mg and K) in the soil. The high yield of sweet potato obtained with increasing amounts of elephant grass as mulch material may also be due to improvements in the soil physical condition such as reduced diurnal soil temperature fluctuations and to moisture depletion. Tian et al. (1993) found maize and rice straw to lower soil temperature and increase soil moisture. Various tests by Bangura and Kamara (1994 unpublished) established that various concentrations of root and shoot extracts of elephant grass have no inhibitory effects on the germination and growth of maize and cowpea. They found the extracts to be highly alkaline in nature. The decomposition of such plant material in the soil may increase the soil pH and therefore may improve the availablility of certain plant nutrients such as phosphorus and other cations. The tuber yield response curve was virtually linear from 5 up to 20 t ha^{-1} green manure rate but thereafter started to level off, with the 20, 25 and 30 t ha^{-1} treatments being statistically comparable. This suggests that high tuber yield of sweet potato could be achieved on the Njala upland soils by applying between 20 and 30 t ha^{-1} of elephant grass green manure.

With spear grass green manure the highest yield and yield components were obtained with 10 t ha^{-1} and this significantly outyielded the control and 5 t ha^{-1} rate. However, there was a significant decrease in these yield parameters with manure amounts above 10 t ha^{-1} (Table 2).

Table 1: Effects of varying rates of elephant grass (*Pennisetum purpureum*) green manure on yield and yield components of sweet potato, var. *Njala White*

Green manure (tons/ha)	No. tubers/plant	Fresh weight/tuber (g)	Fresh tuber yield (tons/ha)	Fresh vine yield (tons/ha)
0	3.0bc	97a	9.4d	3.9c
5	2.9c	100a	9.8d	4.1bc
10	3.1bc	114a	11.6cd	4.8bc
15	3.4bc	124a	13.4bc	5.9ab
20	4.0ab	123a	16.2ab	6.9a
25	4.0ab	118a	17.0a	7.4a
30	4.4a	130a	17.1a	7.5a
CV(%)	15.0	17.0	13.0	18.0

Table 2: Effects of varying rates of spear grass (*Imperata cylindrica*) on yield and yield components of sweet potato var. Njala White.

Green manure (tons/ha)	No. tubers/plant	Fresh weight/tuber (g)	Fresh tuber yield (tons/ha)	Fresh vine yield (tons/ha)
0	1.8ab	62ab	3.7b	2.1b
5	1.5b	75ab	3.8b	2.8b
10	2.6ab	89a	7.9a	4.6a
15	2.8a	69ab	6.3ab	3.3ab
20	2.8a	56b	5.3ab	3.2ab
25	2.5ab	55b	4.8ab	2.6b
30	2.6ab	51b	4.3ab	2.5b
CV(%)	26.0	23.0	30.0	29.0

Means within columns followed by the same letter do not differ significantly at the 5% level of probability according to Duncan's Multiple Range Test.

The decrease in yield with increasing amount of manure material could be explained in two ways.

1) **Relative rate of decomposition**: unlike the elephant grass, the added spear grass plant material decomposed very slowly with increasing rates of application with a large amount remaining undecomposed. The slow rate of decomposition could be attributed to high C:N in spear grass and the resultant immobilization of soil N. Studies conducted at the International Rice Research Institute (IRRI) (1984) showed that most nutrients

from added rice straw residues take months or years to recycle due to their slow rate of decomposition and subsequent slow rate of mineralization. This suggests that very little mineralization might have occured in the spear grass green manure due to its slow decomposition. Taja and van der Zaag (1991) noted that incorporated organic residues with low levels of N resulted in reduced potato yield primarily due to a larger C:N ratio which led to available N shortage in the soil. It therefore stands to reason that spear grass had high C:N ratio and that the C:N ratio in the soil must have probably widened as the green manure rate increased. Thus beyond the 10 t ha^{-1} rate, the beneficial effects of green manuring on the soil physical properties were to some extent counteracted by low nutrient availability leading to a progressive decrease in yield and yield components.

2) **Phytotoxicity**: another explanation for the decline in yield and yield components of sweet potato with increasing amounts of spear grass green manure could be phytotoxicity. Chou (1989) reported phytotoxicity among various grass species including spear grass. He reported various amounts of phytotoxic compounds in these grasses. Eussen and Nieman (1981) had identified eight phytotoxic phenolics, P-and O- conmaric gentisic, vanillic, benzoic and P-ydroxybenzoic acids, vanillin and P-hydroxybenzaldehyde from leaves of spear grass. The decrease in yields of sweet potato with higher amounts of spear grass may be due to high phytotoxicity at the begining of the rottening process. Kimber (1967) reported 45% inhibition of shoot of wheat by unrotted extracts of lucerne and 91% inhibition of root growth by unrotted green pea. He concluded that toxic factors which produce inhibition of root growth are present in the unrotted straw, that they are more prevalent in less matured straws and that they are in fact usually dessipated by microbial action during the rottening proccess. Purvis and Jones (1985) reported an increase in the phytotoxicity of two cultivars of sunflower with a three fold increase in their quantity. This pattern was similar with results obtained with spear grass where lower yields of sweet potato were got with rates beyond 10 t ha^{-1}. This implies that beyond 10 t ha^{-1}, spear grass may become highly phytotoxic.

4 Conclusion

The studies indicate a strong advantage of green manuring sweet potato with elephant grass. Elephant grass, a C_4 plant, has succesfully invaded arable land in Sierra Leone. Although, it is among the worst weeds in Sierra Leone and very difficult to control, its non phytotoxicity and high rates of decomposition make it suitable for green manuring and stuble mulch tillage. However, for potato production, the optimal rates lie between 20 and 25 t ha^{-1}.

The exhibition of phytotoxicity shows that the incorporation of spear grass in large quantities could not be recommended for green manuring in crop production. However where the dominant vegetation is spear grass, small quantities up to 10 t ha^{-1} could be used.

There is a need for a further investigation of the nature of phytotoxicty of spear grass on sweet potato based on factors such as the plant parts, time of rotting, manure quantity and concentrations and the soil type. Moreover decomposition and nutrient release studies to delineate phytotoxic effects from nutrient immobilization effects on crops are needed. This would help in the management of these mulch materials for sweet potato cultivation.

Die unterschiedliche Wirkung von Gründünger, Elephantengras und Imperatagras auf Süßkartoffel in Ferrasols in Sierra Leone

Zusammenfassung

Zwei getrennte Fallstudien wurden mit Pennisetum purpureum und Imperata cylindrica durchgeführt um die Auswirkungen auf Süßkartoffel zu analysieren. Bei einer Gründüngung mit Pennisetum purpureum (20 bis 30 to/ha) nahm der Ertrag von Süßkartoffel konsequent zu, dies unterstreicht die Eigung von Pennisetum purpureum als Gründünger im Süßkartoffelanbau. Bei Imperata cylindrica als Gründünger (bis zu 10 to/ha) nahm der Ertrag zu, bei höheren Gaben fiel der Ertrag. Dies kann mit einer geringen N-Verfügbarkeit wegen einem hohen C:N Verhältnis erklärt werden und führt zu einer geringen Mineralisation. Aber auch eine Phototoxität von Imperata bei hohen Gaben über 10 to/ha kann für den geringen Ertrag verantwortlich sein.

Weitere Untersuchungen zur Unterscheidung von phototoxischen Effekten oder geringer Mineralisierung von Imperata Rückständen sind erforderlich.

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