THE EFFECTS OF TIMING OF WEEDING OPERATIONS ON THE YIELD OF SUGARCANE AND THEIR ECONOMIC SIGNIFICANCE

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Summary and Conclusions

From the figures presented in this paper and taking into account previous papers presented to the S.A. Sugar Technologists' Association's Congress it is clear that:

(*a*) Effective weeding and cultivation can give increments of the order of 20-30 tons cane per acre over the yields of an unweeded cane crop.

(*b*) There is a minimum control of weeds, scuffling the inter-row only, which will give yields capable of returning a profit for weeding of from 9 to 14 tons cane per acre higher than the no weeded yields but some 10-20 tons lower than obtained from husbandry.

(*c*) There is an optimum control of weeds using small amounts of labour, which if timed correctly, can give the greatest profits. This weed control involves an early hand weeding in the line and the timing of this hand weeding is broadly from 30 to 40 days after planting, but is dependent on the stage of growth of the crop rather than the time from planting.

(*d*) There is a stage in the utilisation of labour for removing weeds when it becomes unprofitable. To remove weeds every 7-14 and 21 days has no advantage over removing them every 28 days. At the 28 day weed removal stage a profit is shown for weeding.

(*e*) There is a stage of growth of cane at which weeds must be removed. This would of necessity be at a point of development in the young cane plant which is not necessarily measurable by the period from planting in days. It is a separate study which must follow on the findings given below.

There is much to commend the age old farming axiom that the correct time to eradicate weeds is before they can be seen. If this advice was taken literally, labour might be expended unnecessarily and it is the intention here to evaluate the effect of the minimum operations necessary to achieve the maximum yield from the elimination of competition which weeds cause in a plant cane crop.

Conditions of Work

What is the weed situation confronting the sugar planter? The land, having been prepared for planting by ploughing, harrowing and furrowing, is left, ready to receive the planting material, in a series of ridges and furrows drawn out in such a way as to reduce to a minimum any danger of soil erosion from heavy rains. The prepared setts of cane are then placed in the bottom of the furrows, covered with a suitable layer of soil and left to germinate. Whilst the germination of the cane is taking place the seeds, corms and rhizomes of other plants present in the surface layers of the soil, also start active growth. Some weeks after planting, the cane in the field, still in the ridge and furrow formation, has a green covering of small plants with the planted line of cane demarcated by a line of relatively tall cane shoots standing above the weeds.

Because of the ridge and furrow formation little or no pre-planting cultivations can be carried out to reduce the potential weed population. The cane setts, and whatever weeds are present in the surface soil, start germination together and competition for light, plant food and water ensues.

Early Advantages for Cane

The crop of cane starts at an advantage as the large cane sett carries a reserve of moisture and plant food far greater in capacity than the weed seeds or the rootlets of the competing weed population. For this reason the primary shoots of cane usually stand out after germination clearly above the surrounding weeds and enable the weeder to work through the crop at an early stage of growth.

Assessment of Labour Expended on Weeding

The amount of labour involved in keeping the crop clear of weeds from this stage onwards varies according to the individual farm, but in nearly all instances it is considerable. A glance at the histogram in G. G. Sheppard's[2] paper to the South African Technologists in 1960 shows that in the years 1958 and 1959 respectively approximately 4,600 and 2,500 units of labour were required to remove the cane crop from the estate under consideration during the year, whilst nearer 5,000 and 7,600 units were required over the same periods to remove the weeds, *i.e.* weeding accounted for approximately one half and three-quarters respectively of the total labour force requirements in these two years.

This means that weeding has been more costly than the harvesting of the crop. Yet the tendency is to concentrate on improving the efficiency of the cutter and to disregard the much greater scope for economy presented by improving the efficiency in the control of weeding.

Yield Advantages Gained by Weeding

Before going into the problem of how to reduce the man-hours expended on weeding, it is necessary to assess the gains to be derived from weeding.

In the Technologists' Proceedings of 1955, N.C. King[1] and F. L. Almond reported on an experiment carried out on weeding using selective herbicides, manual and mechanical methods of weeding. In this trial a gain of 34.92 tons cane per acre is recorded between plots which received no weeding and plots which received a pre-emergent herbicide spray, hand weeding and mechanical weeding. The yields were:

No weeding	18.41 t.c.p.a.
Pre-emergent spray, hand and mechanical weeding	53.33 t.c.p.a.
Gain	34.92 t.c.p.a.

Further, from the many treatments included in this trial those that included mechanical cultivations proved superior to those receiving only herbicide treatments. The conclusion that can be drawn from this is that cultivation as well as weed eradication is necessary for optimum yields.

It would appear that when early control of weeds in the line of cane was practised, better yields were obtained.

Recent Experiments in Weed Control

Recent experiments to establish the above losses in cane yields due to the presence of weeds and to find the minimum weeding necessary to give a satisfactory crop were planted in the spring 1958 and autumn of 1959. Any possible difference in the type of weed occurring due to season was thus covered.

The treatments used in a split plot design were:

T0 No weeding at all

T1 Weeded by hand or cultivated every 14 days

T2 „ „ „ „ „ „ 28 „

T3 Inter-row cultivations every 6 weeks only

T4 One hand weeding in the line of cane accompanied by and followed by inter-row cultivations when necessary.

Two levels of fertilizer were used:

M Medium dressings consisting of:

Furrow application	500 lbs.	5:13:5
Top-dressing	300 lbs.	15:0:15

Total plant food 70 lbs. N, 62 lbs. P_2O_5 and 70 K_2O lbs. per acre.

H High dressing consisting of:

	N.	P.	K.
Furrow applications lbs. per acre	20	200	20
Top-dressing lbs. per acre	230	—	230
Total Plant food	250	200	250

The main plots of the split plot designs were given to the two fertilizer treatments as the maximum information was required from the weeding treatments which therefore occupied the sub-plots.

The two trials were given the following code numbers:

(*a*) AW 1/58 planted on 6th October, 1958.

(*b*) AW 2/59 planted on 26th Feb uary, 1959.

Treatments Used

Before proceeding with the weather and growth records of the trials a clear understanding of what actually occurred in the various treatments may make this description of the trials more realistic.

The wording "hand weeding" in the description of the operations carried out consists of scratching and hand pulling the weeds from the line of cane and an area 6″ to 9″ either side of the line. Scratching is done with a hand tool, made of 4 to 6 strands of No. 8 fencing wire, brazed together at one end to form a stiff handle and splayed out in a claw-like fashion at the other. This not only removes the weeds but loosens the soil around the young spindle of cane.

"Scuffling" in these treatments means a mule-drawn Uba cultivator working 3 to 4 times within one inter-row. The cultivator is taken up the inter-row to the one side with the outside tyres dragging as close to the line of growing cane as possible. The return trip is taken on the other side of the inter-row in the same manner. Then the cultivator travels again up the same inter-row in the centre and if the weed growth is heavy a return trip is made in the central area of the inter-row. Thus, with hand weeding a complete eradication of weeds in the line is guaranteed whilst with scuffing the same applies to the inter-row.

Types of Weeds Encountered in the Trials

The anticipated variation in the weed varieties encountered in the two trials was in fact found to occur.

In AW 1/58 the predominant weeds were water grass, stinkblaar (*Datura stramonium*), portulacca (*Portulacca oleracea*) and a number of grasses including barbe (*Panicum maximum*), whilst in AW 2/59 night shade (*Solanum nigrum*) yellow weed (*Senecio juniperinus*) black jack (*Bidens pilosa*) and horse weed (*Erigeron canadense*) were present.

In both experiments the amount of weed present in the unweeded plots completely filled the inter-row and in the plots where the inter-rows only were kept clean the fringe of weeds along the line of cane persisted, despite the filling of the planting furrow by the action of the cultivators.

The Prevalent Climate at the Planting of the Trials

It will be shown later, that the rainfall had a considerable bearing on the timing of the weeding treatments in each of the experiments. It is, therefore, preferable to have a clear idea of the prevailing weather at the time of planting each of the trials before considering the actual treatments used. Table I gives the rainfalls recorded each week prior to and after planting in each trial.

Table 1

Weeks from planting date	Relating to AW 1/58 planted 6/10/58 *Rainfall per week*	*First Weeding in treatments*	Relating to AW 2/59 planted 26/2/59 *Rainfall per week*	*First Weeding in treatments*
0–3	0.29″		0.20″	
0–2	0.10″		4.82″	
0–1	—		—	
zero	planting		planting	
0+1	0.20″		—	
0+2	0.80″		0.63″	
0+3	0.12″		0.20″	T1
0+4	2.38″		0.13″	
0+5	2.41″		—	T2
0+6	0.65″	T1	0.02″	T3
0+7	0.33″		0.11″	T4
0+8	0.72″	T2, T3, T4	0.27″	

From the above table it can be seen that in AW 1/58, planting took place under dry conditions and for three weeks little rain fell. Only in the fourth week was the soil thoroughly moistened and weeding was started two weeks later in the sixth week. In AW 2/59 the 4.82 inches of rain prior to planting left the soil in a thoroughly moist condition and the third week after planting weeding had to be started.

Treatment T4, however, was kept as similar as possible in both experiments; being carried out in the 8th and 7th weeks respectively.

Treatments in Detail

Treatment 1, had 18 hand weedings at two-weekly intervals and 5 scufflings at 6-weekly intervals.

Treatment 2, 9 hand weedings at 4-weekly intervals and 5 scufflings. The scufflings were done the week following the hand weedings for the first five times and then scuffling was discontinued.

Treatment 3, no hand weeding, 5 scufflings at 6-weekly intervals.

Treatment 4, after the first hand weeding in the line in the 8th and 7th weeks respectively for each trial from planting, a thorough cleaning was carried out by scuffling in the inter-row as well. The AW 1/58 trial had 2 further scufflings in the 25th and the 33rd week from planting and AW 2/59 had a further 3 scufflings in the 16th, 24th and 40th week from planting.

Harvest Results

Table II gives the yields recorded in tons cane per acre for the fertilizer treatments and the weeding treatments in both experiments.

Table 2

Treatment	AW 1/58 *Fertilizer treatment*	*Weeding treatment*	AW 2/59 *Fertilizer treatment*	*Weeding treatment*
T0 M	39.54		25.30	
T0 H	41.40		25.09	
T0		40.47		25.20
T1 M	61.92		53.22	
T1 H	63.84		56.67	
T1		62.88		54.95
T2 M	60.66		52.88	
T2 H	64.03		59.88	
T2		62.35		56.38
T3 M	54.41		31.86	
T3 H	55.51		37.05	
T3		54.96		34.46
T4 M	64.62		35.86	
T4 H	63.00		37.72	
T4		63.81		36.54
S.E. % G.M.		13.06	8.27	
Least Significant diff.		6.42 at P=.05 9.34 at P=.01		8.99 at P=.05 13.08 at P=.01

The statistical conclusions from AW 1/58 are that the best treatment T4 was not significantly better than T1 or T2, but these three treatments were all significantly better than the T3 and T0 treatments. There was no differences statistically for fertilizer treatments and no interactions showed up.

AW 2/59. Treatments T1 and T2 gave highly significantly better yields than T3 and T4 whilst T0 was significantly lower than any other treatment.

Therefore, it can be concluded that by weeding yields are likely to be increased from 23.34 to 31.18 tons cane per acre, whilst there is no advantage in weeding more frequently than the T2 treatment, every 28 days, as there is no difference between T1

Table 3

Treatment	*No. of hand weeds*	*No. of scufflings*	*Units hand weed*	*Units scuffling*	*Total Units*	*Cost of Weeding*	*Tons cane p.a.*	*Increase due to weeding*	*Cash return due to weeding*	*Profit due to weeding*
AW 1/58	T0						40.17			
T1	18	5	90	5	95	£ 23 15 0	62.88	22.41	£16 16 0	−6 19 0
T2	9	5	45	5	50	12 10 0	62.35	21.88	16 8 0	3 18 0
T3	—	5	—	5	5	1 5 0	54.96	14.49	10 19 0	9 14 0
T4	1	3	5	3	8	2 0 0	63.81	23.34	17 10 0	15 10 0
AW 2/59										
T0							25.20			
T1	16	6	80	6	86	21 10 0	54.95	29.75	22 6 0	16 0
T2	8	6	40	6	46	11 10 0	56.38	31.18	23 7 0	11 17 0
T3	—	6	—	6	6	1 10 0	34.46	9.26	6 19 0	5 9 0
T4	1	4	5	4	9	2 5 0	36.54	11.34	8 10 0	6 5 0

and T2 treatments in yield. To weed the inter-row only would cause a lowering in yield from the optimum (T2) of the order of from 21.92 to 7.39 tons cane per acre. Therefore, there must be some cleaning of weeds in the lines of cane.

If a line cleaning is put in there is a critical stage in the growth of the cane at which it must be carried out. In the AW 1/58 the T4 treatment, done after 8 weeks gave the best yields in the trial, but the dry soil conditions had persisted for the first 3 weeks, thus delaying weed growth. With the moist soil conditions which prevailed at the planting of AW 2/59, the 7th week after planting was too late for the line weeding and the recorded yields were little different from treatment T3, where the inter-row only was cleaned.

Thus, the maximum increments due to weeding can be obtained if one hand weeding is done at the right time and the inter-rows cleaned thereafter. If this hand weeding is left too late, then the hand weeding is of little advantage as the inter-row cleaning (T3) only will give an equivalent yield, though probably 10 to 20 tons lower than the best cleaned crops.

Economics of Weeding

Having found the varying yields caused by leaving a crop dirty or clean the economic interpretation of these variations should be studied.

The descriptions of the operations given earlier must now be given a monetary value which can be tabulated as follows:

(i) 1 unit of labour at 5s.

(ii) 1 ton of cane at a hypothetical profit value of 15s. per ton of cane.

1 acre of cane can be:

(*a*) Hand weeded by 5 units of labour.

(*b*) Scuffled by 1 unit of labour.

On the above basis Table III can be drawn up for each experiment on a acre basis.

Although some of the greatest yields are derived from keeping the crop completely clean, the table shows that the cost of labour in some instances has been excessive and a financial loss results. The profit column in AW 1/58 clearly shows the gain to be derived if the one hand weeding (Treatment 4) is put in at the right time. Treatment 2 in this trial gave a good yield but the profit is low whilst in Treatment 1, a loss is shown due to too much labour being used in the cleaning operations.

In AW 2/59 the highest profit is shown for treatment 2, whilst Treatment 4, when the hand weeding was put in too late, still shows the second highest profit although this is little gain over Treatment 3 where the lowest labour expenditure occurs.

Acknowledgement

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References

[1]King, N. C. and F. L. Almond, Weed control: herbicides or cultivation? Proceedings, *S.A. Sugar Tech. Assoc.* vol. 29, 1955, pp. 122-5.

[2] Sheppard, G. G. Systematic planning and scientific control of field operations. Proceedings, *S.A. Sugar Tech. Assoc.*, vol. 34, 1960, pp. 128-31.

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