FURTHER STUDIES ON THE USE OF A POLYETHYLENE MULCH IN THE GROWING OF SUGARCANE

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Abstract

Results are reported of six plant and three ratoon crop experiments in which the practice of applying a clear polyethylene film (PE film) to sugarcane was evaluated. A yield response to PE film was obtained in three out of the six plant crop experiments but there was no response to a PE film applied to ratoon cane. In five plant cane and in one ratoon cane experiment, substantial improvements in germination, and increases in cane stalk populations and the rates of stalk elongation were recorded. These effects declined with age. The residual effect of a PE film applied to plant cane was measured in the first ratoon crop in one experiment and found to be negligible. Various widths of PE film (90 cm, 60 cm, 45 cm and 38 cm) were compared and the widest was found to be marginally superior. The reasons for the variable responses to treatments are discussed with particular reference to the effects of season and soil type. It is considered that the use of a PE film could be warranted only for autumn planting.

Introduction

Late autumn planting of sugarcane in the greater part of the South African sugar industry is often associated with poor germination, slow tillering and subsequent uneven growth of cane. This may be ascribed to low soil temperatures and inadequate soil moisture. Where irrigation is practised, germination of an autumn planting is improved but is still poor compared with that of a summer planting.

The application of filtercake in the planting furrow is commonly practised with out-of-season planting. Because of its water-holding capacity it helps prevent the desiccation of the cane setts, and in large quantities may have a favourable temperature effect. The handling and haulage costs of filtercake are high and its use slows down the planting operation. Planting in autumn is, unfortunately, becoming increasingly necessary since the planting programme can seldom be completed in summer because of the growing labour shortage.

Millard[1] has shown that the application of a Polyethylene (PE) film over the cane row resulted in improved germination and crop growth when cane was planted in March on a heavy soil of the Phoenix series. He recorded a yield response to the PE mulch applied over the row of 25 ± 3,9 tons cane per hectare. The PE mulch prevented moisture loss and increased soil temperatures. Fu, *et al*[2] in Taiwan, reported that a PE mulch applied to a ratoon crop of sugarcane improved germination and final yield.

A series of experiments was recently conducted over a range of ecological zones within the South African sugar industry in an attempt to assess the value of a PE mulch in both plant and ratoon cane.

Methods and materials

Experimental design and plot size

Three to six treatment replications were used in a Latin square design in all experiments, with the exception of the one at Pongola, where a randomised block design was used with six replications. In general, the plots comprised five rows of sugarcane 12 m long and spaced 1,4 m apart, from which a net plot of three rows 10 m long was harvested. In addition, five field observation trials were conducted on co-operative farms where several rows within a field were treated with PE film.

Locality of the experiments

The six formal plant cane experiments were conducted at:

Site 1: Seven Oaks on a Balgowan series soil at an altitude of ± 1 000 m

Site 2: Mount Edgecombe on a Phoenix series soil at an altitude of ± 100 m

Site 3: Umhlanga on a Fernwood series soil at an altitude of ± 100 m

Site 4: Paddock on a Cartref series soil at an altitude of ± 200 m

Site 6: Seven Oaks on a Griffin series soil at an altitude of ± 1 000 m

Site 8: Pongola on a Makatini series soil at an altitude of ± 220 m

The three formal ratoon cane experiments were conducted at:

Site 2: Mount Edgecombe on a Phoenix series soil at an altitude of ± 100 m

Site 5: Mount Edgecombe on a Rydalvale series soil at an altitude of ± 100 m

Site 7: Seven Oaks on a Griffin series soil at an altitude of ± 1 000 m

The five observation experiments were conducted on the properties of the following co-operators:

(1) The Tongaat Group on a Longlands series soil

(2) Mr B. Hill of Gingindhlovu on an Avoca series soil

(3) Mr A. Robert of Gingindhlovu on an Avoca series soil

(4) Mr S. Engblom of Gingindhlovu on a Waldene series soil

(5) Mr G. Maitre of Emoyeni on a Waldene series soil

Method of treatment application

The PE film was applied by means of the mulching tool designed by the Engineering department of the S.A.S.A. Experiment Station and described by Millard.[1] For satisfactory application a fine soil tilth was found to be necessary, and the cane was planted on a slight ridge to prevent water ponding on the PE film. The application of the PE film to the ratoon crop was preceded by the removal of any stubble residue from the previous crop.

Generally, a pre-emergence herbicide was applied over the cane row prior to the application of the PE film.

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The polyethylene film

In accordance with the findings of Millard[1] only clear, 20 μ thick PE film was used. The widths of PE film used in the experiments were 90 cm, 60 cm, 45 cm and 38 cm.

Instrumentation and measurements

Soil thermometers were placed at 5 cm, 10 cm and 20 cm depths in three replications of three experiments and the soil temperature was recorded daily at 8h00 and 14h00.

Gypsum resistance units were installed at 10 cm and 20 cm depths, and at a distance of 20 cm from the centre of the cane row in all plots of five experiments. Soil moisture readings were made with a Bouycous block meter at weekly intervals.

Shoot populations and stalk heights were measured in all experiments at approximately six-weekly intervals.

Irrigation

All the experiments were rainfed, except for the one at Pongola, which was irrigated with 60 mm net on a minimum cycle time of 25 days.

Treatment comparisons

Width of PE film

The PE film used was 90 cm wide throughout, except at sites 3, 4, 6 and 8, where widths of 38, 45 and 60 cm were also used in comparison with the untreated controls.

PE Film and Filtercake versus Control

At sites 3 and 6, filtercake at 50 t/ha applied in the furrow at planting, was compared with a 90 cm wide PE film applied over the cane row, and the untreated controls.

Residual effects of PE film

The residual effects of a PE film applied to the plant crop was measured in the first ratoon at site 2.

Results

The response to a PE film over the row on plant cane

Germination and initial crop growth: In five out of the six experiments germination, tillering and subsequent crop growth was improved by applying a PE film over the cane row. The effect of treatment on stalk population in the experiment at site 6 is given as an example and is illustrated in Figure 1.

It is evident from Figure 1, that the PE mulch had its greatest effect in the early stages of crop development, peaking in mid-summer and declining rapidly with the onset of normal stalk mortality, so that at harvest only a small treatment effect on stalk population was recorded. In the experiment at site 4 this early increase in stalk population had disappeared at the time of harvest and no yield response to PE film resulted. At site 3, where a PE film was applied over the cane row on a Fernwood sand, no improvement in germination, tillering or crop growth was recorded. It is probable that soil texture is an influencing factor. The large pore space and consequent low moisture-holding characteristics of the Fernwood sands are such that the transmission and storage of radiant energy is poor in comparison with heavy soils.

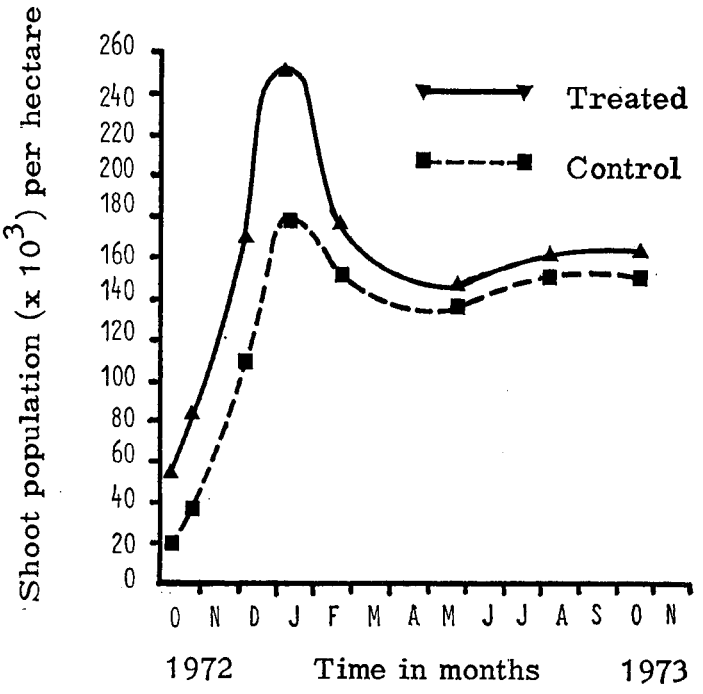


FIGURE 1 The development of stalk populations in plots treated with PE film and in the untreated plots in the experiment at Seven Oaks on plant cane.

In the observation experiments, where a 90 cm wide PE film was applied over the cane row in five commercial fields planted in autumn, improved germination, tillering and stalk elongation resulted. No harvest results are available for these experiments, since their purpose was to visually observe the effect of a PE film on germination and to assess the problems and the feasibility of using PE film on a field scale.

The yield response to treatment: The yield responses in tons cane per hectare to treatment with PE film are given, together with the locality, soil types and season, in Table 1.

The largest yield response to treatment was obtained when the PE film was applied over the cane row in autumn or in early winter. During the period when soil temperatures declined, i.e. autumn and early winter, the increase in soil temperature caused by the PE film caused cane growth to be maintained for a longer period of time than would be possible under normal circumstances. Where cane growth was not severely limited by low soil temperature, the effect of the PE film on cane growth was minimal. Yield responses to PE film

TABLE 1

The yield response in tc/ha to a 90 cm wide clear PE film applied over the cane row at planting

Site	Locality	Yield in tc/ha/100 mm rainfall		Response tc/ha	Season PE film applied	Soil series	Age of crop (months)
		Treated	Control				
2	Mount Edgecombe .	16	14	25*	Autumn . .	Phoenix . .	14,0
6	Seven Oaks . . .	8	7	12†	Winter . .	Griffin . .	21,8
8	Pongola	11	10	11†	Autumn . .	Makatini . .	13,1
1	Seven Oaks . . .	6	6	− 3	Spring . .	Balgowan . .	21,3
4	Paddock	11	12	− 7	Winter . .	Cartref . .	18,0
3	Umhlanga . . .	4	5	− 12	Winter . .	Fernwood .	17,5

* Statistical significance (P > 0,01) † Statistical significance (P > 0,05)

were not obtained in those experiments conducted on the light-textured soils, i.e. Cartref, and Fernwood series soils at Paddock and Umhlanga respectively. Since the response to PE film declines with time, the age at harvest influences the degree of response to treatment. The largest yield responses to treatment were obtained in the experiments at sites 2, 6 and 8, where the crops were harvested when relatively young for the respective areas.

The likelihood of obtaining a response to PE film will be greater in the higher altitude areas, where low soil temperatures are likely to limit growth for a longer period of time than is the case on the coastal lowlands.

The response to a PE film applied over the row on ratoon cane

Germination and initial growth: An initial response to the application of a PE film over the cane row on ratoon cane was recorded in only the one experiment at Seven Oaks (site 7). This initial response in terms of stalk populations, as illustrated in Figure 2, declined rapidly as the crop developed.

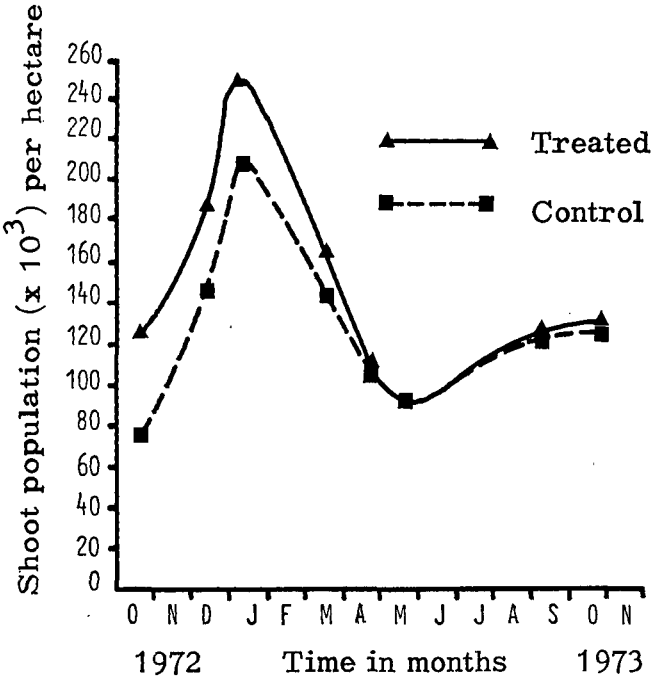


FIGURE 2 The development of stalk populations in plots treated with a PE film and in the untreated plots in the experiment at Seven Oaks on ratoon cane.

The rapid decline in treatment effect in respect of stalk populations after five months may be ascribed to the faster formation of leaf canopy in the ratoon crop than generally occurs in the plant crop. No treatment effects on the rate of tillering or re-growth were recorded in the remaining two experiments on ratoon cane.

The yield response to treatment: In Table 2 the response to treatment in tons cane per hectare is given together with locality, soil type and season.

In no instance was there apparently a real yield response to treatment in ratoon cane. The indication of a negative treatment effect at site 5 is likely to be associated with the effect of weed competition. The enhanced weed growth under PE film is a real problem to contend with.

The response to PE film of various widths

At sites 4, 6 and 8 treatment with the 90 cm wide PE film resulted in slightly quicker germination, better tillering and faster initial cane growth than did treatment with the narrower PE films. These differences were comparatively small and disappeared as the crop developed. The effect of the various widths of PE film on cane yields were similar although, in some instances, the 90 cm wide PE film tended to be marginally more effective. The wide PE film was also considerably easier to apply than was the narrower film.

Soil temperatures taken at 5 cm, 10 cm and 20 cm depths under the wide and narrow PE films showed the wider material to be more effective in this respect.

A comparison of the effects of filtercake and PE film

The yield response to PE film applied over the row at planting at Seven Oaks (site 6) was 12,0 $\pm$ 5,2 tc/ha ($P>0,05$), compared with a response of 7,0 $\pm$ 5,2 tc/ha to the filtercake treatment. Both treatments substantially improved germination, tillering and the rate of stalk elongation in the earlier stages of crop development. The effect on growth of the PE film treatment was maintained for a longer period of time than in the case of the filtercake treatment. In accordance with earlier observations (Alexander[3]), the filtercake treatment depressed sucrose percent cane, thus reducing the slight advantage gained in terms of tc/ha.

In a second experiment involving the same treatment comparisons at site 3 on a Fernwood series soil no yield response to either treatment was recorded. The filtercake treatment resulted in quicker germination and initial growth, but these effects were of short duration.

Soil temperatures measured in the row at a depth of 10 cm in both experiments revealed an increase in soil temperature at site 6 only. Filtercake applied in the furrow at 50 t/ha was apparently insufficient to have any effect on soil temperature.

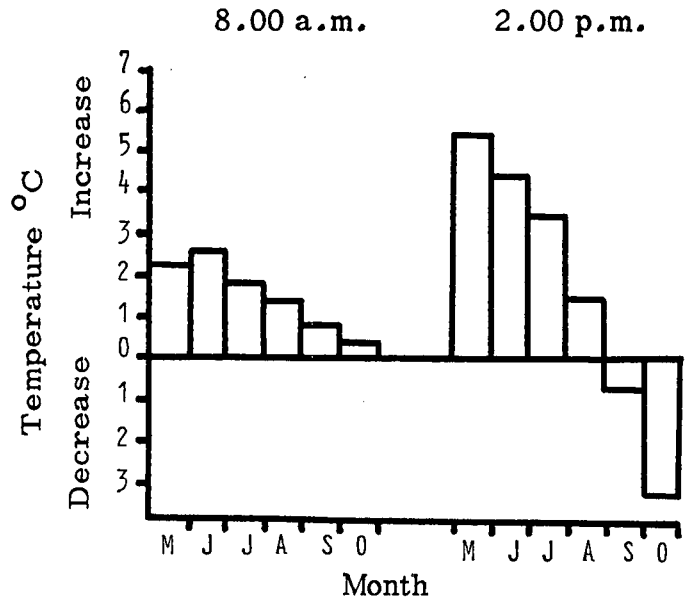
Residual effects of the PE film treatment

The effect of a PE film applied to the plant crop at site 2 was so substantial (25 $\pm$ 3,9 tons cane/ha) that it was decided to measure any residual effect in the first ratoon crop.

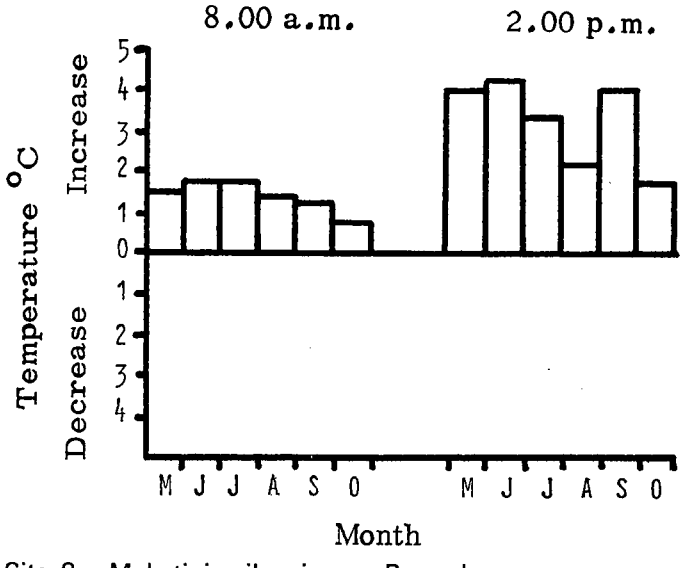
TABLE 2

The yield response in tc/ha to a 90 cm wide PE film applied over the cane row in the first ratoon crop

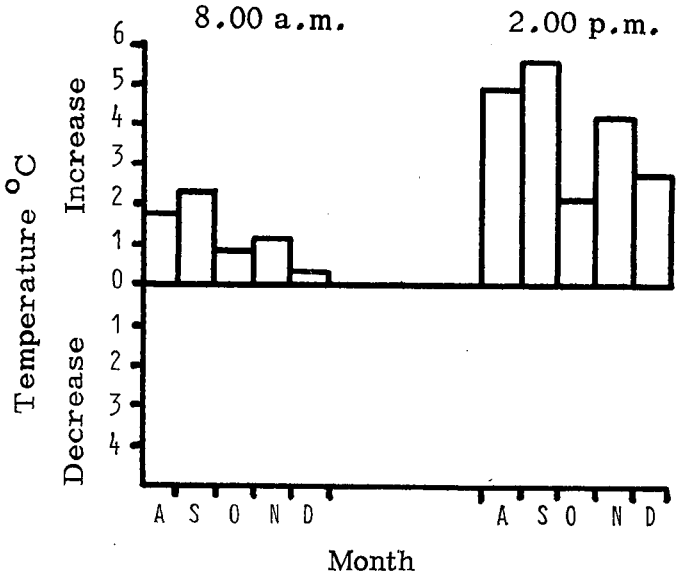
Site	Locality	Yield in tc/ha/100 mm rainfall		Response tc/ha	Season PE film applied	Soil series	Age of crop (months)
		Treated	Control				
2	Mount Edgecombe .	11	10	10	Winter . .	Phoenix . .	14
7	Seven Oaks . . .	5	5	2	Winter . .	Griffin . .	24
5	Mount Edgecombe .	6	6	— 9	Winter . .	Rydalvale .	17



Site 2: Phoenix soil series — Mount Edgecombe



Site 8: Makatini soil series — Pongola



Site 6: Balgowan soil series — Seven Oaks

FIGURE 3 The soil temperature (°C) increase or decrease measured at 5 cm depth at sites 2 and 8 and at 10 cm depth at site 6 due to PE film applied to the different soil series.

The rate of ratoon crop growth indicated initially a carry-over treatment effect, but this did not persist and no significant effect on ultimate yield was measured at harvest.

The effects of a PE film on soil temperature

The effects of PE film on the mean monthly soil temperature at 8h00 and 14h00, expressed as an increase or decrease compared with the untreated control, are presented graphically in Figure 3 for the three soil series, namely Phoenix, Griffin and Makatini, at Mount Edgecombe, Seven Oaks and Pongola respectively. The soil temperatures at Mount Edgecombe and Pongola were recorded at 5 cm depth and at Seven Oaks they were recorded at 10 cm depth.

Because the experiments were not all conducted concurrently and therefore the stage of crop canopy was not necessarily the same at any one time of the year, the effects of treatments on soil temperature are not strictly comparable. It is of interest, nevertheless, that the greatest increases in soil temperature at Seven Oaks and at Mount Edgecombe were very similar, i.e. approximately 2,5° C at 08h00 and 5,5° C at 14h00. At Pongola, in the hotter semi-arid region, the increase in soil temperature was, understandably, not quite so marked, i.e. 2,0° C at 08h00 and 4° C at 14h00. The depressing effect of PE film on soil temperature at Mount Edgecombe in September and October was as a result of the more rapid development of leaf canopy in the treated plots resulting in a shading effect.

The effects of a PE film on soil moisture content

The results obtained from the gypsum resistance units installed at sites 1, 2, 6 and 8 revealed that, where cane growth was improved by a PE film over the row, soil moisture extraction by the crop tended to be proportionally greater. These differences were small, however, and there was no change in the pattern of soil moisture extraction, as might have been expected if the PE film had caused a shallow rooting system to develop.

Discussions and conclusions

The results of this series of experiments indicate that PE film could have a use in the sugar industry if and when the price of Polyethylene becomes more competitive. Its use would be primarily to ensure good cane germination and subsequent uniform growth when planting is carried out during unfavourable conditions, i.e. a cold and wet period. The responses obtained to the use of PE film are considered to be due primarily to the substantial increases in soil temperature, and to a lesser extent to its creating a more humid atmosphere in the region of the setts. The largest responses tended to be obtained when PE film was used on autumn or early winter planted cane compared with late winter or early spring plantings. The action of the PE film in retaining radiant energy in the soil is only possible during the period before full leaf canopy. Full canopy was slowest in forming in an autumn planted crop because of the relatively slow growth occurring in winter and early spring, and it is for this reason that the effect of PE film tended to be greatest when used on autumn/winter planted crops. The potential for using PE film to accelerate re-growth of ratoon crops cut in winter appears, from the results obtained, to be limited. Seemingly, the ratoon crop is inhibited less by low temperature than is the plant crop. The practical problems of eliminating all stubble, and the need for long-term weed control in the cane row, would also require consideration when using PE film on ratoon cane.

A PE mulch was more effective on the heavy soils. These heavier soils generally required more field operations to obtain

the desired fine soil tilth onto which to lay the PE film, and to enable adequate covering of the edges of the film. It was shown under field conditions, however, that the desired soil tilth could be obtained.

When a PE film is used, it is very necessary to use long-term pre-emergence herbicides to eliminate the weed problem which otherwise would tend to be accentuated by the use of a PE film.

The optimum grade of PE film is approximately 20 μ, which allows the young cane shoots to penetrate, but tends to inhibit the penetration of most weeds with the exception of the *Cyperus* spp. The rate at which the PE film degrades is a function of the quantity of ultraviolet light inhibitor impregnated into the Polyethylene, consequently a pollution problem should not materialise. For ease of application and cost economy, a liquid mulch applied as a spray would be ideal. To date, however, no test products have shown promise.

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