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AN ASSESSMENT OF THE SUITABILITY OF FIVE GRAMINACEOUS SPECIES FOR SOIL RECONDITIONING BEFORE REPLANTING TEA

1. EFFECT OF SPECIES ON ENRICHMENT OF ORGANIC MATTER STATUS BY TOP AND ROOT RESIDUES

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Five field experiments were conducted in three tea growing districts (Upcountry, Midcountry and Uva) in Sri Lanka to study the effects of growing Guatemala grass (*Tripsacum laxum* Nash.), Mana grass (*Cymbopogon* confertiflorus C. Steud. Stapf.), Guinea grass (*Panicum maximum* Jacq.), Sugar cane (*Saccharum officinarum*) and weeping love grass (*Eragrostis curvula*) for soil reconditioning before replanting tea. Comparison was also made of using Guinea grass as a source of fodder with growing it purely for soil reconditioning where it is regularly lopped and the loppings used to thatch the soil. The performance of the species varied with the location. Organic matter addition to the soil in the form of loppings (dry weight) varied between 10 and 44 tonnes ha^{-1} with Guatemala grass, 27-58 tonnes ha^{-1} with Mana grass, 18-45 tonnes ha^{-1} with Guinea grass (when lopped and mulched, 11-29 tonnes ha^{-1} with sugar cane and 36 tonnes ha^{-1} with *Eragrostis*. The corresponding insitu addition of root residues in the first 75 cm of soil for these species averaged 12.9, 6.4, 11.5, 4.8, 4.55 tonnes ha^{-1} respectively. When Guinea grass was cut at monthly intervals the availability of fodder ranged from 10-26 tonnes ha^{-1} depending on the location. In the mid country and Uva districts sugar cane yield ranged from 12 to 36 tonnes ha^{-1} of fresh cane. Taking into account organic matter additions in the form of lopping and more importantly the insitu root residue left behind at the end of the reconditioning period it is concluded that Guatemala grass, Mana grass and Guinea grass (when loppings are retained) are more suited as reconditioning species than sugar cane of *Eragrostis* or Guinea grass grown for fodder.

INTRODUCTION

When old tea is uprooted for replanting it is customary to grow a grass such as Guatemala grass (*Tripsacum laxum* Nash) or Mana grass (*Cymbopogon confertiflorus* C. Steud. Stapf.) for a minimum period of 18 months to recondition the soil. The main purpose of this practice is (1) to eradicate root disease producing organisms such as *Poria hypolateritia* and to minimise, if not eliminate, populations of parasitic nematodes such as *Pratylenchus* loosi Loof. (Tolhurst, 1958., Mulder, 1958., Hutchinson, 1962); (2) to improve the toxic effects, if any, produced on young plants of the same species when they are transplanted immediately after a woody perennial (Tolhurst, 1956); and (3) to restore the soil fertility that may have been lost as a result of soil erosion and consequent loss of organic matter as demonstrated by Holland and Joachim (1933) and Hassello and Sikurajapathy (1965) and Sandanam and Rajasingham (1982). The choice of grass as a species for this purpose is governed by its ability to produce an extensive fibrous root system which is capable of improving the structural condition of the soil thereby improving soil physical properties (Martin, 1944., Low, 1955., Clarke *et al*, 1967). Continuous cultivation is known to degrade soil physical properties and fertility. In tea soils such degradation is believed to be low as the crop protects the soil in the manner of a jungle with contributions to soil organic matter in the form of leaf fall, prunings and tippings. The soil under tea, however, remains exposed to different degrees depending on the Jat of tea spacing of tea and the number of vacancies. In addition there is inevitable soil exposure for three to four months after each prune. Therefore there is a degradation in soil fertility. Such degradation in soil physical properties in land under continuous tea cultivation and the improvement in some of these brought about by growing Guatemala grass and Mana grass has also been reported (Sandanam and Ananthacumaraswamy, 1982).

Apart from this, in nematode infested areas soil reconditioning with a grass such as Guatemala grass for a minimum period of 18 months is essential to reduce nematode population (Hutchinson, 1962., Kerr and Vythilingam, 1966). Furthermore, it is also reported that damage to young tea plants by nematodes is more severe in gravelly and heavy clayey soils and that young tea could overcome the damage by nematodes if it could produce roots at a rate faster than the rate at which they are damaged (Kerr and Vythilingam, 1966), thus emphasizing the need for desirable soil physical properties for the successful establishment of young tea. Sandanam *et al* (1976) reported that soil reconditioning increased yield in poor soil (low organic matter content = 2.73%) but did not influence yield in a good soil (high organic carbon content = 4.38%). However, even in soils with high organic matter content in the upcountry soil reconditioning becomes a necessity, if the soil is infested with nematodes. Since soil reconditioning entails a loss of revenue from the land during the soil reconditioning period, the rate of replanting on many estates has been lower than what it should have been. It was therefore necessary to explore the possibility of growing other species which could recondition soil as well as bring in a return from the land. In the Uva and Mid country districts there is the possibility of using sugar cane for this purpose and in the Up country the use of fodder grass which could be fed to cattle on the estate, thus generating some income, seemed feasible. The contribution of a fodder grass or sugar cane towards soil reconditioning, however, is not known. Therefore the present investigation was undertaken to study the effects of using five graminaceous species for soil reconditioning on the benefits that are expected to be derived. This paper reports the effect of enrichment of organic matter.

MATERIALS AND METHODS

In all, five experiments were carried out in three tea growing districts viz: Upcountry, Mid country and Uva. The estates on which the experiments were located and some physical and chemical properties of the sites are given in Table 1.

TABLE 1 — *Some chemical and physical properties of the sites*

Estate	*N* (%)	*P* (*ppm*)	*K* (*m.eq %*)	*Ca* (*m.eq %*)	*Organic carbon %*	*Infiltration rate* (cmh^{-1})
St Coombs	0.281	13.13	0.245	0.970	6.92	6.80
Cannavarella	0.198	68.22	0.441	3.213	—	40.80
Galphilla	0.100	2.79	0.128	0.227	3.44	16.80
Little Valley	0.143	3.49	0.265	0.824	—	15.68
Agratenne	0.131	14.78	0.142	0.283	—	—

(101)

TABLE 2 — *Details of procedure adopted in soil reconditioning in the different experiments*

Estate	*Marking out Plots*	*Uprooting tea*	*Planting reconditioning species*	*Lopping the reconditioning species*	*Uprooting the reconditioning species*	*Planting tea*
St Coombs	May 1977	May-June 1977	July 1977	1st lop 16.2.'78 last lop 14.6.'79	June '79	July '79
Little Valley	August 1977	Sept-Oct 1977	November 1977	1st lop. 26.7.'78 last lop 20.9.'79	September '79	October '79
Galphilla	May 1977	May-June 1977	July 1977	1st lop 7.3.'78 last lop 10.7'79	July '79	July '79
Cannavarella	July 1977	Aug-Sept 1977	October 1977	1st lop 14.6.'78 last lop 11.10.'79	October '79	November '79
Ury	July 1977	Aug-Sept 1977	October 1977	1st lop 1.3.'78 last lop 8.10.'79	November '79	December '79

The treatments were :

1. No soil reconditioning before replanting
2. Reconditioning with Guatemala grass (*Tripsacum laxum*)
3. Reconditioning with Mana grass (*Cymbopogon confertiflorus*)
4. Reconditioning with Guinea grass (*Panicum maximum*) (loppings used as mulch)
5. Reconditioning with Guinea grass but the loppings removed for fodder
6. Reconditioning with Weeping Love Grass (*Eragrostis curvula*)
7. Reconditioning with Sugar cane (*Saccharum officinarum*)

At St Coombs, treatment 7 was not included. In the other four estates treatment 6 was not tested. The experiments were of a randomized block design with 5 replicates. Plot size was 7.93 m x 14.64 m in all the experiments.

The plots were first marked out in old seedling fields and the soil reconditioning treatments were allocated at random in each block. Following this, the tea from plots which were to be reconditioned were uprooted while that in plots with "No-soil reconditioning" treatment were retained. The tea in "No-soil reconditioning" plots was uprooted only at the end of the reconditioning period after which clonal tea was planted in all the plots. The details of the procedure adopted in each experiment are given in Table 2. Guatemala grass was planted at a spacing 0.9 m x 0.6 m, Mana grass at a spacing of 0.9 m x 0.23 m, Guinea grass and *Eragrostis* at a spacing of 0.46 m x 0.23 m. Sugar cane was planted in trenches measuring 0.3 m wide and 0.3 m deep with the three-node cutting spaced 0.23 m apart. The variety of sugar cane used was CO 527.

In all the experiments Guatemala grass, Mana grass, *Eragrostis* and Guinea grass (retained) were lopped once in 3 months. Guinea grass from which the loppings were removed for fodder was lopped once a month. Sugar cane was cut first at the end of one year and again at the time the other species were uprooted and the trash was retained in the plots. To estimate the dry matter addition to the soil in the form of loppings the fresh weight of loppings from each plot was weighed separately and a sample was taken, the percentage dry matter determined by drying in an oven, and the total fresh weight was converted to dry weight per hectare. Root weights at different depths were estimated by taking samples in each plot using a cylindrical core sampler 10 cm in diameter and 15 cm in length. Four samples were taken from each plot, two from the centre of the inter-row space and two in between two plants in the row. The samples at different depths were washed free of soil using a large sieve and the roots separated and dried in an oven for 24 hours at 105°C. These dry weights were later converted to tonnes per hectare.

Infiltration rate was measured with a double ring infiltrometer (diameter 30.5 cm) according to the method outlined by Haise *et al* (1956). Two measurements were taken in each plot in one block only. Infiltration rate was measured before planting the soil reconditioning species and again in the same plots at the end of 1½ years of soil reconditioning.

Water retention characteristics were determined with undisturbed core samples (diameter 5.35 cm and height 6.0 cm.) Water retention at 0.1 bar was measured using a hanging water column and that 15 bar using a pressure plate apparatus. Organic carbon was estimated by Walkley and Black method.

RESULTS AND DISCUSSION

The benefits that accrue to the soil from soil reconditioning are mainly the addition of organic matter in the form of loppings and the root residues left behind in the soil at various depths which improve structure, aeration etc. apart from other benefits such as reduction in the population root disease fungi and nematodes. Thus the quantity of loppings and root residues derived from the different species gives some measure of the usefulness of any species for the purpose of soil reconditioning. The dry weight of loppings obtained from each soil reconditioning species on the different estates are given in Table 3.

TABLE 3 — *Dry weight (tonnes ha*$^{-1}$*) of loppings from the soil reconditioning species*

	Guatemala grass	*Mana grass*	*Guinea grass mulched*	*Guinea grass fodder*	*Sugar cane*	*Era-grostis*	*LSD (P = 0.05)*
St Coombs	44.20	35.67	34.36	18.11	—	36.40	8.14
Galphilla	31.02	58.50	28.21	20.77	16.88	—	5.76
Little Valley	20.21	33.00	18.10	10.48	21.10	—	4.66
Ury Group	18.44	53.15	45.66	18.47	11.63	—	14.93
Cannavarella	10.78	27.78	33.16	26.68	29.81	—	9.58

It would be clear from Table 3 that on most estates in terms of dry matter of loppings mana grass contributed more than the other species. At St Coombs Guatemala grass appeared to contribute more than Mana grass, but this difference is not statistically significant. In general the results confirm that reported by Sandanam *et al* (1976) where the dry weight of loppings obtained from Mana grass was more than that from Guatemala grass. This is due to the coarse nature of Mana grass and its percentage dry matter being higher than that of Guatemala grass. Another important aspect to note is that when Guinea grass is used with the combined purpose of using the loppings as fodder, the grass has to be cut when it is tender and therefore entails frequent loppings *ie.* every month as done here. Therefore, the dry matter harvested is only about 50% (on the average) of that obtained when it is lopped once in 3 months. When Guinea grass is used purely for soil reconditioning the organic material contributed towards soil improvement is generally less than that from Mana grass at Galphilla and Little Valley whereas in other estates the difference was not statistically significant. In comparison to Guatemala grass Guinea grass contributed more dry matter at Ury and Cannavarella, the contribution was similar in magnitude at Galphilla and Little Valley and lower at St Coombs. Climatic difference among these regions may have contributed towards the differences in dry matter production. In general it appears that Guinea grass, if used in the same way as Guatemala grass and Mana grass, could be as useful as the latter species for soil reconditioning. In terms of organic materials added to the soil in the form of loppings, growing Guinea grass to obtain fodder as well would seem less desirable for the purpose of soil reconditioning.

Apart from the addition to the surface soil of loppings the proliferation of roots in the sub soil would contribute more towards improving physical properties, aeration etc. The quantity of root residue at different soil depths for each species on the different estates are given in Tables 4-8.

TABLES 4–8 — *Dry weights (tonnes ha-1) of roots at different depths in soil under the respective soil reconditioning species*

TABLE 4 — *St Coombs*

Soil depth	*Guatemala grass*	*Mana grass*	*Guinea (fodder)*	*Guinea (mulch)*	*Eragrostis*
0-15 cm	10.37	5.10	5.22	6.49	2.23
15-30 cm	7.71	3.64	3.16	4.37	1.66
30-45 cm	3.44	2.03	1.68	3.74	1.58
45-60 cm	1.51	0.88	0.80	1.81	0.80
60-75 cm	0.98	0.45	0.48	0.83	0.28
Total	24.01	12.10	11.34	17.24	5.55

TABLE 5 — *Galphilla*

Soil depth	*Guatemala grass*	*Mana grass*	*Guinea (fodder)*	*Guinea (mulch)*	*Sugar cane*
0-15 cm	10.29	2.76	2.23	3.06	1.71
15-30 cm	1.73	1.13	0.78	1.05	1.08
30-45 cm	0.90	0.68	0.33	0.43	0.73
45-60 cm	0.48	0.33	0.26	0.23	0.40
60-75 cm	0.20	0.20	0.16	0.15	0.25
Total	13.60	5.10	67.3	4.32	4.17

TABLE 6 — *Little Valley*

Soil depth	*Guatemala grass*	*Mana grass*	*Guinea (fodder)*	*Guinea (mulched)*	*Sugar cane*
0-15 cm	9.26	2.48	2.00	2.75	1.54
15-30 cm	1.56	1.02	0.70	0.95	0.97
30-45 cm	0.81	0.62	0.30	0.39	0.66
45-60 cm	0.44	0.30	0.20	0.35	0.60
60-75 cm	0.18	0.15	0.10	0.13	0.23
Total	12.25	4.57	3.30	4.57	4.00

TABLE 7 — *Ury*

Soil depth	*Guatemala grass*	*Mana grass*	*Guinea (fodder)*	*Guinea (mulched)*	*Sugar cane*
0-15 cm	6.25	3.99	7.63	13.45	2.48
15-30 cm	0.85	1.91	2.26	1.63	0.95
30-45 cm	0.35	0.75	0.78	1.46	0.50
45-60 cm	0.23	0.45	0.45	1.40	0.43
60-75 cm	0.10	0.15	0.35	0.32	0.35
Total	7.78	7.20	12.47	17.26	4.68

TABLE 8 — *Cannavarella*

Soil depth	*Guatemala grass*	*Mana grass*	*Guinea (fodder)*	*Guinea (mulched)*	*Sugar cane*
0-15 cm	4.64	1.73	5.62	9.06	4.04
15-30 cm	1.15	0.83	1.08	2.94	0.88
30-45 cm	0.58	0.48	0.65	0.50	0.75
45-60 cm	0.30	0.12	0.25	0.20	0.38
60-75 cm	0.18	0.15	0.10	0.12	0.20
Total	6.85	3.51	7.70	12.82	6.25

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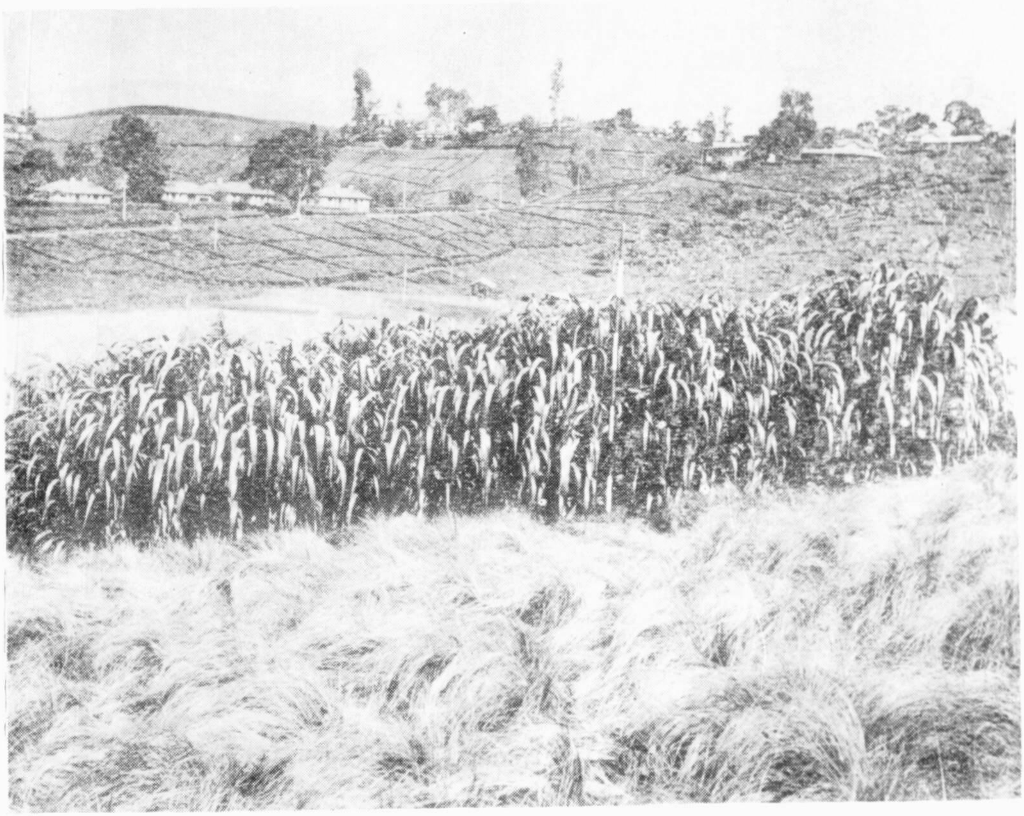

Fig. 1. — Growth of Guatemala and Eragrostis

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Fig. 2. — Growth of Guinea grass for fodder and mulch

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Fig. 3. — Growth of Sugar Cane and Guinea grass for mulch

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It appears from Table 4-8 that the performance of the each species in terms of root growth differed in the various districts. In the Up country (St Coombs) the highest total root weight was from Guatemala grass, followed in turn by Guinea grass (mulch), Mana, Guinea (fodder) and *Eragrostis*. Guatemala grass at St Coombs produced twice the quantity of roots produced by Mana grass and about 39% more than that produced by Guinea grass (mulched). That Guatemala produces more roots than Mana grass and therefore is more suited for soil reconditioning was reported earlier (Sandanam *et al*, 1976). The present investigation shows that Guinea grass is even superior to Mana grass in terms of root production. *Eragrostis* has not been tested for its suitability as a soil reconditioning crop, upto now, although it is used widely for mulching purposes. It is a native species in the mountains of Tanganyika (Hoover *et al*, 1948) and is mainly used for soil conservation purposes in Sri Lanka having been introduced in the 1960's. From the results of the present investigation, it appears that it is not desirable as a soil reconditioning species since the root contribution is almost one fifth of that by Guatemala grass and less than one half of that by Mana grass (Table 1) although return of tops is comparable to that from the other species tested. The tops are very coarse and would serve as only mulching material and it does not readily decompose in the soil thereby not being able to enrich the humus status of the soil.

In Galphilla and Little Valley (Mid Country) Guatemala grass produced the largest quantity of roots (Tables 2 and 3) which was almost 3 times that produced by other species tested. Guinea grass, cut and retained, produced almost similar amount of roots as that produced by Mana grass, but when cut frequently for fodder produced very much less roots. Root weight in plots with sugar cane was comparable to that in plots with Mana and Guinea grass.

In Ury Group and Cannavarella Estate (Uva District) the performance of Guatemala was poorer than that of other species, in terms of root weights, especially compared with Guinea grass (Mulch). The fact that the root weight in Guatemala grass plots was even lower than that in plots with Guinea grass (fodder) that was cut at monthly intervals seems to indicate that Guatemala could have been cut by labour for feeding cattle. This is a usual occurrence on many estates in Sri Lanka and is a prime reason for Superintendents preferring Mana grass for soil reconditioning. Sugar cane, in all 4 experiments produced only 4-6 tonnes ha^{-1} of roots and in 3 out of the 4 experiments the major part of the roots were confined to the 0-15 cm layer. Thus it may not be as desirable a species as Guatemala grass for soil reconditioning. Figs. 1-3 show the nature of growth of some of the species tested.

If the effects in terms of addition of tops are averaged over all the experiments the data indicate that the performance was in the order Mana > *Eragrostis* > Guinea (mulch) > Guatemala grass > Sugar cane > Guinea (fodder). In terms of root weights, however, the order was Guatemala grass Guinea (mulch) Guinea (fodder) Mana grass Sugar cane *Eragrostis* (Fig. 4). The desirability of a species for soil reconditioning depends both on the amount of tops added to enrich the organic mulch on the surface and on the amount of roots produced. The latter, however, is more important since the extent of insitu addition of roots would largely determine improvements in aeration, aggregation, infiltration and water holding capacity of the soil. Incorporation of organic residue into the soil amounting to about 12 tonnes ha^{-1} upto a depth of 75 cm is an impossible task but this is easily achieved by insitu production of roots from a species such as Guatemala grass or Guinea grass. Mulching material of any quantity could always be brought from outside. It therefore appears that Guatemala grass and Guinea grass and Mana grass are more suitable as soil reconditioning species and that Sugar cane and Eragrostis cannot be

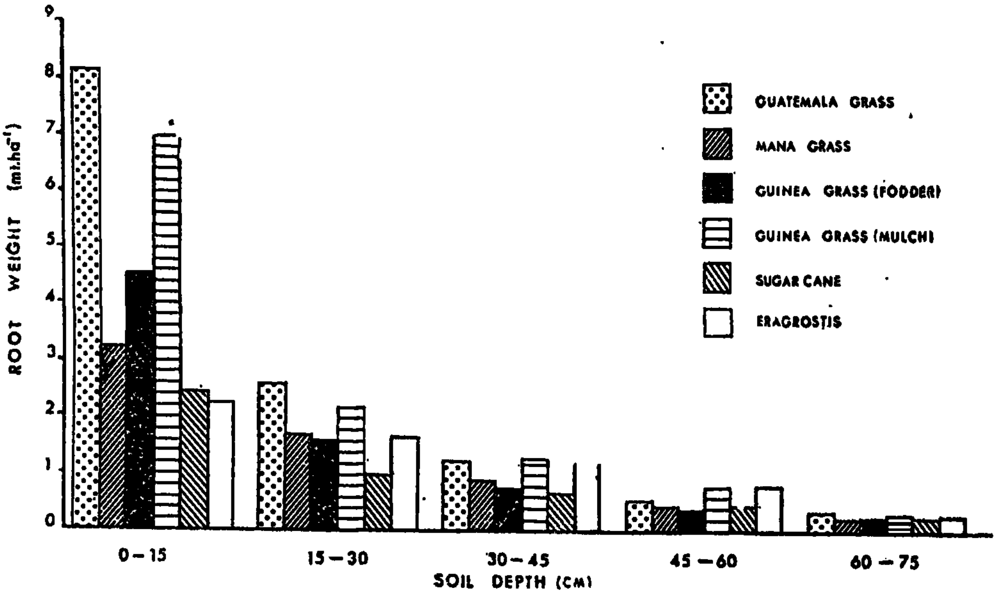

Fig. 4. — Dry weights of roots at different depths in soil

expected to fulfil the purpose adequately. It is also to be noted that when Guinea grass was grown for fodder about 19 tonnes ha^{-1} of dry matter was available for feeding cattle and the sugar cane harvest in terms of fresh cane was 37.6, 20.7, 12.8, 18.8 tonnes ha^{-1} at Galphilla, Ury, Cannavarella and Little Valley estates respectively. These two species therefore appear attractive since they bring in some return from the land while it is being reconditioned. It has to be, however, borne in mind that the contribution to the soil in terms of root residues by sugar cane and Guinea (for fodder) has been very low and therefore these species do not fulfil the primary objective of the exercise *i.e.* reconditioning the soil.

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