

EFFECTS OF YELLOW NUTSEDGE (*CYPERUS ESCULENTUS* L.) COMPETITION ON IRRIGATED SUGARCANE AT MHLUME, SWAZILAND

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Abstract

Populations of yellow nutsedge (*Cyperus esculentus* L.) have been increasing over time in commercial sugarcane (*Saccharum* spp. hybrids) fields at Mhlume (Swaziland) Sugar Company. As current control of the weed is performed empirically, this study was undertaken to quantify and characterise cane and sucrose yield loss in relation to yellow nutsedge population and its control. Two field experiments on different soil types (Westleigh and Zwide soil series) were conducted between 1988 and 1991 on plant, 1st, 2nd and 3rd ratoon cane crops. Four weed control methods [two controls: (a) no weed control, (b) complete hand weeding; and two levels of herbicide application rates: a recommended estate level, which was a mixture of MCPA (1,6 L a.i./ha) with ametryn (1,5 L a.i./ha), and one-half the recommended herbicide application] were imposed on three nutsedge weed populations [1 680 to 1 833 plants/m² (heavy), 1 110 to 1 205 plants/m² (medium) and 550 to 582 plants/m² (light)]. The 12 treatments were arranged in a 3 x 4 rectangular lattice with five replications.

The recommended herbicide rate and complete hand weeding significantly increased cane and sucrose yields by about 15% and 25% respectively, compared with the no weed control treatment in plant cane. Also, complete hand weeding significantly increased cane and sucrose yields by 26% and 28%, respectively, in the 3rd ratoon crop. However, weed control treatments had no effect on cane or sucrose yields in the 1st and 2nd ratoon crops. Although nutsedge presence in plant and 3rd ratoon cane decreased yields, there were no further effects on yields from the levels of weed populations. It was thus not possible to establish a threshold population level for economic control of the weed as this must have been below the 'light' infestation level. However, regeneration of *C. esculentus* in subsequent years was shown to be a function of previous years' populations and the control methods imposed on those populations. Final populations in the subsequent years were lower where weed control was practised than where there was no weed control. The cost of weed control in the plant crop and the older ratoons can therefore be justified by yield responses, whereas control in the 1st and 2nd ratoon crops can be justified by its effect on reducing weed population levels in subsequent years.

Keywords: Yellow nutsedge, *Cyperus esculentus* L., weed competition, Swaziland.

Introduction

Weed control at Mhlume (Swaziland) Sugar Company has featured prominently as one of the estate's most labour intensive operations and, together with herbicides, involves an an-

nual expenditure of approximately 3% (personal communication) of production costs. Populations of yellow nutsedge (*C. esculentus*) have, over the years, increased at Mhlume.

Because of their evident impact on crop yields, weeds have traditionally been considered unwanted plants. Consequently, agriculturalists have concentrated their research on weed-crop competition with relatively little focus on the mechanisms involved (Altieri and Liebman, 1986). Generalisations of crop yield losses due to weed competition apparently justified the development of season-long weed-free systems (Aldrich, 1984). However, farmers need a satisfactory method of relating weed infestation to potential reduction in crop yield, to decide on the extent of weed control that would be economically optimal (Zimdahl, 1980; Swanton and Weise, 1991).

Purple nutsedge (*C. rotundus*) has been reported to lower cane yields by 38% and 75% in Australia and Argentina, respectively (Holm *et al.*, 1977). It was suggested by Chapman (1966) that the severe cane yield reduction was the result of competition for water at the time of tiller formation when, as a consequence, fewer shoots were produced.

Turner (1984) reported that purple nutsedge caused yield losses of up to 85% in plant crops of cultivars N13 and N8 under rain-grown conditions in KwaZulu-Natal. He also observed that cane stalk elongation and tillering were slower in plots containing the nutsedge.

The objective of this study was to evaluate the interference of yellow nutsedge with growth and quality of irrigated sugarcane in northern Swaziland and to quantify or characterise yield loss in relation to yellow nutsedge population and its control.

Procedures

The study comprised two field experiments located at Mhlume (Swaziland) Sugar Company (30°55'E, 26°02'S). The first experiment (9 November 1988) was laid out on 2nd ratoon cane of variety NCo376 growing on a Westleigh soil series under sprinkler irrigation, and the second experiment (15 September 1989) was laid out on N17 plant cane growing on a Zwide soil series under flood irrigation. Row spacing was 1,5 m apart in both experiments.

Three yellow nutsedge populations were established in each experiment at 'heavy', 'medium' and 'light' infestation levels. Fields having uniformly heavy populations of nutsedge were chosen for the experiments. At about four weeks after the cane was planted or ratooned, medium and light infestation treatments were instituted through hand-thinning weed growth to 67% (medium) and 33% (light) of

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the original populations (Table 1). All weeds other than yellow nutsedge were removed by hand for the duration of the experiments.

Table 1
Yellow nutsedge populations established in plant and second ratoon cane crops

Population level	Plant population (plants/m ²)	
	Plant cane	2nd ratoon cane
High	1 833	1 680
Medium	1 205	1 110
Light	582	550

Four weed control treatments were superimposed on the weed population treatments:

- (a) no weed control (the nutsedge was left undisturbed throughout the growth of the crop)
- (b) complete weed control by hand weeding throughout the season
- (c) recommended herbicide application level
- (d) half the recommended herbicide application.

The recommended herbicide treatment used in these studies was a mixture of MCPA (2-methyl-4 chlorophenoxyacetic acid) (400 g a.i./L) at 1,6 L a.i./ha with ametryn (2-methylthio-4-ethylamino-6-isopropylamino-s-triazine) (500 g a.i./L) at 1,5 L a.i./ha. A surfactant, Agrowett, was added to the mixture at 0,5 L/ha. All levels of herbicides were applied in 400 L water/ha using a manually operated CP3 knapsack sprayer at a set pressure of 150 kPa, with a TK5 tapered-edge flat fan nozzle. A spraying swath of 1,5 m and a nozzle height of 0,5 m were used. Herbicides were applied at about four weeks after planting or ratooning the cane.

The treatments were arranged as a 3 x 4 rectangular lattice with six replications. One replication in each experiment had to be discarded due to low population levels of nutsedge. Each gross plot comprised six sugarcane rows 1,5 m apart and 10 m long (90 m²), with a net plot size of four rows 6 m long (36 m²).

Weed counts were done on all plots at the time of herbicide application and again three weeks later. For weed population counts, rectangular wooden frames measuring 0,20 m x 0,30 m were placed in three different positions across each plot in a diagonal arrangement, and the number of actively growing nutsedge plants was counted within each frame (Fisher, 1966). Sugarcane stalk population and stalk height measurements were undertaken monthly.

Sugarcane yield was determined after one year's growth from each net plot. Fifteen stalks were randomly selected from each harvested net plot, and analysed for sucrose (Boyce, 1970).

In both experiments the cane was ratooned (3 September and 11 November 1989 for the plant and 2nd ratoon crops, respectively), and weed control treatments were superimposed on the same plots. Nutsedge populations were allowed to regenerate and were not thinned back. Populations of regenerated nutsedge were estimated after the initial growth flush at approximately four weeks after harvest, and again, three weeks later.

Since one replication had to be discarded, the usual lattice analysis could not be used. The experiment was therefore analysed as an incomplete block design using a linear model approach. Comparisons of stalk growth, populations and

heights were undertaken using standard non-linear statistical models.

In addition to the main experiments described, separate 19,5 m x 19,5 m plots with selected treatments (Table 2) were used for cane growth analysis studies during the first year of each of the two experiments. Seven sample units comprising rows of sugarcane 1,0 m long were sampled across plot diagonals at each sampling date. The first sampling was undertaken at the time of herbicide application, and then fortnightly, until the sugarcane was at full canopy. Sampling was then done monthly up to harvest. The sample unit with a mass closest to the mean was selected and oven dried at 105°C until a constant weight was achieved.

Table 2
Treatments used in the growth analysis trials

1. Heavy infestation, zero control.
2. Complete hand weeding of a light infestation of yellow nutsedge.
3. Heavy infestation of yellow nutsedge controlled with a standard rate of herbicide.
4. Medium infestation controlled with half the standard rate of herbicide.

The growth of sugarcane was observed in the study to be sigmoidal, and was therefore described and interpreted by logistic growth curves. Since sugarcane growth is sigmoidal, the growth curve parameters (asymptote, point of inflection and maximum growth rate) describe the growth better than an average rate would. These three parameters were estimated for each plot, and were then compared between treatments using standard analysis of variance methods.

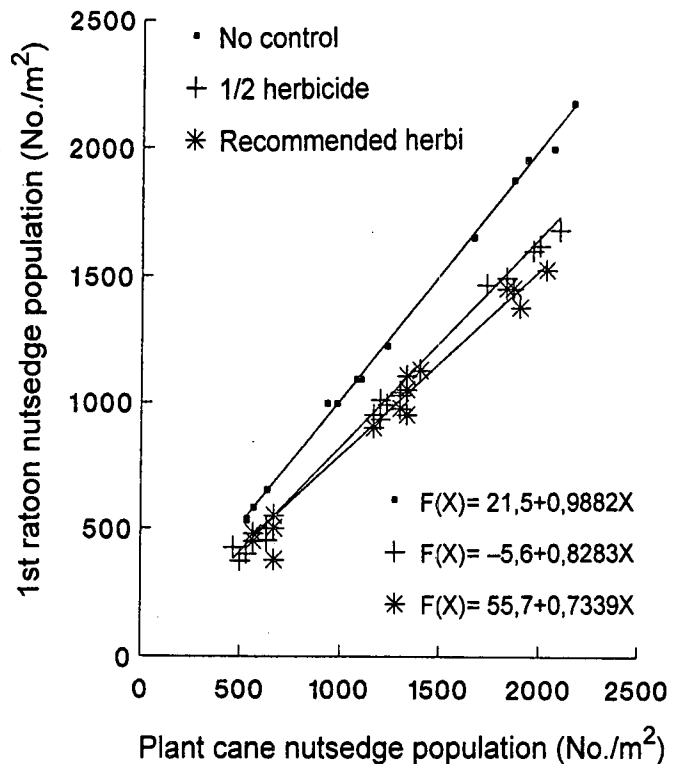


FIGURE 1: The relationship between the level of yellow nutsedge population established in plant cane on a Zwide soil subjected to three levels of weed control, and populations regenerated the following year in the 1st ratoon

Results and Discussion

Yellow nutsedge population levels

The analysis of treatment effects on yellow nutsedge was undertaken by fitting general linear models. The best model for analysis in both experiments was the use of separate lines describing weed control treatments, which indicated that the regrowth levels of yellow nutsedge populations was dependent on the previous year's population and weed control method. The no weed control treatment gave higher populations in the subsequent year than either the one-half or the full herbicide treatments (Figures 1 and 2). In the no weed control treatment the population in the following year was slightly higher than (2nd ratoon), or similar to (plant cane), the previous year's population for each initial level. This was, however, not the case where weed control was instituted, where subsequent populations were similar to or less than the previous year's population. During the 2nd ratoon cycle (Figure 2) the difference in slopes was more marked than in the plant cane (Figure 1).

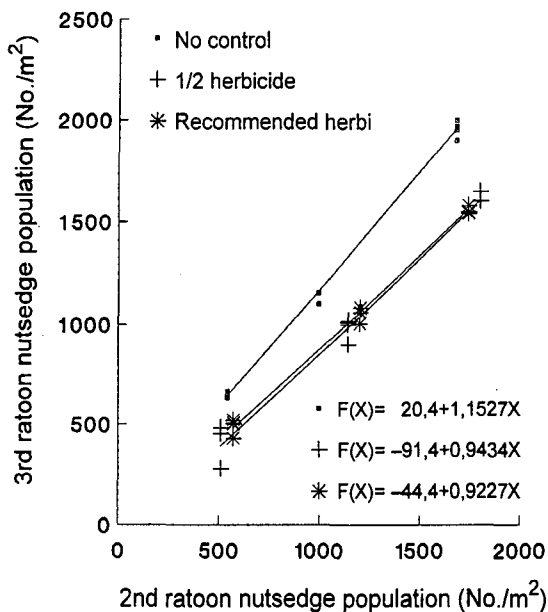


FIGURE 2: The relationship between the level of yellow nutsedge established in 2nd ratoon cane on a Westleigh soil subjected to three levels of weed control, and population regenerated the following year in the 3rd ratoon

Growth analysis of sugarcane

As single growth curves fitted the data as well as separate growth curves for each treatment (Figures 3, 4, 5 and 6), there was no evidence that either stalk population or stalk height was significantly affected by weed population levels or by weed control methods in any of the crop cycles used in the study.

The asymptote, maximum growth rate and points of inflection of dry mass accumulation did not differ significantly between treatments for plant cane (Figure 7). However, for the second ratoon sugarcane crop, the asymptote for the heavy infestation – no weed control treatment combination was significantly ($p < 0,05$) lower than those of the other treatment

combinations (Figure 8). As the whole plot harvest data showed no differences between treatments, either the results based on the asymptote fitting were spurious, or, as indicated, there was a real loss in yield prior to harvest which was negated through compensatory growth. The differences in the maximum growth rates and the points of inflection between treatments were not statistically significant in the 2nd ratoon crop (Figure 8).

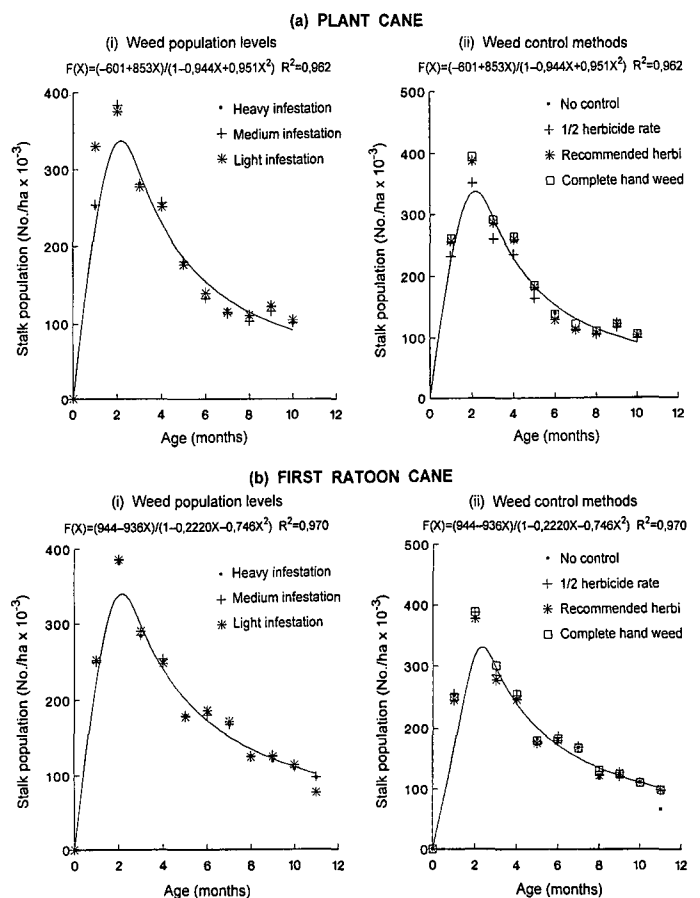


FIGURE 3: Effects of level of yellow nutsedge population and its control on stalk population development in plant and 1st ratoon cane

Sugarcane yield and quality

Yellow nutsedge was shown to interfere strongly with growth in the plant and 3rd ratoon crops of sugarcane, as the institution of the recommended herbicide rate and hand weeding treatments resulted in significantly ($p < 0,05$) greater yields than that of the unweeded control (Tables 3 and 4). However, application of the one-half the recommended herbicide rate treatment to plant and 3rd ratoon cane did not result in a significant yield increase compared with the no weed control treatment. Sucrose % cane was not affected by any of the treatments (data not shown). Sucrose yield was therefore similarly affected by the weed control methods in these crops. The recommended herbicide rate and complete hand weeding treatments produced 15% and 26% more sucrose yield, respectively, than the no weed control treatment (Table 3). The possible reason for enhanced growth of plant crop sugarcane following weed control is that full canopy takes longer to establish, which presents a greater opportunity for early competition by weeds (Zimdahl, 1980). However, the growth analysis study was not sensitive enough to relate yield differences to stalk population or height (Figures 3, 4, 5 and 6).

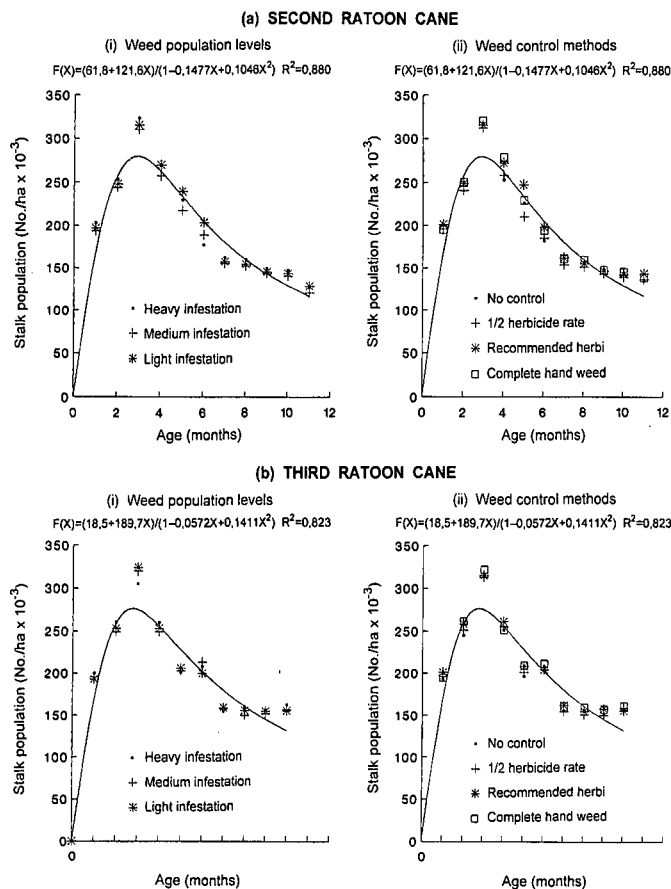


FIGURE 4: Effects of level of yellow nutsedge population and its control on stalk population development in 2nd and 3rd ratoon cane

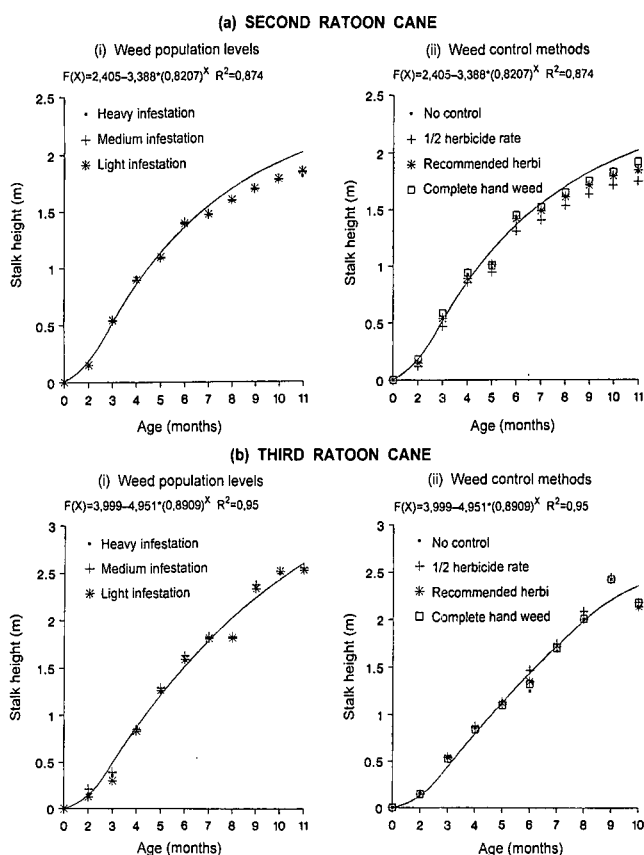


FIGURE 6: Effect of level of yellow nutsedge population and its control on stalk height in 2nd and 3rd ratoon cane

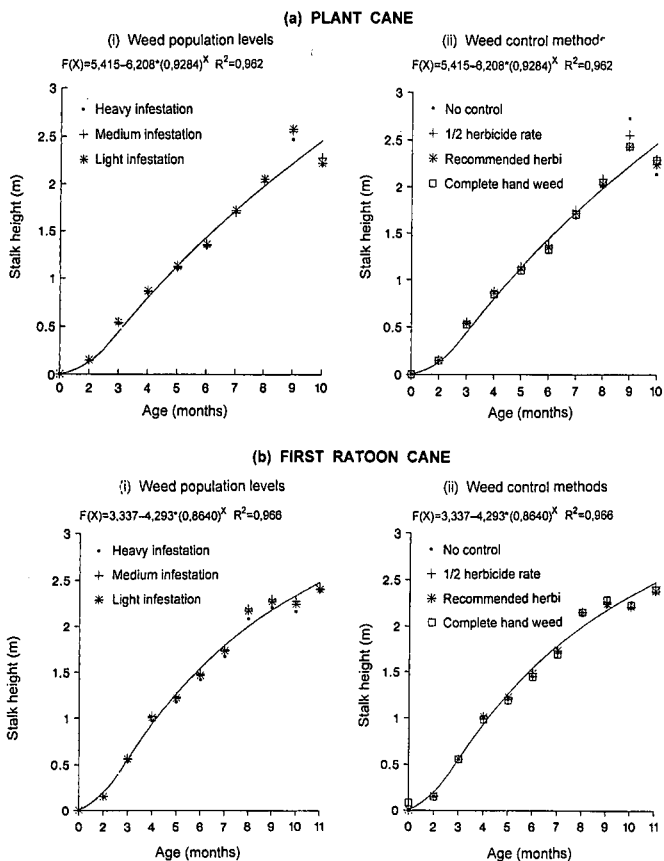


FIGURE 5: Effect of level of yellow nutsedge population and its control on stalk height in plant and 1st ratoon cane

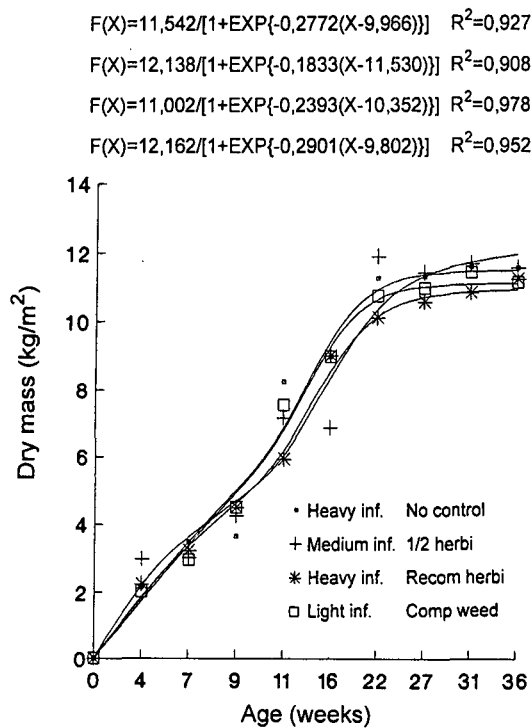


FIGURE 7: Effect of level of yellow nutsedge population and its control on plant cane dry mass accumulation with time

Table 3

Influence of yellow nutsedge population level and method of weed control on cane and sucrose* yields (t/ha) of plant cane grown on a Zwide soil under flood irrigation

Weed control method	Weed population levels						Weed control means	
	Heavy		Medium		Light			
No control	70,07	*(11,65)	68,78	(11,27)	71,52	(11,65)	70,12	(11,53)
Herbicide at half recommended rate	66,02	(11,03)	72,79	(12,22)	76,59	(12,46)	71,80	(11,90)
Recommended herbicide rate**	82,01	(13,52)	75,77	(12,53)	82,89	(13,67)	80,22	(13,24)
Complete hand weeding	86,04	(14,32)	83,59	(14,24)	90,53	(15,17)	86,72	(14,58)
Weed population means	76,03	(12,62)	75,23	(12,56)	80,38	(13,24)		

Standard error of difference (s.e.d.)

Weed population levels $\pm 9,94$ (1,72)

Weed control methods $\pm 11,00$ (1,90)

Weed population levels x weed control methods $\pm 15,90$ (2,74)

* Figures in parenthesis represent sucrose yields

** Recommended rate – a mixture of MCPA (1,6 L a.i./ha) and ametryn (1,5 L a.i./ha)

Table 4

Influence of yellow nutsedge population level and method of weed control on cane and sucrose* yields (t/ha) of 3rd ratoon cane grown on a Westleigh soil under sprinkler irrigation

Weed control method	Weed population levels						Weed control means	
	Heavy		Medium		Light			
No control	69,55	*(12,15)	72,66	(11,68)	77,11	(11,96)	73,11	(11,93)
Herbicide at half recommended rate	61,43	(10,15)	82,60	(13,68)	69,62	(11,44)	71,22	(11,76)
Recommended herbicide rate**	87,19	(13,86)	77,52	(12,86)	70,86	(11,73)	78,52	(12,82)
Complete hand weeding	96,88	(15,75)	90,06	(15,12)	89,99	(14,79)	92,31	(15,22)
Weed population means	78,76	(12,98)	80,71	(13,33)	76,89	(12,48)		

Standard error of difference (s.e.d.)

Weed population levels $\pm 6,75$ (1,16)

Weed control methods $\pm 7,67$ (1,31)

Weed population levels x weed control methods $\pm 10,70$ (1,83)

* Figures in parenthesis represent sucrose yields

** Recommended rate – a mixture of MCPA (1,6 L a.i./ha) and ametryn (1,5 L a.i./ha)

$$F(X)=6,883/[1+\text{EXP}\{-0,2293(X-10,780)\}] \quad R^2=0,869$$

$$F(X)=8,384/[1+\text{EXP}\{-0,2847(X-10,402)\}] \quad R^2=0,965$$

$$F(X)=7,622/[1+\text{EXP}\{-0,2087(X-10,947)\}] \quad R^2=0,921$$

$$F(X)=8,087/[1+\text{EXP}\{-0,1885(X-12,990)\}] \quad R^2=0,921$$

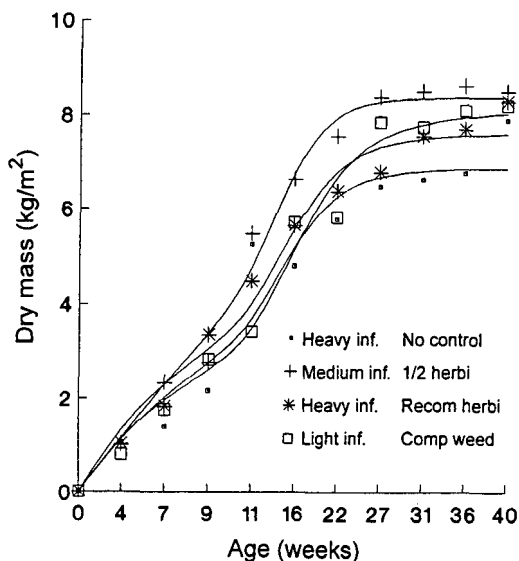


FIGURE 8: Effect of level of yellow nutsedge population and its control on 2nd ratoon sugarcane dry mass accumulation with time

Cane and sucrose yields of the 3rd ratoon crop were significantly ($p = 0,05$) affected by weed control methods. On average, the complete hand weeding treatment gave 26% and 28% more cane and sucrose yields respectively, compared with the no weed control treatment (Table 4). This response may be attributed to a commonly observed deterioration of soil conditions in older ratoons on this Westleigh soil series, resulting in the delayed achievement of full canopy (Nixon, 1992).

Yellow nutsedge did not reduce cane or sucrose yields in 1st or 2nd ratoon sugarcane (Tables 5 and 6). This may be attributed to the more rapid and vigorous regrowth of the first two ratoons, resulting in earlier formation of canopy than in plant or older ratoon crops (Trenbath, 1976; Holm *et al.*, 1977). It may therefore become economic to control nutsedge in young ratoon crops in order to attain partial control and to suppress potential yellow nutsedge populations from regenerating in older ratoons. Alternatively, the results might be explained by the timing of nutsedge regeneration relative to that of cane; the first to emerge gaining advantage of dominance during initial growth. The data recorded in the study represent the responses to only a limited set of environmental conditions during regeneration of the crop and more work will have to be undertaken before any general weed control recommendations could be made.

Table 5

Influence of yellow nutsedge population level and method of weed control on cane and sucrose* yields (t/ha) of 1st ratoon cane (t/ha) grown on a Zwedi soil under flood irrigation

Weed control method	Weed population levels						Weed control means	
	Heavy		Medium		Light			
No control	77,01	*(13,17)	75,46	(13,08)	84,93	(13,40)	77,21	(13,22)
Herbicide at half recommended rate	67,67	(11,62)	80,04	(13,66)	82,33	(13,69)	76,68	(12,99)
Recommended herbicide rate**	75,05	(12,36)	81,01	(13,68)	82,83	(14,06)	79,63	(13,36)
Complete hand weeding	79,16	(13,56)	80,68	(13,85)	74,42	(12,83)	78,09	(13,42)
Weed population means	74,72	(12,68)	79,30	(13,57)	79,69	(13,49)		

Standard error of difference (s.e.d)

Weed population levels $\pm 6,92$ (1,15)

Weed control methods $\pm 7,66$ (1,27)

Weed population levels x weed control methods $\pm 11,10$ (1,83)

* Figures in parenthesis represent sucrose yields

** Recommended rate – a mixture of MCPA (1,6 L a.i./ha⁻¹) and ametryn (1,5 L a.i./ha⁻¹)

Table 6

Influence of yellow nutsedge population level and method of weed control on cane and sucrose* yields (t/ha) of 2nd ratoon cane grown on a Westleigh soil under sprinkler irrigation

Weed control method	Weed population levels						Weed control means	
	Heavy		Medium		Light			
No control	87,81	*(13,68)	80,73	(12,31)	84,93	(13,39)	84,49	(13,13)
Herbicide at half recommended rate	70,92	(11,24)	95,31	(15,13)	85,79	(13,50)	84,01	(13,29)
Recommended herbicide rate**	92,71	(14,40)	81,36	(11,72)	86,36	(14,49)	86,81	(13,54)
Complete hand weeding	101,38	(15,72)	96,99	(15,11)	89,98	(13,52)	96,12	(14,78)
Weed population means	88,20	(13,76)	88,66	(13,57)	86,79	(13,72)		

Standard error of difference (s.e.d)

Weed population levels $\pm 10,5$ (1,47)

Weed control methods $\pm 11,9$ (1,67)

Weed population levels x weed control methods $\pm 15,9$ (2,32)

* Figures in parenthesis represent sucrose yields

** Recommended rate – a mixture of MCPA (1,6 L a.i./ha) and ametryn (1,5 L a.i./ha)

Throughout this experimentation there was no significant response of cane or sucrose yield to the population level of yellow nutsedge. As the weed did exhibit interference with 1st and 3rd ratoon crops, this may indicate that there is a threshold population level above which yellow nutsedge is competitive, independent of populations. The lowest population used in this study would be higher than that threshold.

If this postulate is correct, the interference effects observed may act at an allelopathic level rather than as direct competition for a limiting resource such as moisture. Cane root systems on these soils have been shown to be shallower in plant and older ratoons than in young ratoons (Nixon, 1992). The observed differences in root distribution may render the crop less competitive during these stages of growth and/or more susceptible to allelopathic effects. The intensity of competition for soil factors has been reported to vary with the scarcity of the resource relative to demand for the resource exerted by the crop and the weed (Sony and Ambasht, 1977; Tollenaar *et al.*, 1994). Chapman (1966) suggested that the cause of severe yield loss in cane may be as a result of competition for water at the time of tiller formation. The latter observation might explain why the cane yield loss from purple nutsedge under droughted rain-grown conditions (Turner, 1984) was so much

greater than in this study, where the crop was irrigated and was not exposed to water stress.

Conclusions

It has been shown clearly that for maximum benefit it is important that yellow nutsedge is well controlled during the growth cycles of cane when the crop is less competitive (eg plant and older ratoons). Although results under the environmental conditions and time of regeneration of young ratoons used in this study indicated little, if any, benefit from weed control, this aspect would need further study at other times of the year before no weed control on young, vigorously growing ratoons could generally be recommended.

The relationship that exists between the weed population in the previous year, the weed control method used on that population and regrowth population levels in subsequent years are important, as they emphasise that long term control programmes should be based on expected future weed regrowth.

Acknowledgement

The assistance and technical advice received from Mhlume (Swaziland) Sugar Company is gratefully acknowledged.

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