THE EFFECTS OF TRASH CONSERVATION ON SOIL MOISTURE AND THE SUGARCANE CROP IN NATAL

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After conducting experiments with trashing and burning at Winklespruit, Sawer (1912) stated that a layer of trash and tops undoubtedly assisted in the suppression of weeds during the development of the ratoons, had the effect of a mulch during periods of drought, and increased the supply of nitrates to the crop. These comments still refer to the most important effects of trash in the coastal belt of Natal today, but it has become increasingly important to identify the causes of sugarcane yield responses to trash conservation. The development of herbicides and changes in the socio-economic structure of the industry have reduced the value of the primary effect of trash in suppressing ratoon weeds, and in many instances the economic balance may now be so delicate that the value of a trash blanket in terms of additional crop yield may be a decisive factor. It is therefore particularly important at this stage to define as accurately as possible the conditions under which significant responses to mulching are likely to be obtained.

Pearson (1959) reported the results of a series of experiments involving trash management in Natal. On a black dolerite soil at Mount Edgecombe the mean response to a trash blanket compared with burning was 8.6 tons cane per acre per crop over six ratoon crops in two cycles, the varieties being Co.281 and Co.301. Consistently positive responses were also obtained in experiments conducted on Tugela schist and Dwyka soils, but a depression in yield due to the presence of trash was observed in the first ratoon of an experiment on a recent grey sand at Compensation. This was ascribed to waterlogged conditions being particularly prevalent under the trash, and the position was reversed in the second ratoon stage, a positive response to trash mulching being obtained. A further trial carried out on a Mist Belt T.M.S. soil at an elevation of 2,000 ft. near Doornkop showed no trash treatment effects.

Positive responses to trash conservation are by no means universal. King (1954) reported that in one experiment at Bundaberg, Queensland, where the average rainfall was 43 in. per annum, there had not been a response to trashing compared with burning over a period of twenty years, the cumulative yields being 414 and 410 tons of cane per acre for the two treatments respectively. Samuels, Landrau and Lugo-Lopez (1952) in Puerto Rico found no significant differences in yield over six ratoon crops, on a Vega Alta silty clay, between treatments involving burning and conserving trash. Landrau *et al* (1954) stated that no significant differences in yield were found between various trash conservation treatments and burning of the trash over two ratoons on a Colo clay soil.

A report by Veiga *et al* (1962) from Brazil, however, recorded that a trash blanket gave the highest yields over a four year period when compared with lining of the trash and burning, the lining treatment giving yields intermediate between those of the other two treatments.

It must be acknowledged that the effects of an organic mulch on the soil and the crop may be extremely complex, and that the net response may be made up of both positive and negative components. But the disparity of results from crop to crop and area to area indicate that the conditions favouring a positive response are neither present on all sites nor always present on a single site. The experiments described here were used to study the various effects of trash mulching, and the aspects of soil moisture and the crop itself are reported.

Experimental Procedures

Experiment I

This experiment was the continuation of one described previously by Pearson (1959), being located on a Rydalvale clay loam with a south-westerly slope at Mount Edgecombe. The first crop was planted in 1939 and the third ratoon of the third cycle was harvested in 1964. Sunn hemp was grown in the long fallows between cycles, each cycle consisting of a plant crop and three ratoons. The varieties used were Co.281, Co.301 and N:Co.376 in successive cycles. Four treatments were maintained throughout the experiment in four replications, the treatments being:

(i) plots burnt, mixed NPK fertilizer applied
(ii) plots burnt, no fertilizer applied
(iii) plots trashed, mixed NPK fertilizer applied
(iv) plots trashed, no fertilizer applied.

The stalk populations were estimated by counting the number of stalks in one row of each plot at approximately monthly intervals. Ground cover was measured monthly with a ground cover quadrat of the type described by Cackett (1964), and stalk heights were measured weekly on five stalks per plot, from the top of reference pegs in the ground to the uppermost visible collars on the stalks. Soil moisture variations down to four feet were studied by means of cylindrical gypsum resistance units placed at depths of 6 in., 18 in., 30 in. and 42 in. in both the row and the centre of the interrow. Readings were taken twice weekly with a Bouyoucos meter.

Yield data from nine ratoon crops have now been obtained from this experiment. When the third ratoon crop of N:Co.376 was harvested at 12 months of age in 1964, side and end effects were removed from each plot and the total number of harvested stalks per net plot was counted. Each stalk was topped carefully at the point of attachment of the sixth leaf sheath and one stalk in ten was set aside for stalk length and diameter measurements.

Experiment II

This experiment was planted with N:Co.376 in 1955 on a Waldene fine sandy loam with a northerly slope at Chaka's Kraal. Four trash treatments made up of 0, 7, 16 and 25 tons of field dry trash per acre were the sub-plot treatments in a split-plot design, with two levels of nitrogen (120 lb. and 240 lb. N per acre) as the whole plot factors. Successive ratoons were harvested at 22, 24, 24 and 15½ months of age, the fourth ratoon being harvested at the end of October, 1964. The numbers of stalks harvested per net plot were counted and stalk lengths and diameters were measured on a five per cent sub-sample of the stalks.

Experiment III

A complex split-plot design was used in this experiment to compare irrigated and dryland conditions in whole plots, with burning, trashing and three levels of potassium combined factorially in main sub-plots. Each main sub-plot contained three further sub-plots which were used to compare three levels of nitrogen. The experiment was located on a north-easterly slope at Chaka's Kraal on a Waldene fine sandy loam. It was planted in 1959 and the first and second ratoon crops were harvested at 17 months and 12½ months of age, respectively.

Experiment IV

Run-off from an 11 per cent slope on a Waldene fine sandy loam, planted with N:Co.376, was measured at Chaka's Kraal in three successive parts of this experiment. Three plots each 27 ft. by 7 ft. 9 in. were established in January, 1963, by enclosing six cane rows at 4 ft. 6 in. spacing within a brick wall which protruded one brick height above ground level. A cement bevel was built on the top of the bricks, sloping outwards, so that precipitation onto the wall drained away from the net plot. In the centre of the interrow below the sixth cane row of each plot was installed an aluminium trough, 7 ft. 9 in. wide, with a V-notch to collect all the runoff from the plot. The runoff was conducted by gravity through a buried 2 in. plastic pipe to a 44 gallon receiving drum. Small amounts of runoff were held in a two-gallon capacity plastic bucket suspended beneath the pipe outlet inside the drum. Surface drains were established around the runoff lysimeter sites to prevent inundation of the plots.

Three different treatments were compared on these plots. One lysimeter was covered with a trash blanket equivalent to the residue from 40 tons of cane per acre. The second was left bare without any trash and in the third the same amount of trash as applied to the first was lined into alternate interrows.

In September, 1963, the experiment was re-established on an adjacent site with the addition of a further three plots. The new crop was still a first ratoon, the plant stage on the new site simply having been cut at a later stage than that on the first site. The same operational procedures were followed as for the first trial, but only two treatments, the "trash blanket" and "no trash" were retained with three replications of each. The plots were harvested in September, 1964, when millable stalks were counted and weighed, and a subsample of one stalk in ten was used to measure lengths and diameters.

The third part of the experiment commenced in October, 1964, with two replications of each of three treatments superimposed equally on the previous two treatments. The second ratoon treatments were:

(i) trash blanket,

(ii) no trash, soil undisturbed,

(iii) no trash, interrow soil built into shallow basins (basin listing).

Experiment V

The relative amounts of evaporation from bare and trash-covered Rydalvale clay loam soil were determined at Mount Edgecombe by sampling plots daily over a period from January, 1962, to January, 1963. Samples were taken each weekday morning to a depth of 7 inches, cores from each of eight plots being made into a composite sample for each treatment for the gravimetric determination of soil moisture content. No crop was planted in the plots and the area was maintained weed-free by removing weed seedlings as they appeared. The plots were protected from wash by drains established up-slope and across the contour. The experimental design was entirely systematic, alternate plots being bare and trash-covered.

On the mulched plots the trash was moved to allow the taking of soil cores and immediately and carefully replaced. A raingauge was installed on the site and was read daily.

Experiment VI

The amount of precipitation intercepted by trash from rainfall and overhead irrigation spray was measured during 1964 at Chaka's Kraal. Six carefully constructed raingauges, exactly 12 in. in diameter were used for the experiment. Three of the raingauges, complete with wire-gauze platforms, were used as controls and an amount of trash equivalent to the residue from 40 tons of N:Co.376 cane per acre was placed on the gauze platforms in the other three. Routine measurements of rainfall were carried out daily at 8 a.m.

The same equipment was used to measure the amounts of irrigation water intercepted by 1, 8 and 16 tons of trash per acre.

Experimental Results

Yield Data

The yield responses due to trash in Experiment I are shown in Table 1. The mean response to a trash blanket compared with burning was 4.06 tons of cane per acre per annum in the presence of fertilizer and 4.61 tons of cane per acre per annum in the absence of fertilizer. Although these average results indicate a slight nutritional effect due to trash, it can be seen that the effect derives mainly from the second ratoon results in the third cycle, when the trash-fertilized plots suffered particularly severely from a prolonged drought. On these grounds, therefore, the nutritional benefits to be derived from trash are not considered to be economically important, even after twenty-five years of treatment.

TABLE 1

Experiment I: Yield responses due to trash compared with burning

Cycle	Crop	Age	Response to Trash compared with Burning			
			Cane/Ac.		Sucrose/Ac.	
			Fertilizer	No Fertilizer	Fertilizer	No Fertilizer
		Months	Tons	Tons	Tons	Tons
1	1R	23	9.79	6.80	1.39	0.87
	2R	24	10.96	6.85	1.55	0.83
	3R†	25	14.90	11.74	2.01	1.64
2	1R**	24	4.15	7.65	0.75	1.08
	2R*	25	5.24	7.42	1.09	1.49
	3R†	24	8.00	5.75	1.12	0.90
3	1R*	24	10.15	14.30	1.36	1.52
	2R	24	2.10	13.32	-0.45	1.96
	3R	12	4.01	4.96	0.23	0.65
Total		205	69.30	78.79	9.05	10.94
Mean response/annum			4.06	4.61	0.53	0.64

In Tables 1, 2 and 3 the following notations refer to the levels of significance of treatment differences in terms of tons sucrose per acre:

† = significant at 10 per cent level.
* = significant at 5 per cent level.
** = significant at 1 per cent level.

The cumulative yields of cane per acre over four ratoons in Experiment II were 240 tons, 265 tons, 260 tons and 256 tons for the 0, 7, 16 and 25 tons trash per acre treatments, respectively, the response to trash decreasing with increasing amounts of trash. The yield responses due to 7 tons of trash per acre compared with no trash are shown in Table 2.

In Experiment III the response to a trash blanket compared with burning was greater under dryland conditions than under irrigation as shown in Table 3. Rainfall during the second ratoon stage was fairly adequate, as evidenced by the small response to irrigation, and under these conditions the response to a trash blanket was limited even under dryland conditions.

TABLE 2

Experiment II: Yield responses due to a trash blanket of 7 tons per acre compared with no trash

Crop	Age	Yield Response	
		Cane/Ac.	Sucrose/Ac.
	Months	Tons	Tons
1R* . . .	22	4.15	0.82
2R . . .	24	9.44	1.12
3R* . . .	23	7.90	1.25
4R** . . .	15	3.53	0.59
Total . .	84	25.02	3.78
Mean response/annum . .		3.57	0.54

TABLE 3

Experiment III: Yields and responses due to a trash blanket compared with burning in the presence and absence of irrigation

Crop	Age	Treatment	Cane/Ac.			Sucrose/Ac.		
			Trash	Burnt	Response	Trash	Burnt	Response
	Months		Tons	Tons	Tons	Tons	Tons	Tons
1R**	17	Dryland	41.9	34.5	7.4	6.48	5.05	1.43
		Irrigated	59.0	57.3	1.7	9.60	8.98	0.62
2R	12½	Dryland	41.7	41.2	0.5	6.59	6.23	0.36
		Irrigated	46.6	49.3	-2.7	6.86	7.19	-0.33

The mean responses to a trash blanket compared with no trash or burning in Experiments I and II for successive ratoons showed no consistent trend. The mean increased yields over four cycles in tons of cane per acre per annum was 3.65 for first ratoons, 3.43 for second ratoons and 4.96 for third ratoons. Previous indications that there was no residual benefit from trash after ploughing out and replanting sugarcane (Wilson, 1960) were confirmed, the total yields from the plant crops of the second and third cycles in Experiment I being 110 tons per acre on plots previously trashed and 112 tons per acre on plots previously burnt.

No significant effect due to trash on sucrose per cent cane was apparent in either experiment as shown in the average results in Table 4.

TABLE 4

Experiments I and II: Mean sucrose content for 12 ratoon crops

Experiment	No. of Crops	Trash Blanket	Trash Burnt or No Trash
		%	%
I	9	14.36	14.51
II	3	14.80	14.84

Harvested Crop Characteristics

The average results of the harvested stalk counts, weights and measurements for Experiment I are shown in Table 5, where the marked effects of both trash and fertilizer treatments are apparent. A trash blanket caused a smaller population of stalks to be thicker, longer and heavier than the stalks comprising a larger population in the burnt plots. These effects of trash were observed consistently as shown in the summarized data for Experiments I, II and IV in Table 6.

TABLE 5

Experiment I: Harvested crop characteristics for the third ratoon

Characteristic		Treatment			
		Burnt Fertilizer	Burnt No Fertilizer	Trashed Fertilizer	Trashed No Fertilizer
Stalk diameter (mm)	Top	21.7	20.8	24.6	24.3
	Centre . . .	23.8	22.1	26.6	25.1
	Bottom . . .	26.6	24.4	28.6	27.4
	Mean . . .	24.1	22.4	26.6	25.6
Stalk length (cm)		149.7	112.3	163.5	131.2
No. of stalks/ac. (X 10^{-3})		63.9	44.7	53.4	39.6
Lb/stalk		1.31	0.86	1.73	1.21

TABLE 6

Experiments I, II and IV: Comparisons of harvested crop characteristics in 1964

Expt.	Variety	Soil	Crop	Item	Trashed Plots	No Trash Plots	Trash/ No Trash
I . . .	N:Co.376	Rydalvale Series . .	3R	Diameter (mm)	26.1	23.2	1.13
				Length (cm)	147.3	131.0	1.12
				Stalks/ac. (X 10^{-3}) . . .	46.5	54.3	0.86
				Lb/stalk	1.47	1.09	1.35
II . . .	N:Co.376	Waldene Series . .	4R	Diameter (mm)	22.0	21.7	1.01
				Length (cm)	135.7	128.1	1.06
				Stalks/ac. (X 10^{-3}) . . .	59.7	59.0	1.01
				Lb/stalk	1.34	1.23	1.09
IV . . .	N:Co.376	Waldene Series . .	1R	Diameter (mm)	24.5	23.6	1.04
				Length (cm)	102.7	86.3	1.19
				Stalks/ac. (X 10^{-3}) . . .	65.3	71.5	0.91
				Lb/stalk	0.92	0.73	1.26

Plant Populations and Ground Cover

The effects of trash treatments on stalk populations appear to be specific and are shown in Figure 1 for the third ratoon crop of Experiment I. At the mid-summer peak, the burnt-fertilized plots contained almost twice the population of the trash-fertilized plots, but by the time of harvest the difference had been reduced to 7,200 stalks per acre.

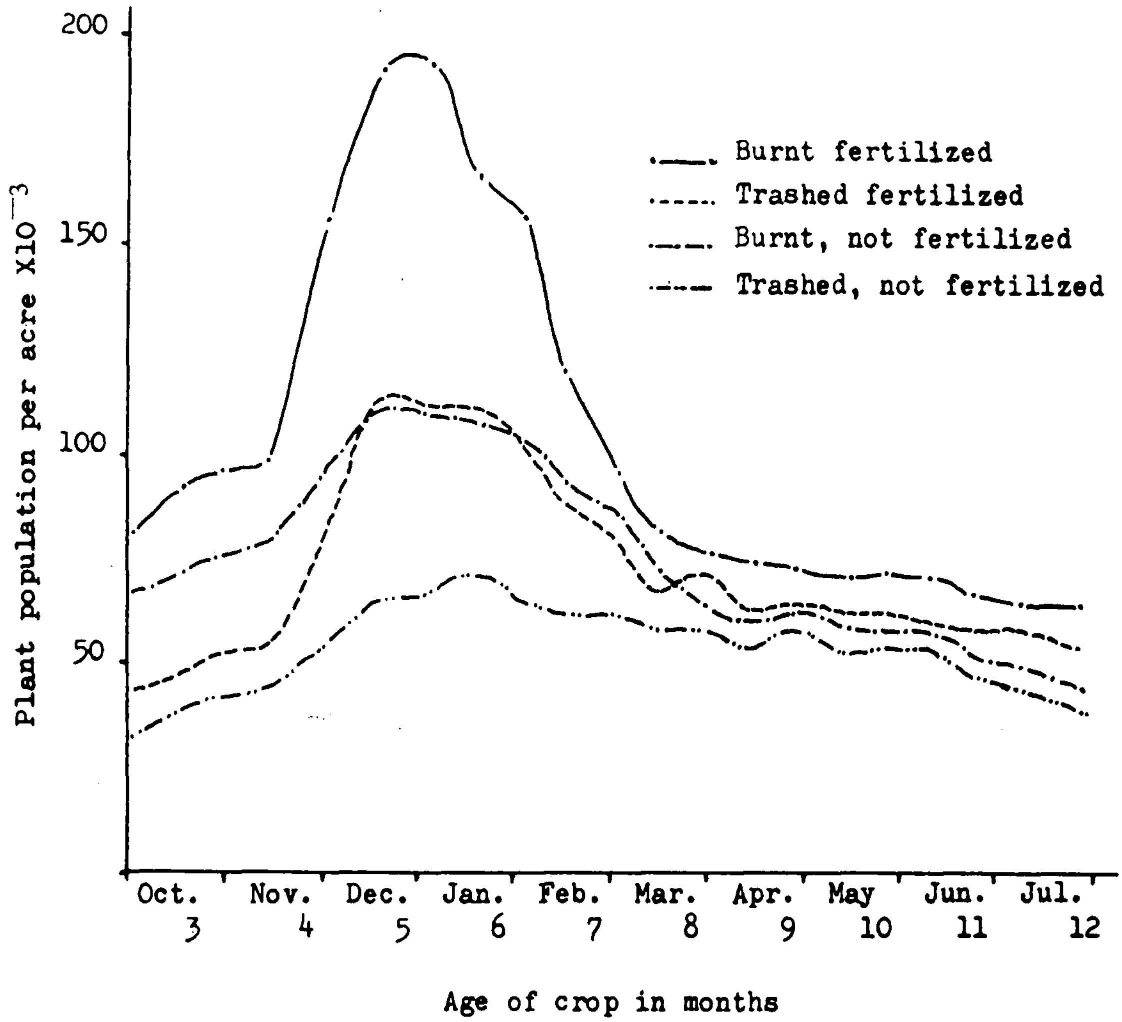

Fig. 1. Experiment I: Mean stalk populations for four treatments in the third ratoon crop

It appeared likely that the much higher stalk populations in the burnt plots would result in an earlier formation of leaf canopy and ground cover, which might also result in a higher consumptive use of water through transpiration. Measurements of ground cover and stalk counts in the fourth ratoon stage of Experiment I, however, showed that this effect did not occur under fertilized conditions as shown in Figure 2. Despite large differences in populations, the fertilized trashed and burnt plots showed an almost identical development of ground cover.

Crop Height

The mean daily growth increments for the different treatments in the third ratoon stage of Experiment I are shown in Figure 3. The cane in the trashed plots increased in length at a greater rate than the cane in the comparable burnt plots almost continuously. The rate of growth of the cane in the fertilized plots was often remarkably higher than that of the cane in the unfertilized plots, but there were periods when the rate of development of the unfertilized cane exceeded that of the fertilized cane. These inconsistent relative growth rates were associated with soil moisture availability. Due to the lower consumptive use of water by the unfertilized crops, the soil moisture reservoir in these plots tended to last longer into rainless periods than it did in the fertilized plots, which became severely affected by drought.

Figures 1 and 3 refer to the same crop and it is clear that the first summer of crop development was of paramount importance in terms of both population development and stalk elongation. Both crop characteristics declined rapidly after peaks in January, and a mean daily growth rate in excess of 4 mm. per day was only maintained for a five-month period from November to April.

The mean cumulative heights of the crops in the four treatments in the third ratoon stage of Experiment I are shown in Figure 4. It is apparent that the

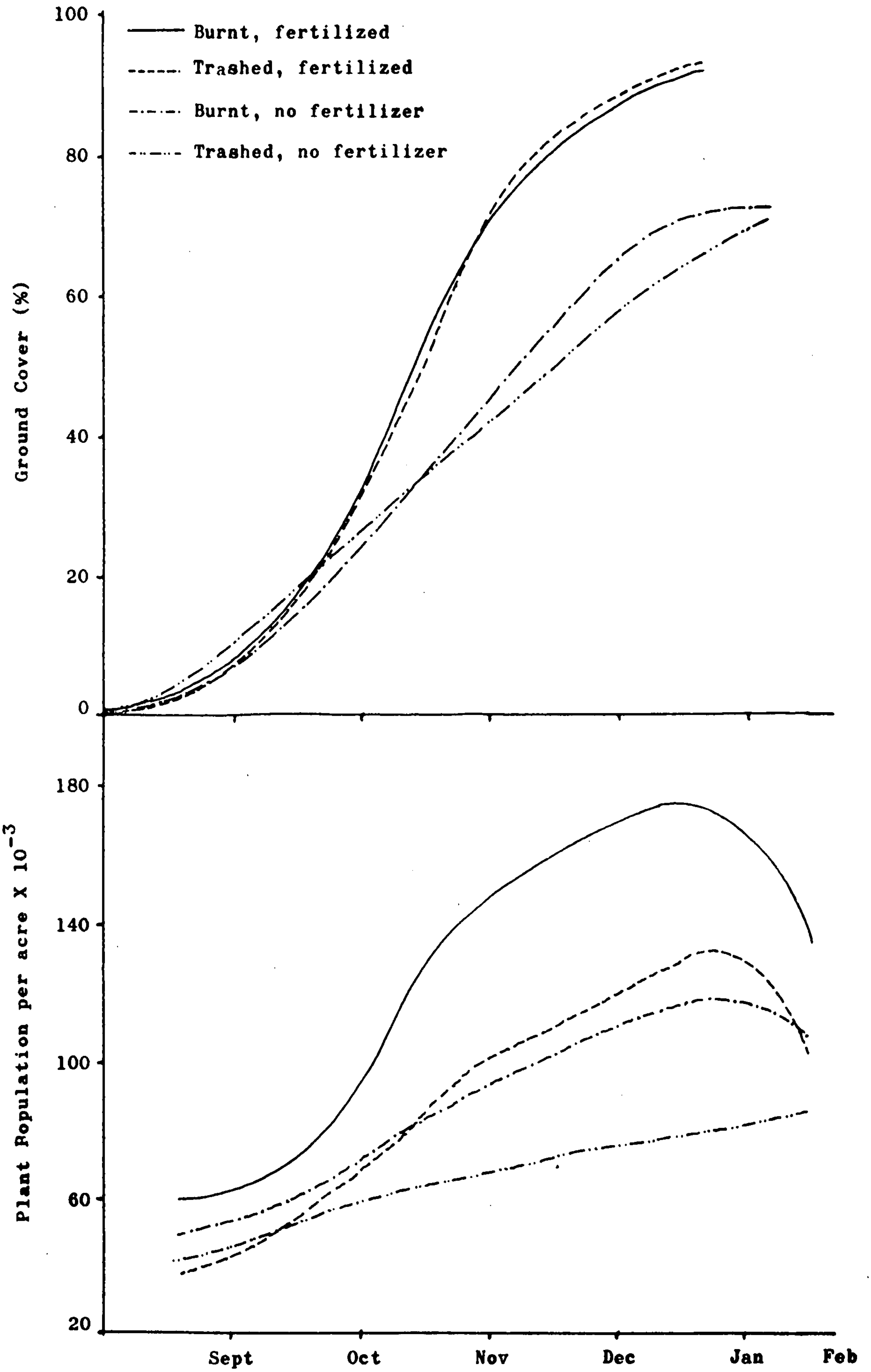

Fig. 2. Experiment I: Mean stalk populations and degrees of ground cover for four treatments for the fourth ratoon crop

TABLE 7

Experiment I: Cumulative height differences between cane in trashed and burnt plots

Crop	Age of Crop	Differences in Cumulative Heights	
		Fertilized Plots	No Fertilizer Plots
	months	cm	cm
2R .	6	6.9	12.2
	9	13.5	25.2
	12	15.2	28.7
	15	17.1	30.0
	18	17.3	30.8
	21	—	36.1
3R .	3	3.6	5.8
	6	7.8	11.4
	9	12.4	29.4
	12	14.8	33.8

total height of the cane in the trashed plots exceeded that of the comparable burnt plot cane throughout the duration of the crop. Most marked for all treatments was the rapid summer growth followed by the winter plateau when growth was reduced considerably. The height differences between the cane in trashed and burnt plots for both fertilizer treatments in the second ratoon of the third cycle of Experiment I are shown in Table 7 for various ages of the crops.

The height differences were always greater in the unfertilized plots, and the second ratoon data show that by far the majority of the total trash treatment effects in both fertilizer treatments occurred in the first twelve months of the crop.

Soil Moisture

Gypsum Resistance Units

Since the yield results of the long term burning *vs.* trashing experiments showed that nutrition was not likely to be the cause of responses to trash conservation, it appeared most likely that the effect of the mulch on soil moisture would be important under local conditions of inadequate rainfall. This was confirmed by the gypsum resistance unit data obtained during the third ratoon stage of Experiment I, and the results for the fertilized plots are shown in Figure 5 together with the rainfall and growth measurement data over the period when the crop was 4 to $11\frac{1}{2}$ months old.

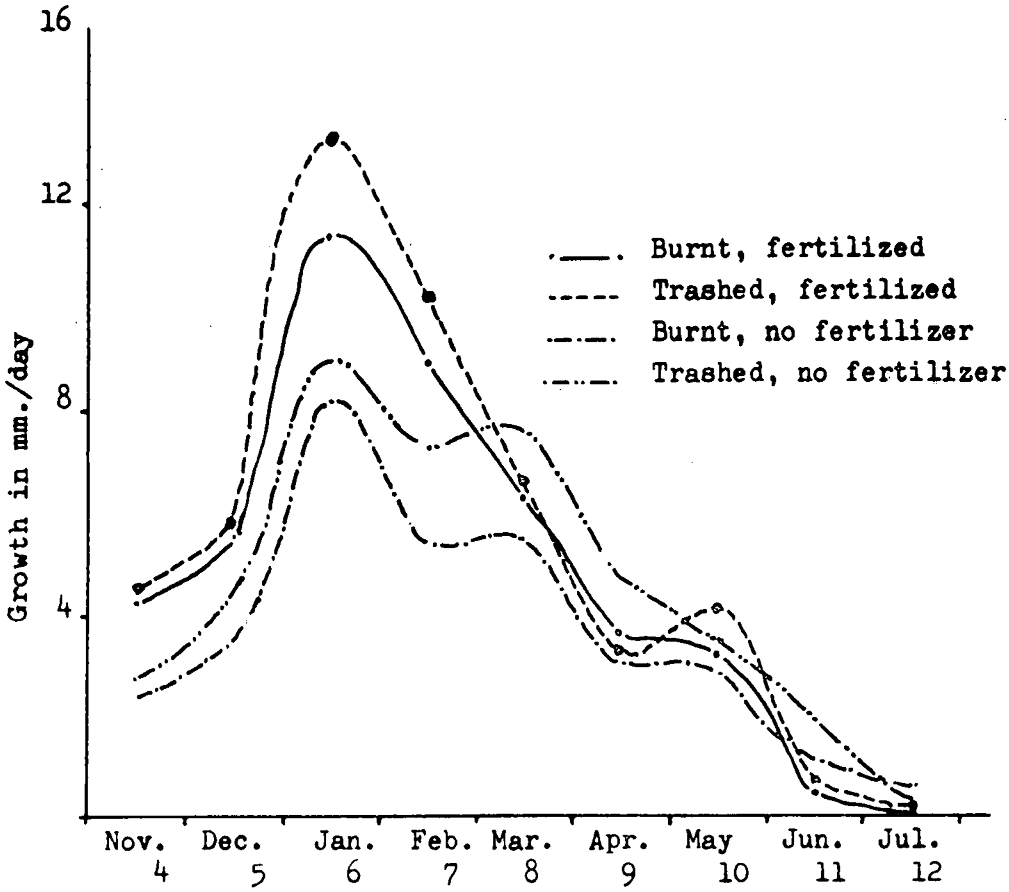

Fig. 3. Experiment I: Monthly mean growth rates for four treatments in the third ratoon crop

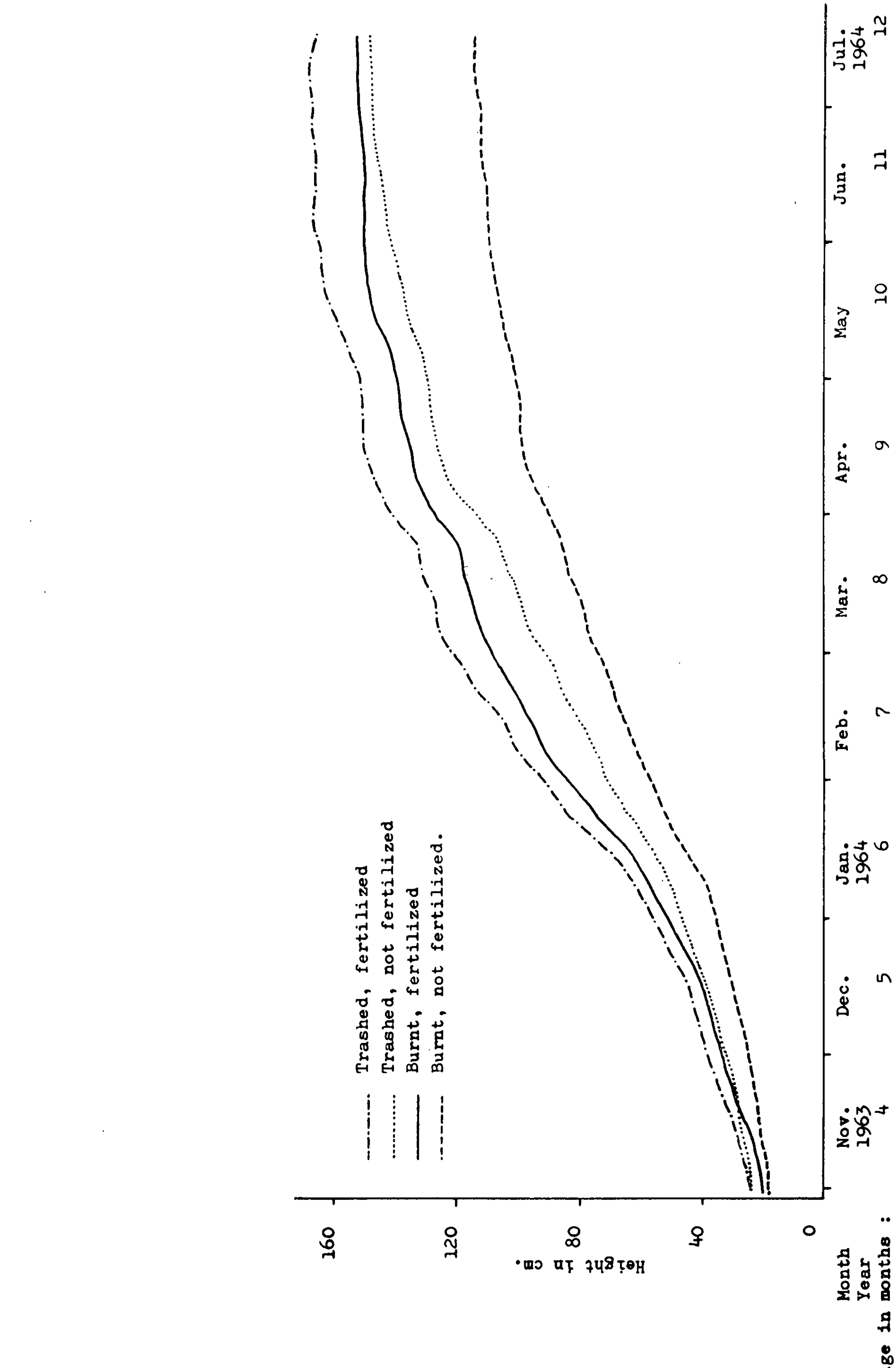

Fig. 4. Experiment I: Cumulative height (cm.) for four treatments in the third ratoon

It was of interest that the resistance unit data at the end of the preceding ratoon showed that the soil moisture had been exploited equally thoroughly to a depth of four feet in both trashed and burnt plots. Subsequent rains restored the soil moisture throughout the profile, but by December, 1963, when the crop was five months old, the soil in the burnt plots had dried out considerably to a depth of four feet, whereas in the trashed plots only the top two feet of soil had been exploited sufficiently to give a reduced Bouyoucos meter reading. Following saturating rains in January and February, however, there was complete exploitation of soil moisture at all depths in both treatments by the following June.

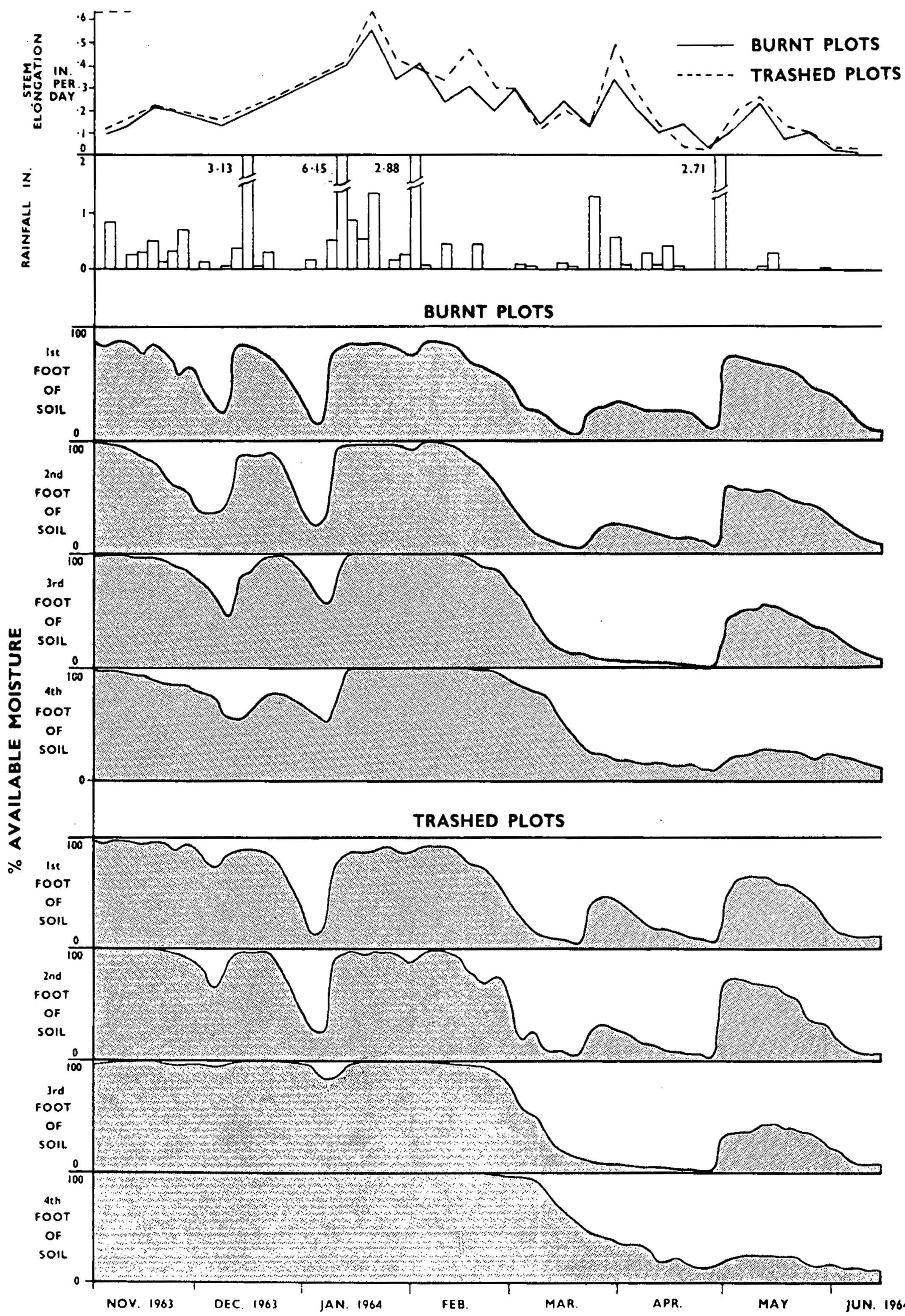

Fig. 5. Experiment I: Growth, rainfall and patterns of moisture removal from the soil in the third ratoon.

Surface Runoff

It was necessary to study the causes of soil moisture conservation by trash so that the conditions under which yield responses were most likely could be recognised. The results of Experiment IV given in Tables 8, 9 and 10 show that the reduction of runoff by trash on a Waldene fine sandy loam made an important contribution to soil moisture conservation. In Part I of the experiment a trash blanket conserved more than 3½ inches of rain compared with no trash over a six month period following a late December harvest, and lining of the trash was almost as efficient as a trash blanket. After a September, 1963, harvest, trash reduced runoff by only about 1 inch over the ensuing six months in Part II of the experiment, and this was also the total amount conserved during the entire 12 months duration of the crop.

After a September, 1964 harvest, the maximum reduction of runoff due to trash compared with a bare soil was less than 0.5 inches in Part III of the experiment. Basin listing of the interrow was even more effective than trash in reducing runoff, and of

TABLE 8

Experiment IV, Part I:

Runoff from plots under three treatments

Month	Rainfall (in.)	Runoff (in.)		
		Trash blanket	Trash lined	No trash
Jan., 1963 .	6.86	0.33	0.46	1.27
Feb. . . .	3.50	0 01	0.11	0.42
Mar. . . .	7.50	0 14	0.26	2.11
Apr. . . .	2.13	0 00	0.01	0.04
May . . .	0.07	0.00	0.00	0.00
June . . .	5.08	0.00	0.02	0.29
Total . . .	25.14	0.48	0.86	4.13
% Rain . .		1.90	3.40	16.4

TABLE 9

Experiment IV, Part II: Runoff from plots under two treatments

Month	Rainfall (in.)	Runoff (in.)		Month	Rainfall (in.)	Runoff (in.)	
		Trash blanket	No trash			Trash blanket	No trash
12–30 Sept., 1963 . .	0.54	0.00	0.00	Apr. 1964 . . .	2.66	0.00	0.00
Oct. . . .	3.68	0.00	0.00	May	0.35	0.00	0.00
Nov. . . .	2.28	0.00	0.00	June	0.76	0.00	0.00
Dec. . . .	2.92	0.00	0.02	July	1.67	0.00	0.00
Jan. 1964 . .	10.02	0.29	1.17	Aug.	0.09	0.00	0.00
Feb. . . .	2.45	0.00	0.02	1–12 Sept. . . .	0.23	0.00	0.00
Mar. . . .	1.48	0.00	0.00				
Sub-Total	23.37	0.29	1.21	Grand Total . .	29.13	0.29	1.21
% Rain		1.20	5.20	% Rain		1.00	4.20

TABLE 10

Experiment IV, Part III: Runoff from plots under six treatments

Month	Rainfall (in.)	Runoff (in.)						
		Present treatment	Trash blanket	Trash blanket	No trash	No trash	Basin listed	Basin listed
		Previous treatment	Trash	Bare	Trash	Bare	Trash	Bare
Oct. 1964 . . .	4.81		0.00	0.02	0.07	0.27	0.00	0.01
Nov.	2.96		0.00	0.00	0.00	0.01	0.00	0.00
Dec.	5.04		0.00	0.00	0.14	0.16	0.00	0.01
Jan. 1965 . . .	2.52		0.00	0.00	0.00	0.01	0.00	0.00
Total	15.33		0.00	0.02	0.21	0.45	0 00	0.02
% Rain . . .			0.00	0.10	1.40	2.90	0.00	0.10

particular interest was the observation that runoff from trashed, basin-listed and bare plots was always less when the treatment was imposed on a plot previously trashed than when the previous treatment was bare soil.

Surface Evaporation

The results of Experiment V are shown in Table 11 where the number of days in the second column refers to those days in each month which were either rain-free or when the amount of rain was insufficient to cause percolation below the 7-inch depth.

It should be appreciated that this study in the absence of a crop over a period of a year was intended only to determine the possible effect of trash in inhibiting evaporation, and not as a quantitative measure for direct application to crop conditions. In the presence of a crop, removal of water from the soil by the crop itself would reduce the proportion lost inefficiently by direct evaporation, and also the shading effect of the crop on soil surface evaporation would eventually become predominant. Cowan and Innes (1956) found that open pan evaporation was reduced by about 90 per cent under a sugarcane crop canopy.

A further aspect of the evaporative component of evapotranspiration is that it is affected by the fre-

TABLE 11
Experiment V:
Mean daily evaporation from bare and trash covered soil by months

Month	No. of Days	Evaporation/Day (in.)	
		Bare Soil	Trash covered
Jan.	20	0.101	0.036
Feb.	23	0.073	0.031
Mar.	23	0.063	0.031
Apr.	28	0.045	0.019
May	28	0.040	0.015
June	30	0.008	0.009
July	31	0.009	0.011
Aug.	26	0.019	0.014
Sept.	29	0.033	0.014
Oct.	24	0.052	0.029
Nov.	14	0.129	0.046
Dec.	15	0.096	0.029
Mean		0.048	0.021

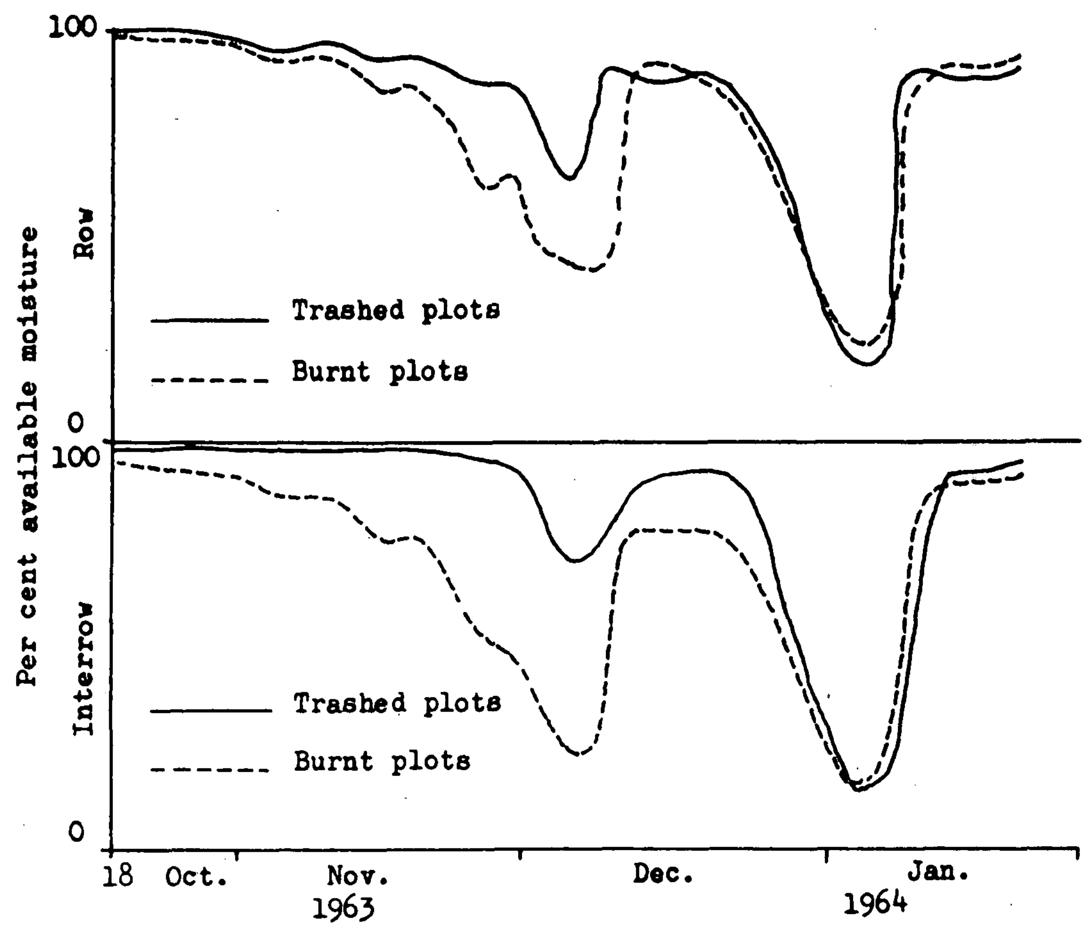

Fig. 6. Experiment I: Drying patterns of surface soil in the row and interrow

quency of soil wetting. Field data for evaporation therefore refer to specific conditions of rainfall and should be interpreted with the necessary caution. The data presented in Table 11 can be used as a rough guide to the amounts of water lost by evaporation from the soil in different months of the year, and with reference only to the period immediately after harvesting, when transpiration and crop shading of the soil are not significant.

The separate data from gypsum resistance units placed in the row and interrow of plots in Experiment I gave some indication of the effect of evaporation under crop conditions during the early development of the third ratoon. The results are shown in Figure 6 where per cent "available moisture" in the top two feet has been plotted against time over the period from October, 1963, to January, 1964. The greater soil moisture depletion in the burnt plots must be ascribed largely to evaporation, and the greater losses from the interrow compared with the row confirm this suggestion.

Interception

On account of the rough nature and large surface area of trash the interception of some precipitation can safely be predicted. It was of practical interest to know the extents of the interception from different amounts of precipitation and by different amounts of trash.

In Experiment VI, an amount of trash equivalent to that from 40 tons of cane per acre was placed in three of the six specially constructed raingauges already described. The raingauges were so designed that the wire screen, upon which the trash was placed, was sufficiently far below the rim of the gauge that the danger of splash losses was minimized. The replications with and without trash gave good agreement in amounts of measured rainfall. The results are shown in Figure 7 together with the results of tests carried out with an overhead irrigation sprinkler, using three levels of trash equivalent to 1 ton, 8 tons and 16 tons per acre.

As expected, almost all of small falls of rain were intercepted by trash and the amount intercepted increased with increasing amounts of trash. This effect may have contributed towards the depression of yield with increasing amounts of trash greater than 7 tons per acre in Experiment II. The pattern appeared to be very similar whether the precipitation was natural or artificial.

The importance of interception by fresh trash was gauged from the facts that an average trash blanket held back over 50 per cent of 0.1 in. of rain, about 18 per cent of 0.5 in. of rain, and 9 per cent of 1.0 in. of rain. The exercise of calculating the amount of rain which might be intercepted annually by such a layer

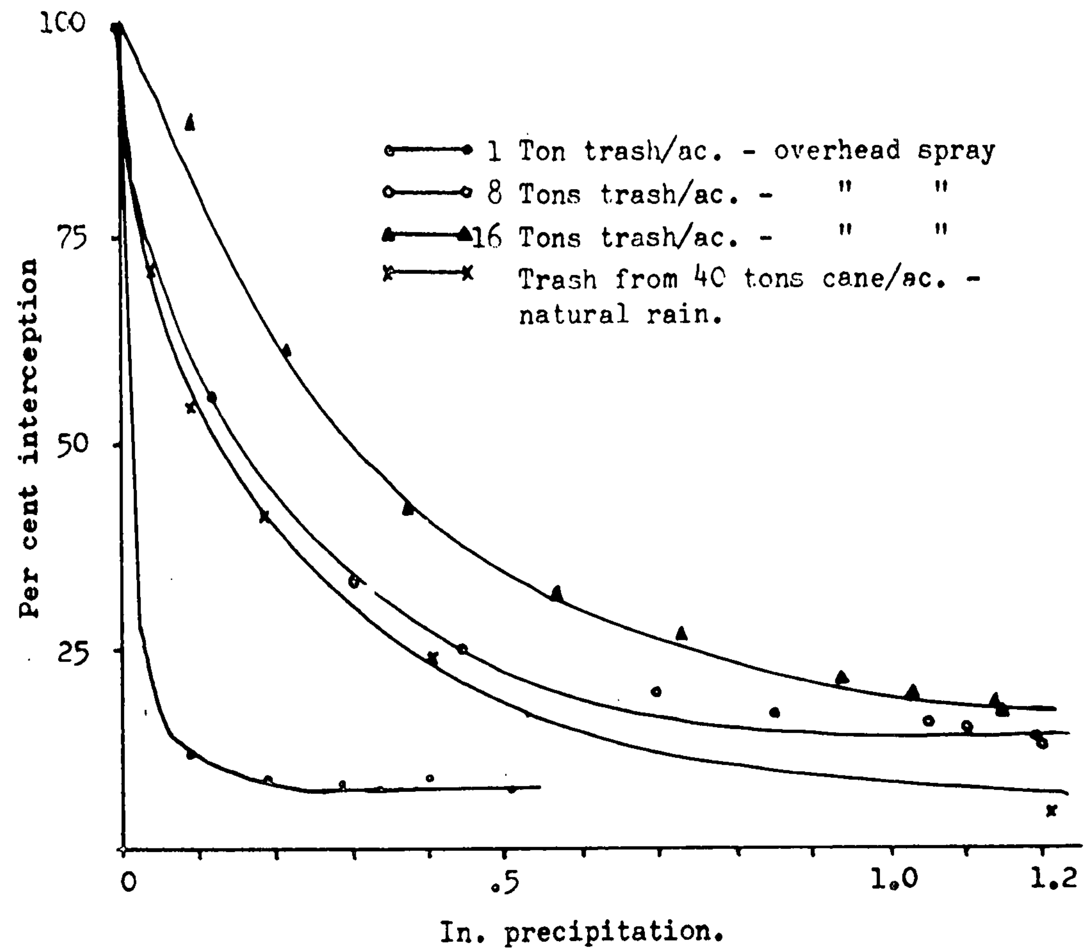

Fig. 7. Experiment VI: Rainfall and overhead spray intercepted by different amount of trash

of trash was not carried out because, firstly the nature of a trash layer changes with time, and secondly the developing canopy of sugarcane leaves channels precipitation into the cane row so that the importance of the effect of interception by trash becomes progressively less.

Discussion

The results of Experiments I and II showed that, on two soils of different textural class, an annual response of 3.5 to 4 tons of cane per acre due to trashing compared with burning could be expected. Increasing amounts of trash greater than 7 tons per acre in Experiment II tended to suppress yields progressively, and only sufficient trash to effect adequate weed control in the ratoons should give the best results. In Experiment III it was evident that the response to trash was not obtained under irrigated conditions, and that the response under dryland conditions decreased when the response to irrigation decreased. The possibility that water conservation by trash was a major factor involved in crop responses to this treatment was confirmed by the soil moisture data obtained from the gypsum resistance units with a Bouyoucos meter.

In order to estimate the effect of soil moisture on growth the gypsum unit data were used despite their acknowledged limitations for the quantitative measurement of soil moisture. A further limitation of the gypsum units was their insensitivity over the low soil moisture tension range, but this was regarded as a fortuitous advantage when comparing soil moisture and stalk elongation. At low soil moisture tensions crop growth is relatively independent of soil moisture content, whereas at average soil moisture tensions from about one to 15 atmospheres the relationship should be strong.

The average gypsum unit readings for the top two feet of soil in all fertilized plots for weekly periods from 8/1/64 to 16/7/64 were calculated. Multiple regression procedures were then carried out and the regression of growth in mm. per day (y) on maximum atmospheric temperature (x_1) and mean gypsum readings (x_2) was found to be highly significant. Similarly the regressions due to x_1, eliminating x_2, and due to x_2 eliminating x_1, were both highly significant. The multiple correlation coefficient (R) was 0.8979, and R^2 was 0.8062. Substituting mean minimum temperature for mean maximum temperature as x_1 gave slightly higher values, $R = 0.9029$ and $R^2 = 0.8153$. Most of the variations in growth were therefore explained in terms of atmospheric temperature and soil moisture content.

The use of growth measurement increments to represent yield increments was considered to be justified since cane yield and mean stalk length were very highly correlated in both the second and third ratoon crops of Experiment I at all times after the crops were five months old. The highest correlation coefficient ($r = 0.9302$) was obtained when the third ratoon was 7½ months old in march, 1964.

The established associations were thus mainly indirect. Yield was correlated with growth measurements during the development of the crop and height could therefore be used as a progressive measure of yield. Growth increments in trashed plots were shown to be significantly greater than those in burnt plots at certain stages of crop development, and growth increments were strongly correlated with available soil moisture. The inference therefore was that the increased growth of the trashed cane compared with the burnt cane was due largely to better soil moisture conditions.

The soil moisture data from Experiment I indicated that the value of a trash mulch in conserving water was greatest early in the development of the crop. The "available" soil water down to 4 feet was greater under trash than in burnt plots during the spring and early summer, but thereafter in fertilized plots particularly the amounts tended to be similar. Certainly by the time of harvest all fertilized plots were reduced to wilting point or nearly so down through 4 feet of soil and the observation that the effects of a trash mulch were neither cumulative through successive ratoons, nor carried over during a plough-out and fallow, could on these grounds be well understood. The additional moisture available to the trashed crop was always completely exploited within the fertilized crop period and no residual effect could be expected.

One of the first approaches made to the analysis of the historical yield data from Experiments I and II was to attempt to correlate yield response with total rainfall for the crop. A good negative correlation was required to establish an association of the kind which would explain yield response in terms of inadequacy of rainfall. In the event a non-significant correlation coefficient of -0.0661 was obtained, and the small value of total rainfall data was exposed. As an alternative, a theoretical monthly moisture balance was determined for each crop, based on actual rainfall and estimated crop water demand. The methods used to estimate potential evapotranspiration for periods of complete and incomplete canopy were those described by Thompson and Collings (1963). Rainfall was presumed to be entirely efficient, but any excess within a single month was not carried over to the next month. Percolation was also ignored. For each month of each crop an estimated moisture deficit was thus obtained.

The correlation of yield response with total deficit for the crop period was poor, $r = 0.2848$ and $r^2 = 8.1$ per cent. When the relative importance of the early portion of the crop period became apparent, the cumulative soil moisture deficits up to the end of February in the first year of each crop were calculated. The correlation coefficient now became very highly significant, $r = 0.6936$ and $r^2 = 48.1$ per cent, thus confirming that the yield response to trash conservation depended largely on the soil moisture available to the crop in the early stages of its development.

The results of the runoff experiments showed that, under the conditions of the experiment, the value of trash in reducing runoff was greatest when the preceding crop was harvested in December. This particular observation may reasonably be generalized for the cane belt as a whole since runoff is always likely to be limited in spring when the early rains fall on a dry profile.

The loss of moisture by evaporation from a bare soil was also greatest in the midsummer period as shown in Table II. This condition could only be aggravated due to the frequent rewetting of the soil by the summer rains.

Conclusions

Economically important responses to trash conservation can undoubtedly be obtained from sugarcane on the Natal coastal belt. The responses are mainly due to moisture conservation in the soil, and are therefore more likely to be obtained under dryland than under irrigated conditions. Areas known to be susceptible to losses through runoff should benefit most from a trash blanket.

Since it has been shown that the benefits from trash accrue during the early development of the crop, and that both runoff and evaporation losses are most severe in the midsummer period, it is suggested that the greatest yield responses to trash conservation should result where fields are cut late in the season, from November onwards. The potential response to a trash blanket compared with burning may therefore be in excess of 4 tons of cane or 0.5 tons of sucrose per acre per annum since all of the experimental crops were harvested between June and September.

If it is necessary for any reason to burn fields which are likely to respond to trash conservation, this should preferably be done only in alternate crops so that advantage can be gained from the residual effects of a trash blanket in improving water acceptance by the soil.

Summary

Long-term experiments comparing a trash blanket with burning showed that a consistent response was obtained due to trash conservation, and the mean increase in yield was approximately 4 tons of cane or 0.5 tons of sucrose per acre per annum. This response was due mainly to moisture conservation by trash through the reduction of runoff and evaporation. Trash intercepted a certain amount of rain but the losses thus incurred were more than offset by the moisture conserving effects. Moisture conditions during the early development of the crop were critical in determining the extent of the response due to trash mulching.

Acknowledgments

Thanks are due to:

(i) Mr. R. A. Wood of the Chemistry Section of the S.A.S.A. Experiment Station, Mount Edgecombe, for the construction and installation of the gypsum resistance units.

(ii) Messrs. N. Klette and R. Kruuse for the measurements carried out on the harvested stalks.

¶ This paper contains mainly material being used for post-graduate work in the Department of Crop Science, University of Natal.

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Mr. Wilson (in the chair): Mr. Thompson has examined exhaustively the factors involved in burning and trashing.

He says that once the canopy has closed there is no difference between burnt cane and trashed cane. But it was noticed in Pongola four or five years ago, even with fully grown cane, that there was a marked difference in response to frost between burnt and trashed crops.

Mr. Thompson: When there is a tall crop, insolation is intercepted fairly effectively but back radiation may not be intercepted as efficiently because it is vertical, whereas insolation can be at an acute angle. From a bare soil back radiation will take place and there is a fairly big heat sink in the soil itself, but where there is a trash layer there is a small heat sink due to the trash layer insulating itself against the soil. I would therefore expect air temperature differences at night between trashed and burnt fields to be much smaller in tall cane than in short cane, but no doubt they still exist.

Mr. Bartlett: How was weed growth controlled in the burnt plots?

Mr. Thompson: In the burnt plots weeding was done by hand and by cultivator in the inter-row and where weeds occurred in the trashed plots they were taken out by hand.

Mr. Bartlett: In connection with basin listing, what effect will better cultivation have in the burnt plots?

Growers are now being encouraged to cut cane at a younger age, but will this give an effective trash blanket?

Mr. Thompson: Basin listing is a good proposition. I think 40 tons per acre of N.Co:376 will give what is required to get a maximum response to the trash blanket and at less than 40 tons per acre it will not be possible to obtain effective control of weed growth with trash.

Mr. Hempson: There is a very efficient machine called a van Rhyn harrow which will deal with weeds in a trash blanket and it forms the basin effect between rows even with trash there.

Mr. Pearson: In Australia there has been poor response to trash, but time of cutting might have something to do with it.

Mr. Thompson: I cannot offer any reason why Australia should get no response from trashed cane compared to burnt cane.

I do not think that age at harvesting would have much effect but I think timing of harvesting is important.

There is no cumulative effect in succeeding ratoons from trash and on ploughing-out no benefit is obtained.

Mr. Hill: What effect does trash have on soil structure and is there an accumulative effect with various cycles of crops?

Mr. Thompson: The only effect we have measured is water stability of soil crumbs. The water stability of soil crumbs, particularly in the top three inches, is improved considerably by trash.

Mr. Aucock: There is a growing practice in certain areas for trash to be removed, the land to be scarified, and then the trash replaced. What is the effect of this?

Mr. Thompson: Where an organic mulch is put onto a soil which has been cultivated, run-off is reduced more than when the mulch covers a soil which is capped.

Mr. du Toit: You say, Mr. Thompson, that the experiments were cut in August/September but had they been cut in November/December an even greater response could have been expected.

Mr. Thompson: Run-off and evaporation are much greater in the peak summer period and therefore the advantages accruing in moisture conservation from the presence of trash immediately after harvesting is greater in the middle of summer. In the middle of summer the bare soil is exposed to higher evaporation losses and, in general, higher run-off losses. In spring water falls on a dry profile and is readily accepted but in summer the profile is probably not as dry.

Mr. von der Meden: In Table 9, what were the bulk densities of the trash and no trash plots? Mr. Hill mentioned in a paper last year that as a result of a multiple regression analysis he found that trash was not significantly related to run-off but rather to bulk density.

Mr. Thompson: I have no data for the soil from that particular site but on Rydalvale clay loam trash was found to have no effect on bulk density or porosity.

Mr. Gunn: Is the average trash associated with a normal crop 7 tons per acre of cane?

Mr. Thompson: Field trash is about 10 tons — on a 40 ton per acre crop of N:Co.376.

Mr. Date: Would not a temperature effect decrease the response in the early part of the season. The lowering of temperatures in August/September would affect growth more than in a November/December cut.

Mr. Thompson: In Experiment Number 3, the irrigated dry land one, work was done on soil temperatures. Temperatures were lower in the trash than the burnt plots, but growth differences were very small mainly because there is not much growth anyway at that time of the year.

Mr. de Robillard: Regarding conservation of moisture by trash. The experiments were carried out with N:Co.376 but will the conclusion apply to other varieties?

Mr. Thompson: Other varieties have also been used, e.g. Co.281, Co.301, N:Co.376, N:Co.339, and the conclusions do apply.

Mr. Bartlett: Can Mr. Thompson tell us in what areas it is advisable to either burn or trash?

Mr. Thompson: In the Midlands for most of the year it would be advisable to burn. N:Co.293 cut in winter may give no ratoon at all.

At the coast it is advisable to maintain a trash blanket, provided the economics of weed control in the ratoon justify the extra expense of trashing at harvest.

If conditions are such that evaporation and run-off are not an important factor then burning can be carried out with impunity.

Yield response must also be considered while harvesting is still done by hand. When mechanisation of harvesting comes, burning will probably be the general rule.

Mr. Wilson: Basically, the argument about trashing and burning comes back to economics, which of course must always be one of the first considerations in any agricultural enterprise.