PLASTIC MULCHING OF SUGARCANE

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ABSTRACT

The results of three experiments to ascertain the feasibility of improving germination in plant cane by mulching with polyethylene film are reported. Various films were screened to test their ability to increase soil temperature and to allow penetration of germinating cane shoots. Clear film 20 μ thick was found to be the best. The method of application and the effect of plastic on soil temperatures, soil moisture, crop characteristics and yield are described. Mulching over the cane row accelerated germination, increased stalk population, rate of stalk elongation and yield by 25 ± 3,9 tons cane/ha and 2,8 ± 0,68 ters/ha.

Introduction

In the majority of South Africa's non-irrigated cane-growing areas planting operations cease during the cool, dry late autumn and winter months of May, June and July. To fully utilize the summer growth months it is considered desirable to plant as early in spring as conditions will allow. However, spring rainfall is frequently inadequate. Spring and summer planting coincide with an intensification of other operations, particularly weeding, and during this period labour is frequently in short supply. Consequently, there is an increasing tendency to plant later in the season, viz. March and April, when labour is more readily available. When planting is delayed until late autumn, germination is likely to be adversely affected by low soil temperatures and dry conditions. Verret[4] in Hawaii has shown that air temperatures below 20°C are too low for cane germination and suggests that 35–38°C is the optimum temperature range. Ruker *et al.*[3] have shown that cane roots and shoots cease growing when soil temperatures reach 11°C and that below 21°C minimal growth occurs. In a growth study of four cane varieties affected by two air and two root temperatures Mongelard *et al.*[2] reported that "both the low air and the low root temperatures affected growth in leaf area but the effects were more pronounced at cool root temperatures".

One method of improving germination when cane is planted in cool unfavourable climatic conditions is to apply large amounts of filtercake in the furrow. Because filtercake is bulky, cartage and handling costs often preclude its use in certain areas.

Fu *et al.*[1] in Taiwan have shown that soil temperatures can be increased, and cane germination improved by using polyethylene plastic as a mulch in the cane row.

A series of experiments was initiated in the S.A. Sugar Association Experiment Station, Mount Edgecombe, to assess the effects of plastic mulching on germination and subsequent cane growth.

Materials and methods

The screening of several different polyethylene (p.e.) films to assess their potential for increasing soil temperature was conducted in Experiment I. Experiment II was a small glasshouse experiment to assess the ability of 4 different cane varieties to penetrate two p.e. films of different thickness. Experiment III was a fully replicated field experiment in which the effects of clear p.e. film on sugarcane and soil were measured.

Experiment I

Copper constantan thermocouples were inserted 4 cm deep in a Rydalvale clay soil and connected to a Yew Multipoint constant reading millivolt recorder. Each p.e. film treatment was mulched over one thermocouple and one unmulched control plot was included. The various materials tested were thin black p.e.; thick black p.e.; thin black p.e. with painted silver surface downwards; thick black p.e. with painted silver surface upwards; thick black p.e. with painted silver surface downwards; medium clear p.e.; medium clear p.e. with painted silver surface upwards. Thin, medium and thick p.e. films were 30, 50 and 80 μ thick respectively. Temperature readings were taken hourly during the daytime and occasionally during the evening and night-time, for a period of 6 days (5–10 September 1971).

Experiment II

Ten single-eyed setts of varieties NCo 376, NCo 293, N 55/805 and N 53/216 were planted in 40 x 30 x 15 cm trays filled with soil and mulched with 35 μ p.e. film. Two replicates of each variety were used. An identical trial was conducted using 20 μ p.e. film. Germination and penetration counts were done.

Experiment III

A field experiment of 18 plots, each plot being 5 rows wide and 12 m long (90 m^2 gross — 45 m^2 net) was established on a Phoenix heavy clay at Mount Edgecombe Experiment Station on 11 and 12 April 1972. Three treatments (p.e. film on the cane row, p.e. film on the interrow and a control without p.e. film) were incorporated into a double latin square design with 6 replications. Cane variety NCo 376 from heat-treated stock was cut into 4-eyed setts and dipped in a mercuric fungicide prior to planting. Very shallow planting furrows (± 8 cm) were drawn. Single superphosphate containing 8,3 kg/ha of P was applied in the furrow and the setts were planted so that they overlapped. The seed was mechanically covered to a depth of about 5 cm and then compacted with a roller, leaving a slightly raised and cambered ridge before spraying with 1,8 kg a.i. Alachlor and 2 kg a.e. 2,4–D per ha over the row. Clear plastic film, 90 cm wide and 50 μ thick was applied mechanically (see Fig. 1) to both row and interrow treatments following planting and spraying. The 50 μ film was used only because it was more readily available than the 20 μ material.

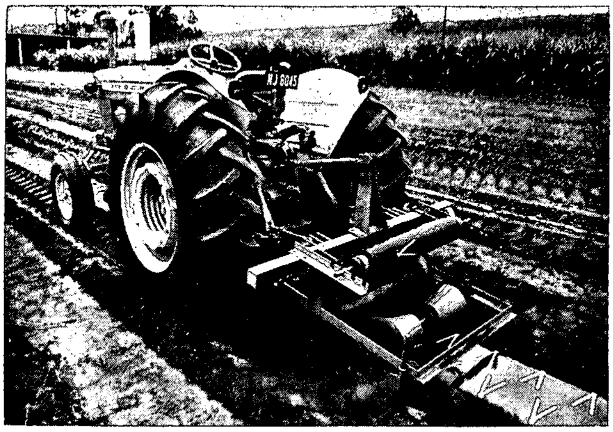

FIGURE 1 A plastic mulching tool designed by the Agricultural Engineering Department of the S.A. Sugar Association Experiment Station.

Stalk populations were counted every week following germination. From 1 July 1973 until harvest, 20 random stalks per plot were measured from ground level to the top visible dewlap.

Soil thermometers were placed at 5 and 20 cm depths in three replications. The thermometers in the control plots were 15 cm from the centre of the cane row. The thermometers in the mulched plots were also placed 15 cm from the centre of the cane row but under the p.e. film. The thermometers in the interrow-mulched plots were under the p.e. film in the centre of the cane interrow.

Temperatures were recorded at 08h00, 10h00, 12h00, 14h00 and 16h00 for 6 weeks. Subsequently, readings were taken only at 08h00 and 14h00 three times a week.

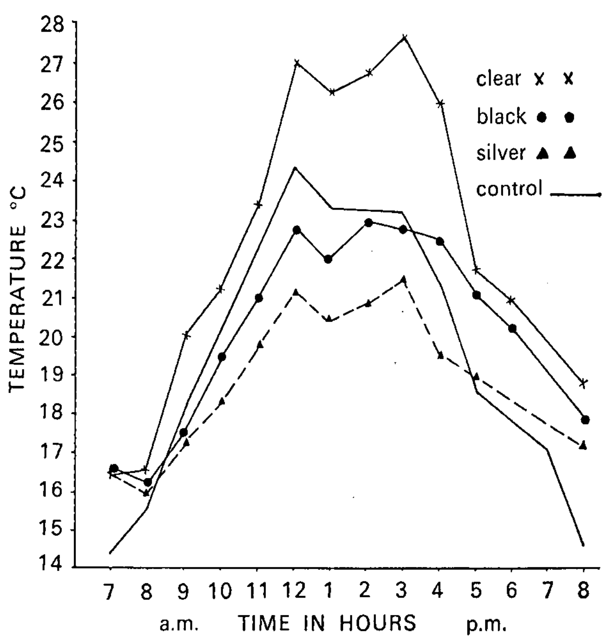

FIGURE 2 Diurnal soil temperature variations at 4 cm depth under three plastic treatments and in a control.

Cylindrical gypsum blocks were placed in all plots at 10 and 20 cm depths and 20 cm from the centre of the cane row. Weekly readings were taken with a Boyoucos meter.

The experiment was weeded as necessary.

The experiment was harvested at 14 months of age on 11 June 1973. Cane from the net plots was weighed and twelve random stalks from each plot were milled for the determination of estimated recoverable sugar content (ERS % C.). Diameters were measured at the top, centre and bottom of 30 random stalks.

Results

Experiment I

The soil temperature results are presented graphically in Fig. 2.

For clarity of presentation several treatments have been omitted from the graph. Although thick black p.e. film tended to give slightly larger temperature increases than did the thin black p.e. film, they followed a similar pattern and only the average results are given. The two reflective silver film treatments were almost exactly the same in their effects and the average results of these two treatments have also been given. Having a silver surface facing downwards provided a small "thermos flask" effect in that night-time temperatures were slightly raised. It can be seen from Fig. 1 that black plastic is effective in raising late afternoon and night-time temperatures, but reductions in midday soil temperatures are apparent. Clear p.e. film was markedly superior to all other materials in raising both day and night-time soil temperatures. It was also noticed that mulching with clear p.e. film caused a flush of weeds, particularly *Cyperus* spp., to germinate.

Experiment II

When mulched with 35 μ p.e. film, about 50% of the shoots of varieties NCo 376 and NCo 293, and 20% of the shoots of varieties N 55/805 and N 53/216 broke through the film.

When the film thickness was reduced to 20 μ, 100% of the shoots of variety NCo 376 and NCo 293 and 80% of N 55/805 and N 53/216 penetrated.

Experiment III

The effects of mulching the interrow were barely measurable and the results have been omitted.

Soil temperature

Soil temperature results are presented in Fig. 3.

Soil temperature increases were greatest in the first three months after applying the film and then declined rapidly. This decrease is partly due to the plastic degrading, but in addition, from September onwards, better cane growth in the plots having p.e. film on the cane caused additional shading of the soil. It is apparent that p.e. film can cause large soil temperature increases at shallow depths. Daily increases of 9°C for 4 hours were measured. When in-coming radiation was high, treatment effects tended to be greatest. In contrast to the measurements at 5 cm depths, the temperatures at 20 cm showed small fluctuations between 8 a.m. and 2 p.m.

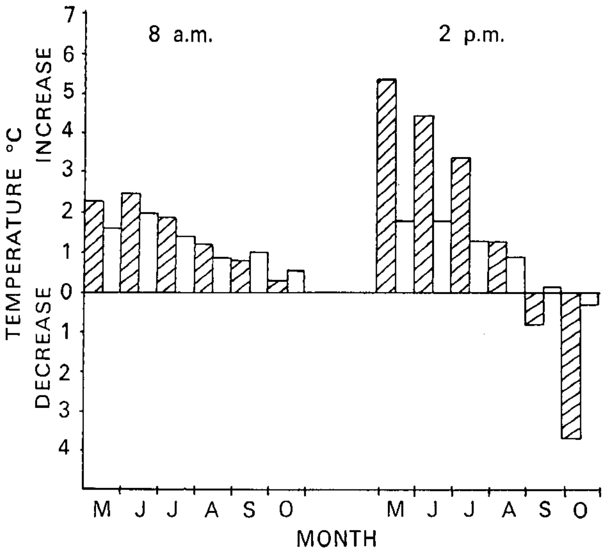

FIGURE 3 Variations in mean monthly soil temperatures at 5 cm and 20 cm depths, recorded at 8 a.m. and 2 p.m., due to plastic mulch on the cane row.

Soil moisture

Seventy-nine mm of rain were recorded four days after planting and the gypsum block readings remained at 100% for 4 months at the 20 cm depth in all treatments. During the spring and summer the cane in the plots having p.e. film on the row grew more rapidly and extracted more moisture than did the cane in the control plots.

Stalk population

Clear p.e. film over the row advanced germination by 3 weeks. The effect on stalk populations is shown in Fig. 4. The effect of mulching the interrow was barely measureble and the results have therefore been omitted.

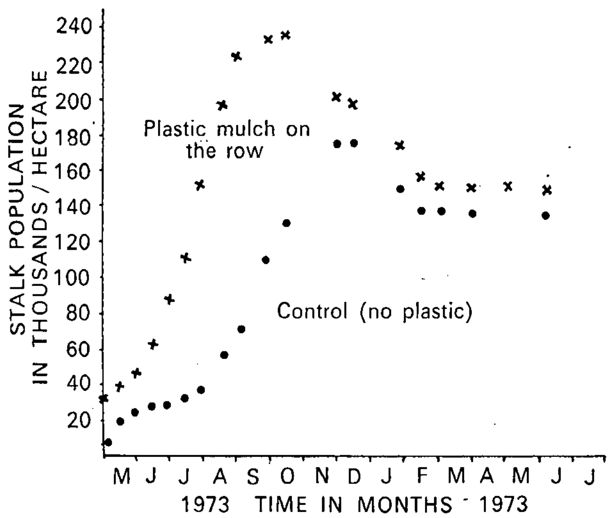

FIGURE 4 The development of stalk populations in plots treated with a plastic mulch and in control plots.

From Fig. 4 it can be seen that p.e. film on the row encouraged rapid tillering during the winter months of May, June and July, while in the control treatment profuse tillering only started in August. Full leaf canopy was advanced by seven weeks in the plots treated with plastic film on the row, obviating two hand weedings that were necessary in the control treatment. Stalk mortality was rapid from December until early January and the average final stalk population at harvest in the plots having plastic film on the row was only 6% higher than the average for the control plots. Early growth in treated and untreated plots is shown in Fig. 5.

FIGURE 5 The difference in growth between a mulched and unmulched plot after 5 months of winter growth.

Root development

When the crop was 6,5 months old, a pit was dug to study effects of the treatment on root development. The roots were washed with water from a mist sprayer, painted and photographed. Fig. 6 shows the difference in root development between a plastic treated row and an untreated control row.

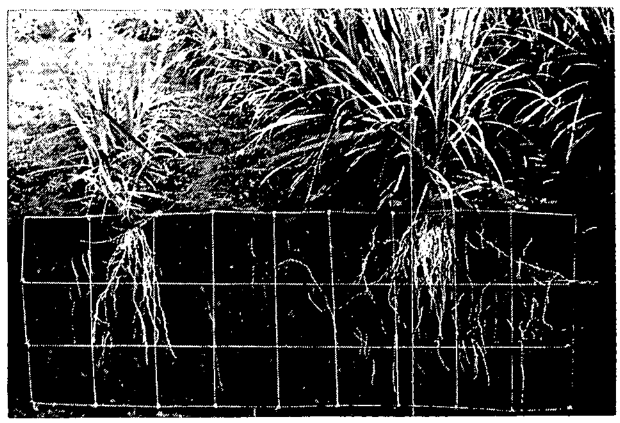

FIGURE 6 The effect of plastic mulch on root development at 7,5 months of age.

Stalk elongation

Stalk elongation results are presented in Fig. 7, Fig. 8 shows representative samples of stalks from control and treated plots.

After 6 months, the rate of stalk elongation in the plots with plastic film on the row was markedly faster than that of stalk in the control plots. This rapid

TABLE 1

The effect of plastic mulch on the yield, quality and harvested crop characteristics of sugarcane

	tc/ha	ERS % cane	ters/ha	kg/stalk	Pop^n x 10^3	Stalk height cm	Stalk diam. mm
Control	133	9,9	13,1	0,97	139	183	26
Plastic on row	158	10,1	15,9	1,08	147	197	25,5
Plastic on interrow	129	10,2	13,1	0,99	131	183	24,9
Mean	140	10,0	14,1	1,01	139	188	25,5
S.E. of single plot	± 6,8	± 0,49	± 1,18	± 0,05	± 5,4	± 5,9	± 0,91
C.V. %	4,8	4,9	8,4	5,2	3,9	3,1	3,6
S.E. of difference between treatment means	3,9	0,28	0,68	0,03	3,1	3,4	0,52
L.S.D. (0,05)	9,6	0,69	1,7	0,07	7,7	8,3	1,28
(0,01)	14,6	1,05	2,5	0,11	11,6	12,6	1,94

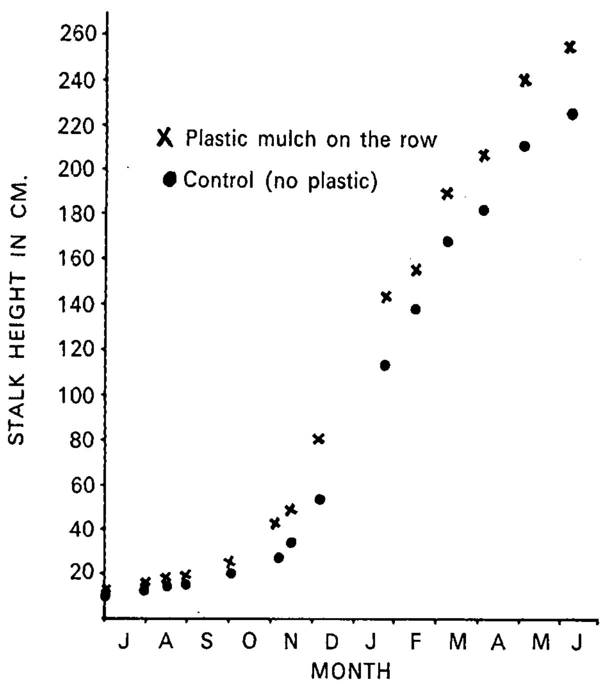

FIGURE 7 Cane stalk elongation in plastic mulch plots and in control plots.

growth rate was probably due to a better-developed root system because temperature effects were not apparent from November onwards.

Harvest results

Crop yield and harvested stalk characteristics are presented in Table 1.

Significant (P = 0,01) yield increases of 25 ± 3,9 tons cane/hectare and 2,8 ± 0,68 tons estimated recoverable sugar/hectare were obtained by mulching with p.e. film over the cane row. Stalk population at harvest was significantly (P = 0,05) higher and stalk length was significantly (P = 0,01) greater in mulched plots than they were in control plots. Individual stalk weights were significantly (P = 0,01) heavier where p.e. film was mulched on the row. P.e. film on the interrow did not cause the stalk characteristics to differ from those of control plot cane.

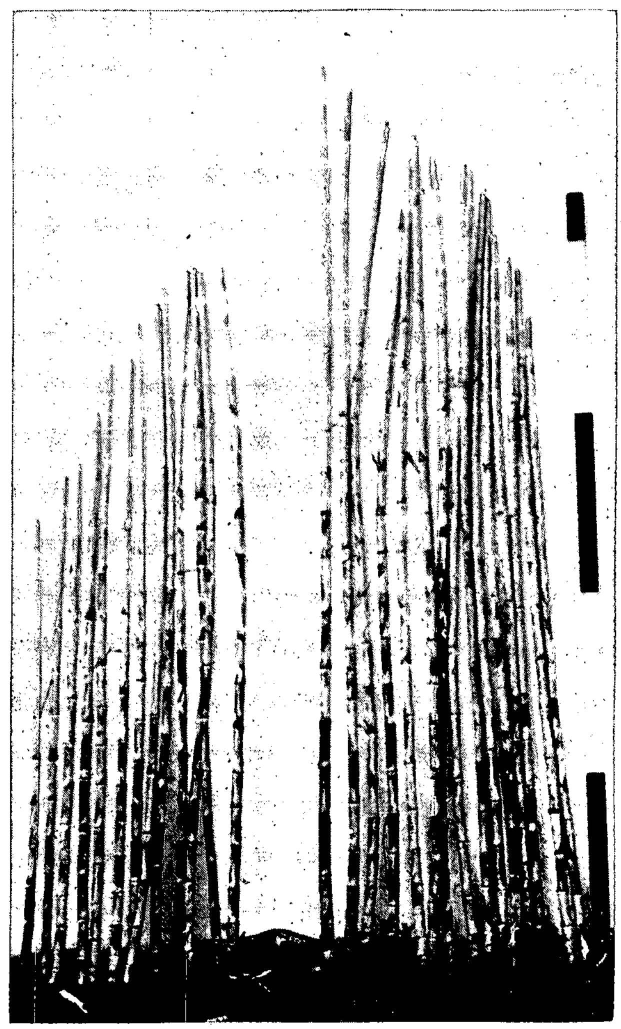

FIGURE 8 Stalks from control plots (*left*) and from plots treated with plastic mulch on the row (*right*).

Discussion

It is considered that the growth and yield responses obtained by mulching clear p.e. film over the cane row were mainly due to increased soil temperature in the initial stages of crop development. Cane in the plots with a mulch on the row quickly developed a vigorous root system and even when the temperature effect was negated by leaf canopy, the cane continued to grow faster than did the cane in the control plots. Wet conditions followed planting and the gypsum block results showed us differences between control and mulched plots. However, condensation of moisture on the underside of the p.e. film kept the soil moist, creating the warm humid conditions ideal for good germination. It is essential to plant at a shallow depth beneath the mulch to make optimum use of these humid conditions. Shallow planting also facilitates penetration of the germinating cane shoots through the plastic.

A plastic mulch would probably prove detrimental to germination if applied during the summer months because soil temperatures would then become too high during the mid-day period. The Natal midlands are probably the areas best suited to this treatment because of the long cold winters, high incoming winter radiation and easily-worked soils. Provided that the soil moisture status remains satisfactory, planting could continue throughout the late autumn and winter in areas where filter cake is not available or too expensive.

If plastic mulch were to be applied on a commer cia scale care would have to be taken with land preparation, and land planing would be necessary in some instances. Using a tractor with two assistants 1,5–2 ha/day can be mulched. At an estimated cost of $\pm$ R80,00/ha for plastic and $\pm$ R20,00/ha application cost, this treatment is comparable with the cost of using filtercake in many parts of the industry.

Further experimentation is currently under way to ascertain the effect of p.e. mulching in various soil types and ecological regions of the sugar industry, and to assess the feasibility of reducing the width of the mulch, thereby reducing costs.

Conclusions

Clear p.e. film causes substantial day-time and moderate night-time soil temperature increases, and is more effective than other plastic materials in raising soil temperatures.

For mulching sugarcane, a film 20 μ thick is probably best. If the mulch is thicker, cane shoots do not penetrate readily, and thinner film is difficult to extrude and tends to tear during application in the field.

Clear film mulched on the cane row induced excellent germination at a time of year when soil temperature would generally be the limiting factor for planting. Cane in this treatment developed a more extensive root system, produced more stalks/ha, grew taller and significantly outyielded the control treatment. It is considered that p.e. film could be used effectively to improve germination where circumstances prevent the use of filtercake.

Acknowledgements

Thanks are due to the Agricultural Engineering department, who developed the machinery for applying the plastic mulch.

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