

Original Research Article

Effect of different types of mulching and plant spacing on weed control, canopy cover and yield of sweet potato (*Ipomoea batatas* (L.) Lam)

ABSTRACT

Aim: To determine the effects of mulching, plant spacing and other control measures on effectiveness of weed control, canopy cover and sweet potato yield.

Study design: The cultivar Blesbok was planted in a randomized complete block design where seven treatments were replicated four times.

Place and Duration of Study: Field trials were established at the Agricultural Research Council - Roodeplaat Vegetable and Ornamental Plant Institute in Pretoria, South Africa during 2006 and 2007.

Methodology: Seven treatments were applied: 1) HW = Hand weeding, 2) NS = Narrow plant spacing (0.5 m between the rows and 15 cm between plants), 3) CO = Organic mulch (compost), 4) PL = Inorganic mulch (black plastic), 5) E*F = Eptam (EPTC; Thiocarbamate) followed by Fusilate (fluazifop-p-butyl), 6) L*F = Afalon (Linuron) followed by Fusilate (fluazifop-p-butyl), and 7) CN = Control (untreated plot). Organic mulch (compost) was omitted in the second trial as it will be beneficial for both weeds and the crop making it difficult to control the weed. Instead, grass straws (ST) and newspaper (NP) mulches were added.

Results: Narrow row spacing, hand weeding, plastic mulch, and newspaper mulch outperformed the other treatments and obtained more than 90% canopy cover by 5 weeks after planting. Effective reductions in weeds were detected with plastic and newspaper mulched plots and was similar to the hand-weeded treatment, followed by narrow spacing. Plots with newspaper mulch and narrow spacing produced marketable yields similar to the hand-weeded treatment. Inorganic mulching and narrow plant spacing were the most effective weed management treatments.

Conclusion: Newspaper mulch seems to be a viable option for small holder farmers to control weeds in sweet potato plantings, eliminating the cost of labour to conduct hand weeding. Compost and grass mulch should not be adopted for weed control since these did not control weeds effectively.

Keywords: herbicides, paper mulch, plastic mulch, sweet potato, newspaper

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) is one of the five most important crops in the developing world [1]. It is believed to have originated in Central America [2]. The crop belongs to the *Convolvulaceae* or morning glory family and is a vital staple food [3;4]. Sweet potato is used for human consumption, livestock feed and for industrial processing. When yellow-orange flesh sweet potatoes are consumed vitamin A deficiency can be combated [5]. Sweet potato also contributes towards vitamin C and minerals in diets [5]. Sweet potato has

a large number of existing cultivars throughout the world. The most popular sweet potato variety in the USA is Beauregard, because of its high yield [6;7]. The popular cultivars grown in South Africa include Blesbok, Bosbok, Ribbok and Beauregard [8]. Sweet potato crop, once established, requires little field management apart from weed control [9]. Mechanical weed control (hand-hoe) is laborious and time-consuming. Depending on the number of individuals in the household and the size of the farm, weed control can take up to several weeks, during which a large portion of crop yield could be lost due to weed competition. According to the findings by Mischler [10], hiring labor to hand hoe fields was twice as expensive when compared to other control measures. Effective weed control is a major constraint to small-holder farmers because of a lack of infrastructure and money to pay for chemicals and labour. Unfavorable conditions like rainy periods soon after transplanting may make the weed control measures ineffective, causing severe yield losses due to weed competition [11]. Furthermore, weed control in sweet potato production is difficult because of the vine-like growth habit of sweet potato, and the availability of only a few registered herbicides for this crop and evidence of herbicide injury in certain cultivars [12]. Research has shown that a weed-free period of 2-6 weeks after planting was required for the cultivar Beauregard. Harrison and coworkers showed that the growth type of the cultivar has an effect on its susceptibility to weed interference [11]. Their results demonstrated that a cultivar with a vigorous, erect shoot growth habit may be less susceptible to weed interference than cultivars with spreading shoot growth such as Beauregard. Weed research of sweet potato has been insufficient over the past decade. Most weed management strategies were developed for large scale agriculture. As a result, these are either not applicable or affordable to small-holder farmers. Alternative mechanical weed control measures include mulching, flooding, burning and cultural weed control [13]. Mulching reduces weed growth by preventing light [which is needed by the germinating weed seed] from reaching the soil surface [14]. Studies by Ossom and coworkers in Papua New Guinea reported some benefit to sweet potatoes dry matter yield of applying mulches, though it was not conclusive [15]. In addition, Aldrich reported in general for crops that plant spacing can affect weed growth and its ability to compete with the crop [16]. The objective of the present study was to determine the effectiveness of different types of mulching, narrow plant spacing and other control measures on weed control, canopy cover and yield of sweet potatoes.

2. MATERIAL AND METHODS

Field trials were established at the Agricultural Research Council-Roodeplaat Vegetable and Ornamental Plant Institute (ARC-VOPI) in Pretoria (25.56°S, 28.35°E) during the 2006 and 2007 planting seasons. The first trial was conducted in January 2006. The soil type used was a Hutton with 20-25% clay. The cultivar Blesbok was planted in a randomized complete block design where seven treatments were replicated four times. The following treatments were applied: 1) HW = Hand weeding, 2) NS = Narrow plant spacing (0.5 m between the rows and 15 cm between plants), 3) CO = Organic mulch (compost), 4) PL = Inorganic mulch (black plastic), 5) E*F = Eptam (EPTC; Thiocarbamate) followed by Fusilate (fluazifop-p-butyl), 6) L*F = Afalon (Linuron) followed by Fusilate (fluazifop-p-butyl), and 7) CN = Control [untreated plot].

Afalon was applied at 2.0 L/ha and Eptam at 3.5 L/ha [17]. Fusilate, a post emergence herbicide, was applied after emergence and after two months at the rate of 2 L/ha. Organic and inorganic mulch were placed on the ground within 24 hours of sweet potato planting. Plastic was placed on top of the ridges with the edges buried under the soil to hold the plastic in position. For all treatments sweet potato cuttings were planted on ridges of 30 cm high. Each plot consisted of four ridges of 3.3 m long. Between rows spacing of 1 m and within rows plant spacing of 0.3 m was used for all treatments with the exception of the narrow plant spacing treatment, where plant spacing of 15 cm and between ridges spacing

of 0.5 m was used. Complimentary water application was applied through overhead irrigation. Soil samples were collected and fertilizer applied based on the recommendations of Allemann [17]. A total of 800 kg/ha of NPK fertilizer 2:3:4 (30) was applied. Fertilizer was broadcasted and worked into the soil before planting. Top dressing of 150 kg/ha of LAN was applied six weeks after planting.

Visual estimation of the percentage weed control effectiveness [area clean of weeds] and the percentage canopy closure per plot were recorded at weekly intervals. Five months after planting, sweet potatoes were harvested manually. The storage roots were sorted as follows: Good quality roots were grouped as extra-large (800-1200g), large (500-800g), medium (250-500g) and small (100-250g). The unmarketable classes consisted of unmarketable large (>1200g), unmarketable small (< 100g), rat damaged, insect damaged, rotten, long curved and sprouted tubers.

During 2007 a follow-up trial was planted (established in December 2006 and harvested April 2007). The experimental design, planting method, watering, fertilization and data collection was the same as the first trial. The Treatments were altered as follows. Organic mulch (compost) was omitted since it will favour the growth h weeds and the crop making it difficult to control the weeds. Instead, grass straws (ST) and newspaper (NP) mulches were added. Herbicides were also excluded. The treatments applied were therefore as follows: 1) Hand weeding (HW); 2) Narrow plant spacing (0.5 m between the rows and 15 cm between plants) (NS); 3) Organic mulch (grass straws) (ST); 4) Inorganic mulch (black plastic) (PL); 5) Newspaper mulch (NP); and 6) Control (untreated plot) (CN).

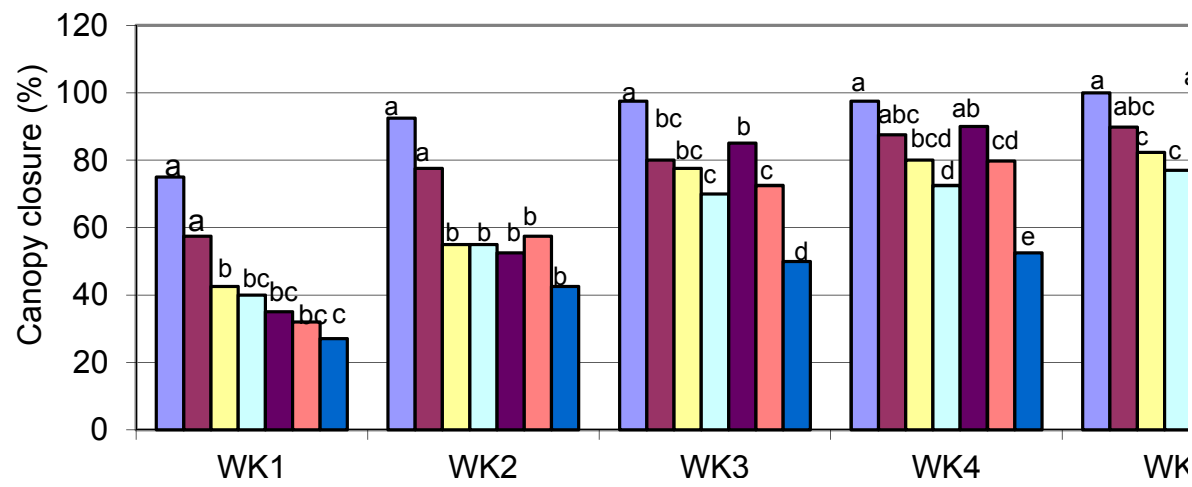
An ANOVA (analysis of variance) was conducted with the statistical program Genstat 2003 to test for differences among treatments. Treatment means were separated using Fisher's t-test least significant differences (LSD) at the 5% level of significance [18].

3. RESULTS AND DISCUSSION

Canopy closure and weed control effectiveness

The results of the 2006 showed that narrow row spacing (NS), plastic mulch (PL), and hand weeding (HW) had similar results with more than 90% canopy cover by 5 weeks after planting, while the control treatment had less canopy cover by that time (Figure 1). In 2007, nearly all the treatments obtained more than 90% cover by week 5, except grass straws mulch (ST) and the unweeded control treatment (CN) (Figure 2). However, canopy cover for the narrow plant spacing (NS) plots was faster than that of other treatments. In 2006, at week 2 and 3, narrow spacing exceeded ($P=0.05$) the canopy cover of most other treatments, and in 2007 there was a tendency of higher cover at week 2 and 3 (Figures 1 & 2).

Canopy closure (2006)



NS= Narrow row spacing	CO= Organic mulch	HW= Hand weeding	CN=Untreated control
PL= Plastic	E*F= Eptam	L*F= Afalon	WK=Week

Fig. 1 Weekly canopy closure (%) of sweet potato at different weed control treatments during 2006.

Bars marked by the same letter do not differ significantly at the $P \leq 0.05$.

Canopy closure (2007)

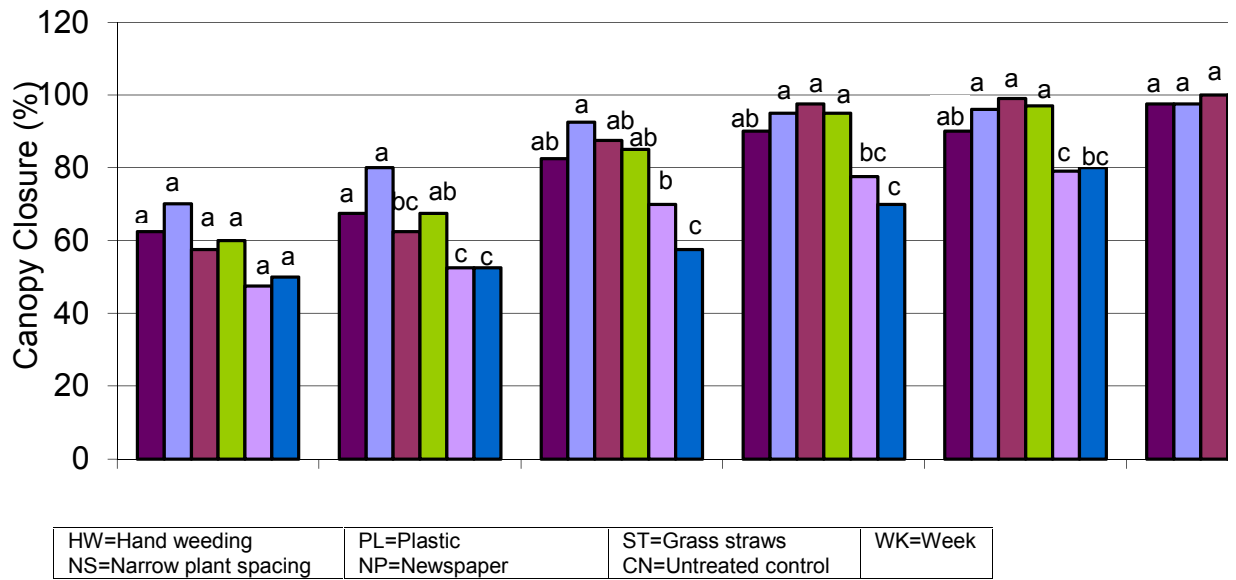
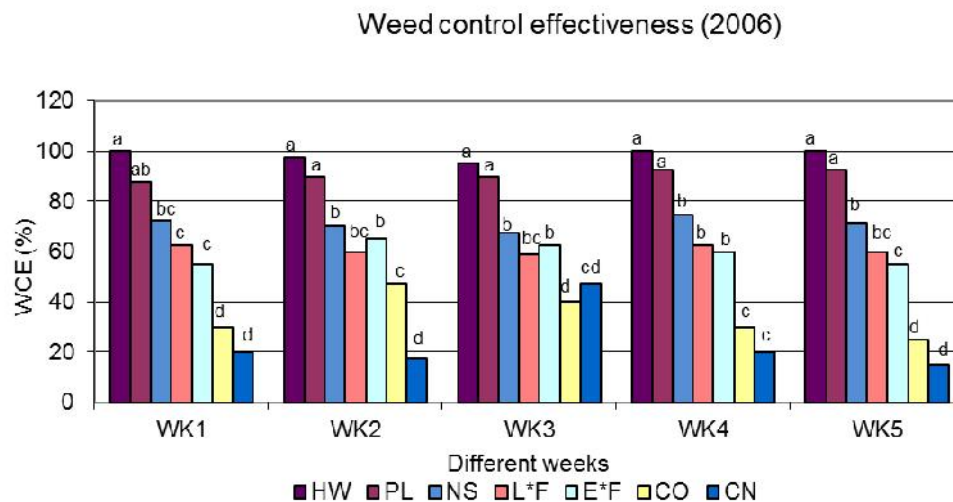


Fig. 2 Weekly canopy closure (%) of sweet potato at different weed control treatments during 2007.

Bars marked by different letters differ significantly at the $P=0.05$ significance level.



HW= Hand Weeding	NS= Narrow Row Spacing	E*F= Eptam	CN=Untreated Control
PL= Plastic	L*F= Afalon	CO= Organic Mulch	WK=Week

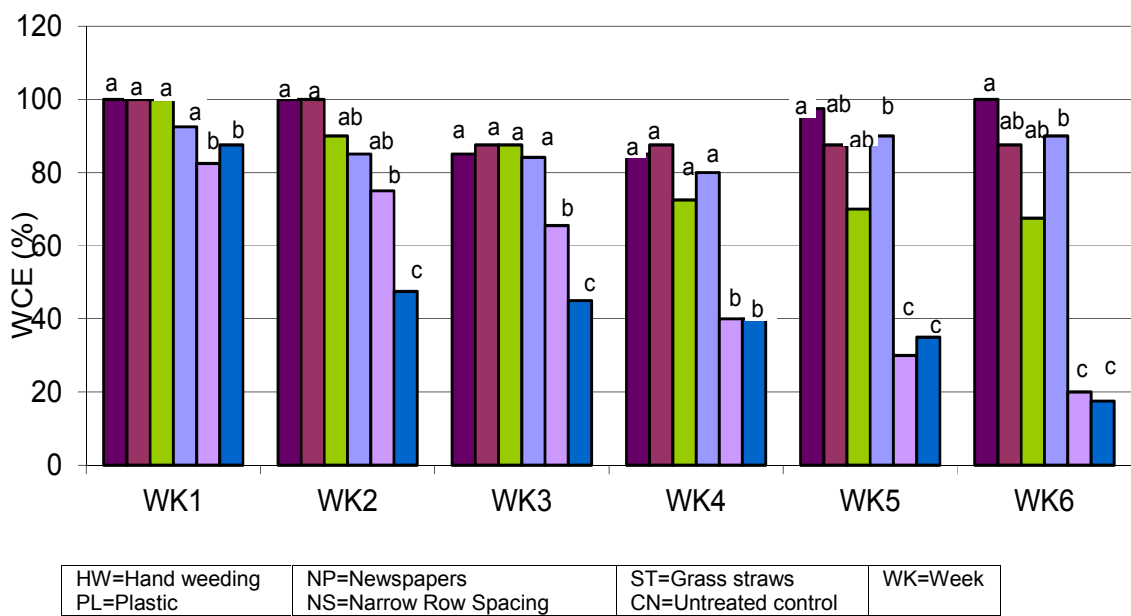
WCE= Weed control effectiveness

Fig. 3 Weekly weed control effectiveness (WCE) at different weed control treatments of sweet potato during 2006.

Bars marked by different letters differ significantly at the $P=0.05\%$ significance level.

Plastic (PL) and newspaper (NP) mulched plots effectively controlled the weeds for most of the first weeks and were similar to the hand-weeded (HW) treatment [Figure 3 & 4]. The narrow plant spacing successfully controlled most of the weed population. Weed control efficiency of compost (CO) and grass straw (ST) mulch plots deteriorated weekly as from week 3 (Figure 3 & 4), which showed that these treatments were ineffective in suppressing the weeds.

Weed control effectiveness (2007)

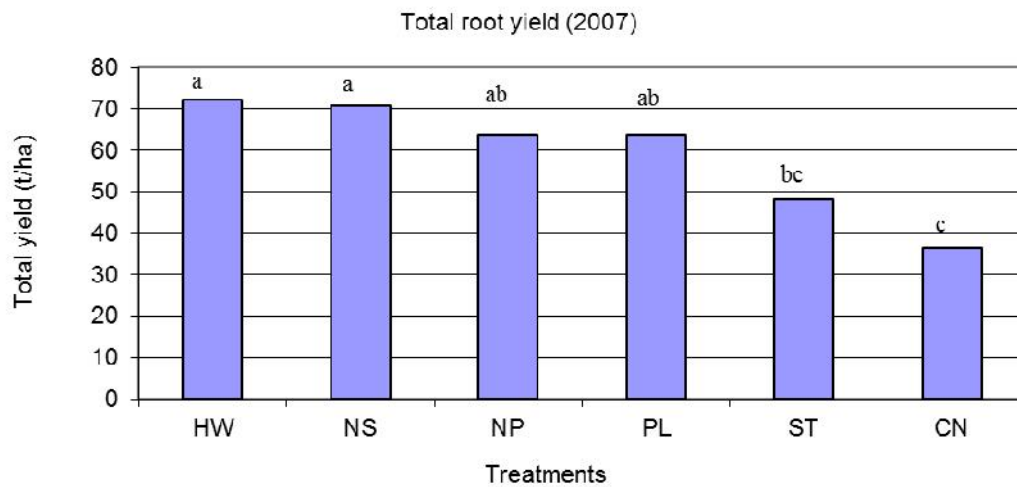


WCE=Weed control effectiveness

Fig. 4 Weekly weed control effectiveness (WCE) of sweet potato during 2007.
Bars marked by different letters differ significantly at the $P=0.05\%$ significance level.

Yield

In 2006, there were no significant differences in crop yield with various treatments from the control treatment because plants were killed by frost before reaching maturity. However in 2007, almost all treatments exceeded the unweeded control in marketable root yield and total root yields (Figure 5 & 6). Hand weeding (HW) and narrow spacing produced the highest total yields of above 70 t/ha (Figure 5). Plastic (PL) and newspaper (NP) mulched plots produced total yields of 60 t/ha as compared to the control treatment which produced total yields of less than 40 t/ha (Figure 5).



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HW=Hand weeding	NP=Newspapers	ST=Grass straws
NS=Narrow plant spacing	PL=Plastic	CN=Untreated control

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176 **Fig. 5 Total root yield (t.ha⁻¹) of sweet potato at different weed control treatments**
177 **during 2007.**

178 Bars marked by different letters differ significantly at the $P=0.05\%$ significance level.
179 (LSD($P=0.05$)= 21.46, CV%= 24.0)

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181 Hand weeding, narrow spacing (NS) and newspaper (NP) plots yielded the highest
182 marketable root yield, exceeding 50 t/ha as compared to 24.5 t/ha for the unweeded control
183 (CN) (Figure 6). Plots mulched with plastic (PL) and grass straws (ST) produced average
184 marketable root yields, around 40 t/ha (Figure 6). This may be due to weed competition at
185 early stages of growth in the case of grass straws. However, low marketable yield with
186 plastic mulch was due to the number of sprouted storage roots.

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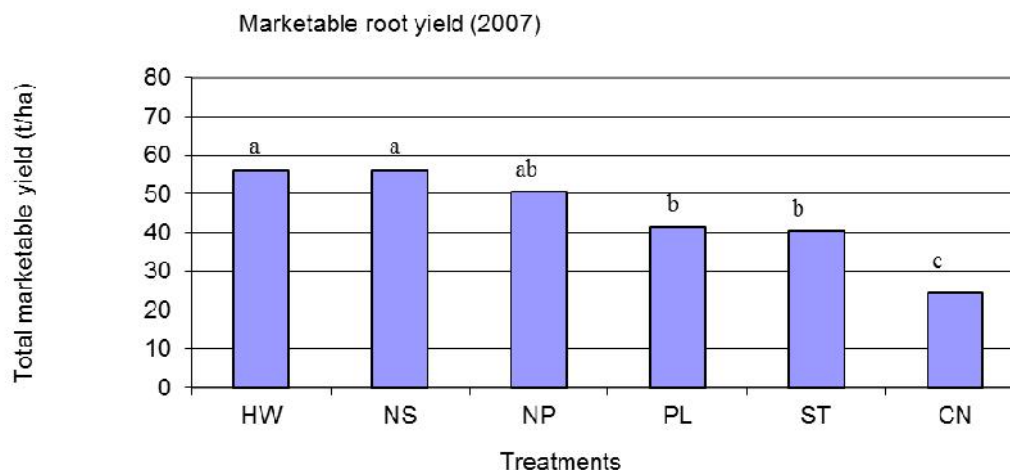
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HW=Hand weeding	NP=Newspapers	ST=Grass straws
NS=Narrow plant spacing	PL=Plastic	CN=Untreated control

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Fig. 6 Marketable root yield (t.ha⁻¹) of sweet potato at different weed control treatments during 2007.

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Bars marked by different letters differ significantly at the $P=0.05\%$ significance level.

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(LSD_($P=0.05$) = 13.33, CV% = 19.7)

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Size classes

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There were no significant difference in percentage roots per marketable size class with other treatments, except for extra-large % for which hand weeding (HW) and newspaper (NP) plots had the highest percentages (Table 1). Despite the non-significant differences in different treatments on the other three size classes, narrow plant spacing showed a tendency of higher percentages for both small and medium size classes (Table 1).

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Table 1 Mean percentage roots per marketable size classes achieved by sweet potato at different weed control treatments during year 2007

Treatments	Means per size class			
	Small %	Medium %	Large %	Extra-large %
Hand weeding (HW)	38.1	27.4	21.0	13.60 a
Newspapers (NP)	42.1	37.2	14.5	6.25 b
Narrow plant spacing (NS)	41.2	37.4	18.6	2.90 b
Grass straws (ST)	41.4	37.7	17.5	3.40 b
Plastic (PL)	41.0	37.1	19.7	2.23 b
Control (CN)	48.3	38.9	11.1	1.73 b
<i>P</i> =.05	.714	.332	.147	.020*
CV %	21.2	21.1	30.8	92.0
MSE	79.2	57.2	27.6	21.3

Means followed by the same letter do not differ significantly at the *P*=.05% significance level

* F-probability significant at *P*=.05

CV% = Coefficient of variance in percentage

MSE = Mean Square Error

The herbicide application combinations did not provide advantages in terms of canopy cover and weed control efficiency above narrow row spacing (NS) and plastic mulch (PL). Lewthwaite and coworkers tested application of a large number of herbicides for weed control in sweet potato [19]. None could be justified by improved economic returns and also herbicide phytotoxicity was detected.

Most of the mulch treatments reported above are novel for use in sweet potato. Some research on sweet potato has been conducted by Ossom and coworkers, who found grass to lower the number of weed species and reduce weed weight [15]. However, they also emphasized the danger of grass establishment in fields and therefore, did not recommend its use. In their experiment, the use of sawdust was not effective as compared to grass and coffee pulp mulch. They also reported a decrease in soil temperature due to mulching and found the effect on dry matter yield was not significant. Gawronski used newspaper mulch on silver beet, and found it to be potentially useful [20]. However, there were confounding effects in the experiment causing the results to be inconclusive.

4. CONCLUSION

This study showed that mulching (plastic and newspapers) and narrow plant spacing could be used to improve weed management in sweet potato, since these provided effective weed control and earlier canopy closure. Newspaper mulch particularly, seems to be a viable option for small holder farmers to control weed in sweet potato plantings and resulted in high marketable root yield and optimum size class, similar to hand weeding.

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