THE USE OF SWEET POTATO (Ipomoea batatas, (L.) Lam) IN ANIMAL FEEDING I AGRONOMIC ASPECTS[1]

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An agronomic experiment with two varieties (C-1 and C-15) of sweet potato was carried out, in which the distance between plants (10, 20, 30 and 40cms) was varied, a. was the time of defoliation (at two or three months or only at harvest of roots) and the levels of intensity of defoliation (leaving one or two runners per plant.) At the end of the vegetative period both foliage and tubers were harvested in all plots.

The results showed that the total production of forage (defoliation plus the final harvest) did not differ between treatments. On the other hand, the production of tubers was negatively affected (P <0.01) by defoliation. The plots v&shout defoliation produced 22,812 kg/ha of tubers (25.5% DM) while those that were defoliated produced 15,579 kg/ha (23.0% DM).

Forage production in 811 treatments wag high, mean of 3,994 kg (DM/ha for C-1 and 5,567 kg DM/ha for C-15. The crude protein content (12.22 in C-15 and 17.3% in C-l) was high at the time of harvest. These two characteristics of production and high protein suggest the possibility of using sweet potato as a ruminant feed. Thus from this experiment, where only a single defoliation was carried out before the final harvest, it is suggested that sweet potato should be grown without defoliation,even when it is being used as-a dual purpose crop, ie for the production of tubers for human consumption and forage for animal feeding.

Key words: Sweet potato, agronomic management, dual-purpose crop, production, composition and digestibility.

Traditionally sweet potato has been grown exclusively for the production of tubers and the foliage has been considered a wasted material. The energy rich tuber is the main reason for growing this plant (2.6M cal of metabolizable energy/kg dry matter according to McDowell et al 1974), but it only contains 3.4% crude protein (Backer 1976). However the forage contains 11% crude protein and the digestibility of the principal nutrients is greater than 62% (Backer 1976; Ffoulkes et al 1978). This material could therefore provide an important resource as animal feed in the tropics. Consequently the production of both parts of the plant has become important.

The data in the literature show that the production of tubers is negatively correlated with that of the leaves (Enyi 1977; Kamalam et al 1977) and with the total aerial parts (Pushkaram et al 1976). For this reason it has been assumed that defoliation might be one way of increasing tuber production. However the results of this practice have been contradictory since in some instances frequent (Gonzalez et al 1977) and infrequent (Lopez & Caraballo 1975) defoliation have produced negative effects on the production of tubers and starch content, whilst in another case (Montaldo 1972) this effect was not observed.

The importance of plant spacing has received little attention; however it would appear that decreasing distance between plants reduces the yield of tubers (Mandal et al 1971) and increases the production of leaves (Gamboa 1962). Based on these results the present experiment was undertaken to study the effect of planting distance and frequency and intensity of defoliation on biomass production in two varieties of

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sweet potato grown as a sole crop. The work also included a study of the chemical and nutritional composition of the forage and the tuber of sweet potato.

Materials and Methods

Location: The experiment was conducted in the valley of Turrialba, situated at 630 m above sea level, in plots of soil (Juray series), with an open clay texture (Aguirre 1971), The field work was carried out between July and December 1978, when the mean monthly rainfall was 227 mm and the mean temperature 21.8°C.

Varieties: Two varieties of sweet potato were used; C-15 also known as B-4096 Salvador, which is the most widely used in the region and C-1 Asbana introduced from Taiwan and characterized by dense foliage and a short vegetative period (Roger Meneses, personal communication 1979).

Planting distance: Both varieties of sweet potato were sown at 4 different plant spacings; 0.4, 0.3, 0.2 and 0.1 m, maintaining a constant distance of 0.5 m between rows. These spacings gave populations of 50,000; 60,670;100,000 and 200,000 plants/ha respectively.

Age at defoliation: Defoliation of some plots took place 2 or 3 months after sowing in addition to the harvest at the end of the vegetative period.

Intensity of defoliation: Three intensities of defoliation were compared.

a. Intense - leaving only one stolon per plant and cutting the rest at 5 cm from the base of the plant.

b. Moderate -leaving two stolons per plant

c. Zero -without any cutting during the vegetative period.

Statistical analysis and experimental management: A design using divided plots for analysis of different factors in different ways was adopted. Comparison of production from the aerial parts was made with an arrangement of 2 x 4 x 2 x 2 (two varieties, four planting distances, two defoliation times and two defoliation intensities), eliminating for obvious reasons those plots with only a single cutting done at the end of the vegetative period. In the case of the analysis of total biomass (aerial and tuber parts) and chemical composition, the factorial arrangements of treatments was 2 x 4 x 3 (two varieties, four planting distances and three methods of defoliation).

There were two replicates of each treatment. Grass plot size was 20m^2, although harvest data were taken from the central 10m^2 portion.

Each plot was fertilized with 125, 130 and 48 kg of N, P_2O_5 and K_2O/ha respectively, applied in two equal doses at one and two months after planting. Manual weeding was carried out at the same time.

All plots were harvested at the end of the vegetative period for both aerial and tuber fractions. Cultivar C-15 had a vegetative period of 165 days and cultivar C-1 of 131 days. The samples of each plot were dried and tested for their content of dry matter, crude protein and digestibility in vitro following known techniques (Baseman 1971; Tilley and Terry 1963).

Results and Discussion

Production of foliage at defoliation: The effects of the various treatments on yield of forage at defoliation and final harvest are presented in Table 1. The Cultivar C-15 produced 13.1% more foliage than C-1; however the difference did not attain significance.

Table. 1:
Production of sweet potato forage at defoliation and final harvest

Factor	Defoliation	Final Harvest
Cultivar	kg DM/ha	
C-15	2006	3971
C-1	1775	2530
Planting distance		
10 cm	1770	3009
20 cm	1967	3123
30 cm	2505	2749
40 cm	2327	2895
Age of plants at defoliation		
2 months	1642	3570
3 months	1913	2932
Intensity of defoliation		
1 stolon left	2091	2944
2 stolons left	1692	3558

Planting distance significantly affected (P < 0.01) forage production when the plants were defoliated at two and three months. Planting at an inter-plant distance of less than 30 cm leads to a reduction in the yield of leaves implying a lower photosynthetic rate as a consequence of competition for the light. Other workers (Gamboa 1962; Sanabria et al 1975) found that foliage yield increased with decreasing planting distance,

The production of foliage at three months after planting was 16.5% greater (P< 0.01) than that obtained in the harvest at two months. On the other hand a more intense defoliation (leaving a single stolon) resulted in a 23.5% increase in forage production (P< 0.01). These results are as expected in view of the longer time available for vegetative development in the case of the three month defoliation and the greater proportion of the plant harvested when defoliation was-more intense.

The interaction of variety x time of defoliation significantly (P <0.01) affected the production of forage at defoliation. In the case of the defoliation at two months the cultivar C-1 was 8.8% better than C-15. However at 3 months defoliation, the cultivar C-15 produced 32.5% more forage.

Production of forage of final harvest: At final harvest only age and intensity of defoliation gave significant results (P< 0.05) with respect to the production of forage. It can be seen from Table 1 that those plants which were defoliated at two months gave a 21.7% higher yield of foliage at final harvest than plants defoliated at three months. This is a consequence of the longer recuperation time available to the plots defoliated earlier. In the case of less intensively defoliated plots the production of foliage at final harvest was 20.8% greater than that obtained from plots which had received more intense defoliation. Apparently leaving a greater leaf area promoted a faster rate of recuperation. Cultivar C-15 produced 57% more forage at final harvest. However, probably due to the experimental design this difference was not significant. Greater yields of foliage were obtained from plots having closer spacings. This can be explained by the fact that after defoliation,competition between plants for light, was either eliminated or reduced,enabling a greater vegetative growth in the second phase of development.

Total production of forage: Table 2 presents total forage production and the rate of forage growth as a fraction of the different variables under study.

Table 2:
Total yield and rate of growth of sweet potato forage

Factor	Total forage yield kg DM/ha/cycle	Rate of growth kg DM/ha/day
Cultivar		
C-15	5979	36.2
C-1	4305	32.9
Planting distance		
10 cm	4779	32.3
20 cm	5090	34.5
30 cm	5254	35.5
40 cm	5222	35.3
Defoliations		
Only at final harvest	4136	27.9
At 2 months and at harvest	5212	35.2
At 3 months and at harvest	4845	32.7
Intensity of defoliation		
1 stolon left	5035	34.0
2 stolons left	5250	35.5

Of these only time of defoliation significantly affected production and rate of growth of forage. Thus, in plots where defoliation was practised, increments of 26 and 17% were obtained for defoliations at two and three months respectively, compared to those plots where there was no defoliation. It should be remembered that in no case was defoliation total, which could well have had a negative effect on forage production

Cultivar C-15 gave a greater yield of total forage than cultivar C-1 by 38.9%, whereas its rate of growth (which is perhaps a more suitable comparison) was only 10% greater. It is interesting to note that the rate of growth of sweet potato forage is better than that of natural pasture under the same ecological conditions (Gonzalez 1979); similar to that of grass legume associations (Coimbra 1979) and poorer than that obtained with grass receiving moderate amounts of fertilizer and being managed under an intensive grazing system (Rocha 1978).

Tuber production: As with total forage production, the only variable which significantly (P <0.05) affected the production of tubers and the proportion of commercial tubers produced was whether or not defoliation was carried out before the final harvest (see Table 3). Removing foliage at defoliation decreased tuber production, probably because it reduced leaf area resulting in a lower efficiency of utilization of solar energy for the formation of tubers (Lizarraga 1976).

Table 3:
Total root production and proportion of marketable roots

Factor	Yield of roots kg DM/ha	Proportion of marketable roots %
Cultivar		
C-15	3153	58.9
C-1	3962	31.8
Planting distance		
10 cm	3342	36.5
20 cm	4465	49.1
30 cm	2978	47.2
40 cm	2850	48.8
Defoliations		
Only at final harvest	5634	49.7
At 2 months and at harvest	3706	47.6
At 3 months and at harvest	3409	43.2
Intensity of defoliation		
1 stolon left	3416	43.1
2 stolons left	3699	47.7

Cultivar C-1 yielded 25.6% more tubers than C-15; however a greater proportion of these were not marketable. Although no significant differences were found between planting distances the 20 cm distance gave the greatest yield of tubers (4,465kg DM/ha) this being achieved without affecting the marketable tubers. Notwithstanding, the planting distance considered optimum from the commercial point of view is 40 cm between plants.

Chemical composition and digestibility in vitro: There was a significant difference in crude protein levels between varieties (P <0.05 at final harvest.) The time of harvest also appears to affect crude protein levels.

The constituents of cell walls (lignin, cellulose and hemi-cellulose) principally were affected (P <0.01) by the time at which defoliation was undertaken, although these differences were not apparent at final harvest. Table 4 summarizes these results. The values of dry matter are very low and it is suggest ed that the consumption of forage could therefore be limited by the high intakes of water in the material. Another consequence of this low level of dry matter is that if the material were to be ensiled it would be necessary to add other material to increase the dry matter percentage, or alternatively, the sweet potato could be wilted before ensiling to raise the level of dry matter to 30% (Catchpoole and Henzell 1971; Demarquilly 1972), Table 4 also contains data for in vitro digestibility of sweet potato leaves. None of the factors under study gave significantly different results between treatments although cultivar C-1 was consistently superior to C-15. Judged by its content of crude protein and its digestibility the sweet potato forage is obviously of high quality and this leads to the probability that when used for animal feeding high levels of production would result. The voluntary intake results found by Ffoulkes et al(1978) support this hypothesis.

Table 4:
Crude protein (CP) content, proportion of cell wall constituents (CWC) and in vitro digestibility
(IVD) of sweet potato forage

Factor % CP % CWC % IVD % DM

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Factor	% CP		% CWC		% IVD		% DM
	Defol-iation	Final harvest	Defol-iation	Final harvest	Defol-iation	Final harvest	
Cultivar							
C-15	17.5	12.2a[1]	28.2	29.7	74.0	72.3	----
C-1	20.2	17.3b	29.8	33.6	80.2	77.2	----
Planting distance							
10 cm	18.2	13.6	28.6	31.8	75.3	75.5	----
20 cm	18.9	15.6	29.1	31.3	75.3	71.7	----
30 cm	18.5	15.6	28.9	31.5	71.4	77.4	----
40 cm	19.9	15.7	29.5	31.5	77.8	75.4	----
Defoliations							
Only at final harvest	20.3a	14.5	26.0	32.0	77.6	74.7)	-
At 2 months and at harvest	17.4b	15.0	32.0	31.0	76.6	75.0)	11.7
At 3 months and at harvest	----	13.7.	----	29.5	----	75.1	14.6
Intensity of defoliation							
1 stolon left	18.7	14.6	29.0	31.2	78.2	71 5	----
2 stolons left	19.0	14.9	29.1	31.8	76.2	7.4	----

[1] Different letter prefixes indicate significant differences

General comments

It is obvious from this study that the practice of partial defoliation during the growth of sweet potato is not conducive to a high total production of forage in the life of the plant. Moreover the production of roots is negatively affected in teems of quantity, although not quality. The practice of defoliation appears to inhibit formation of roots.

Another possible method for increasing the production of forage per unit area and per unit time is to increase the population. In contrast to other situations (Meyreles et al 1977) neither the production of forage nor of roots was affected significantly by increasing population. Therefore due to the reduced inputs of time, work, planting material and capital, a planting distance of 40 cm between plants and 50 cm between rows is recommended (Montaldo 1972).

From this study it was found that the level of foliar protein was superior in cultivar C-1. If this crop is to be used as a dual purpose crop cultivar C-1 is recommended. If the purpose is traditional (for roots or tubers only) it would be preferable to use cultivar C-15 whose root quality was better.

The volume and quantity of sweet potato forage produced are high and it suggested that ruminants could use this production efficiently. One hectare could feed twelve young bulls over a period of 100 days without the necessity of protein supplements. This quantity should be sufficient to give high live. weight gains.

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