



Effect of Different Types of Mulching and Plant Spacing on Weed Control, Canopy Cover and Yield of Sweet Potato (*Ipomoea batatas* (L.) Lam)

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Authors' contributions

This work was carried out in collaboration between all authors. Author MNM designed the study under supervision of supervisors, wrote the protocol and executed the trials. Author HMN wrote the first draft of the manuscript and arranged for statistical analysis by the Biometry division. Author SML supervised, Author MNM during her studies, managed analyses of the results and wrote large parts of the manuscript. Author CPDP supervised the study as program manager and made inputs at all phases. All authors read and approved the final manuscript.

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ABSTRACT

The aim of the study was to determine the effects of mulching, plant spacing and other control measures on effectiveness of weed control, canopy cover and sweet potato yield. The cultivar Blesbok was planted in a randomized complete block design where seven treatments were replicated four times. Field trials were established at the Agricultural Research Council - Roodeplaats Vegetable and Ornamental Plant Institute in Pretoria, South Africa during 2006 and 2007. 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

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beneficial for both weeds and the crop making it difficult to control the weeds. Instead, grass straws (ST) and newspaper (NP) mulches were added. 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. 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]. Manual weed control (by 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 mechanization 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 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 mentioned methods might not be suitable for large-scale production and as effective as chemical control, however, these can provide small-holder farmers with useful options.

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. MATERIALS 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 2006 (Trial 1) and 2007 (Trial 2) planting seasons. Trial 1 was established 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 prior to planting to control broadleaved and grassy weeds [17]. Fusilate, a post emergence herbicide, was applied after emergence of grass weeds two months after planting 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⁻¹ 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⁻¹ of Limestone ammonium nitrate (LAN, 28% N) was applied six weeks after planting. The nutrient application was therefore 95 kg ha⁻¹ N, 80 kg ha⁻¹ P and 106 kg ha⁻¹ K.

Weed control effectiveness was determined based on visual estimation of the percentage area free of weeds. The percentage canopy closure per plot were determined by visual estimation. Both parameters were recorded at weekly intervals. Unfortunately early frost killed

of the plants in Trial 1 before the storage roots reached maturity.

Trial 2 was planted to determine the effect of weed control treatments on root yield and was 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 favours the growth of weeds, 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). 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.

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

3. RESULTS

3.1 Canopy Closure and Weed Control Effectiveness

The results of Trial 1 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 (Fig. 1). The canopy cover for the narrow plant spacing (NS) plots was faster than that of other treatments. In Trial 1, at week 2 and 3, narrow spacing exceeded ($P=0.05$) the canopy cover of most other treatments, and in Trial 2 there was a tendency of higher cover at week 2 and 3 (Figs. 1 and 2). In Trial 2, by week

4 the narrow row spacing (NS), plastic mulch (PL) and newspaper much (NP) performed significantly better than grass straws (GS) and the untreated control (CN) (Fig. 2). Together with the hand weeding (HW), these treatments obtained more than 90% cover by week 5 (Fig. 2).

Plastic (PL) were similar to the hand-weeded (HW) treatment in effectiveness of weed control as seen from the results of Trial 1 (Fig. 3), while

the narrow plant spacing (NS) and herbicide treatments successfully controlled most of the weed population. In Trial 2, newspaper mulch (NP), plastic mulch (PS) and narrow spacing (NS) controlled the weeds as effectively as hand weeding (HW) from week 3 onwards (Fig. 4). Weed control efficiency of compost (CO) and grass straw (ST) mulch plots deteriorated weekly as from week 3 (Fig. 4), which showed that these treatments were ineffective in suppressing the weeds.

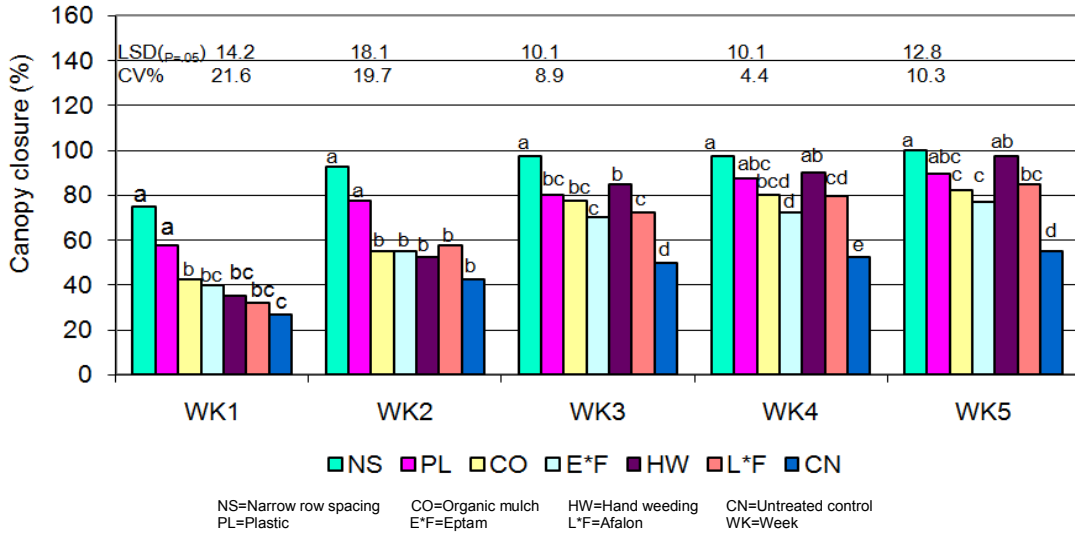


Fig. 1. Weekly canopy closure (%) of sweet potato at different weed control treatments for Trial 1

Bars marked by different letters differ significantly at the P=.05 significance level

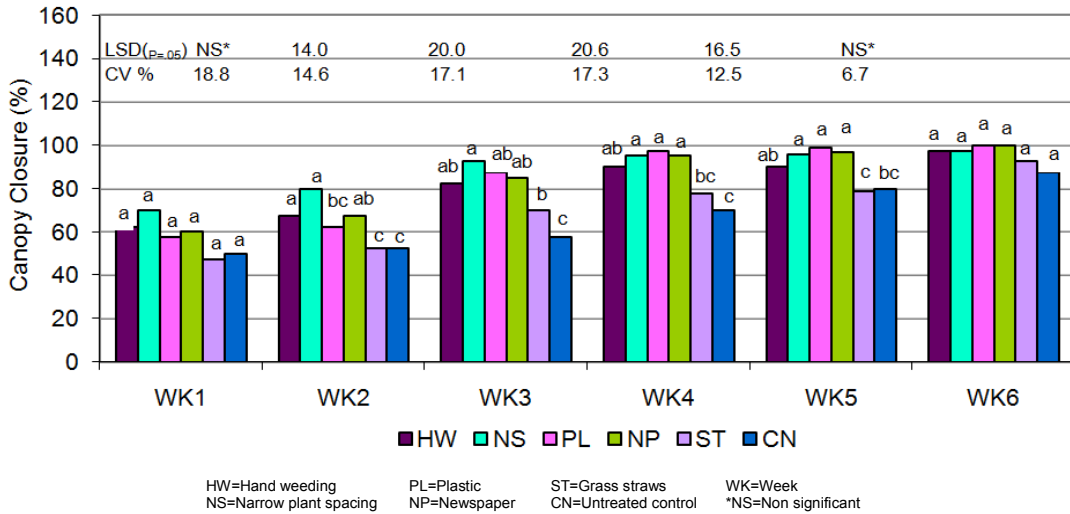


Fig. 2. Weekly canopy closure (%) of sweet potato at different weed control treatments for Trial 2

Bars marked by different letters differ significantly at the P=.05 significance level

3.2 Yield

In Trial 1 there were no significant differences in crop yield with various treatments from the control treatment because plants were killed by frost before the storage roots reached maturity. However in Trial 2, almost all treatments exceeded the unweeded control in marketable root yield as well as total root yields (Figs. 5 and 6). Hand weeding (HW) and narrow spacing (NS) produced the highest total yields of above 70 t/ha (Fig. 5). Plastic (PL) and newspaper (NP) mulched plots produced total yields of 60 t/ha, which were not significantly lower than hand weeding (HW). The control

treatment produced total yields of less than 40 t/ha (Fig. 5).

Hand weeding, narrow spacing (NS) and newspaper (NP) plots yielded the highest marketable root yield, exceeding 50 t/ha as compared to 24.5 t/ha for the unweeded control (CN) (Fig. 6). Plots mulched with plastic (PL) and grass straws (ST) produced average marketable root yields, around 40 t/ha (Fig. 6). This may be due to weed competition at early stages of growth in the case of grass straws. The lower marketable yield detected with plastic mulch was due to the number of sprouted storage roots (data not shown).

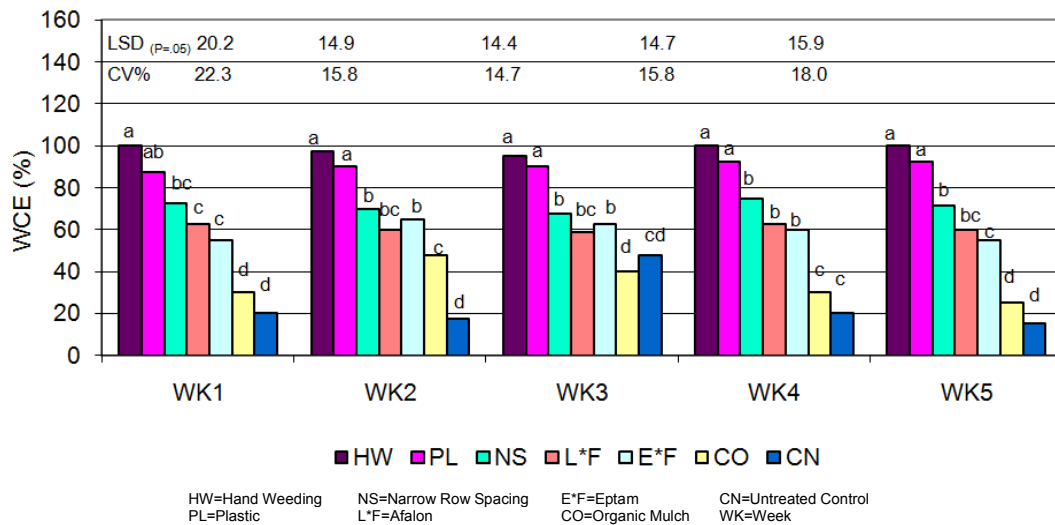


Fig. 3. Weekly weed control effectiveness (WCE) at different weed control treatments of sweet potato for Trial 1

Bars marked by different letters differ significantly at the P=.05 significance level

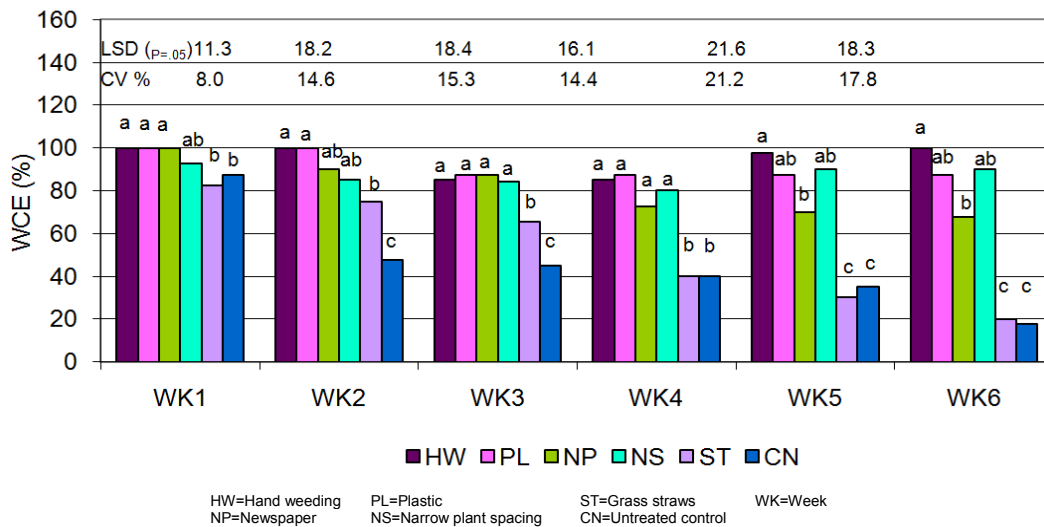


Fig. 4. Weekly weed control effectiveness (WCE) of sweet potato for Trial 2

Bars marked by different letters differ significantly at the P=.05 significance level

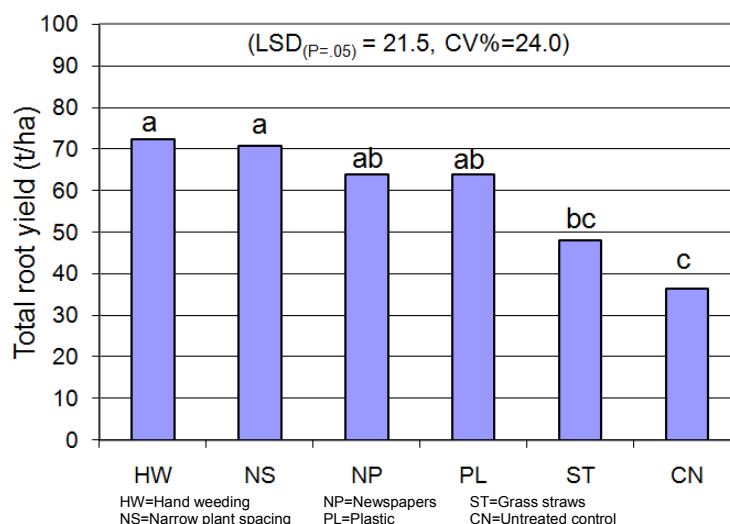


Fig. 5. Total root yield of sweet potato at different weed control treatments for Trial 2 Bars marked by different letters differ significantly at the $P=0.05$ significance level

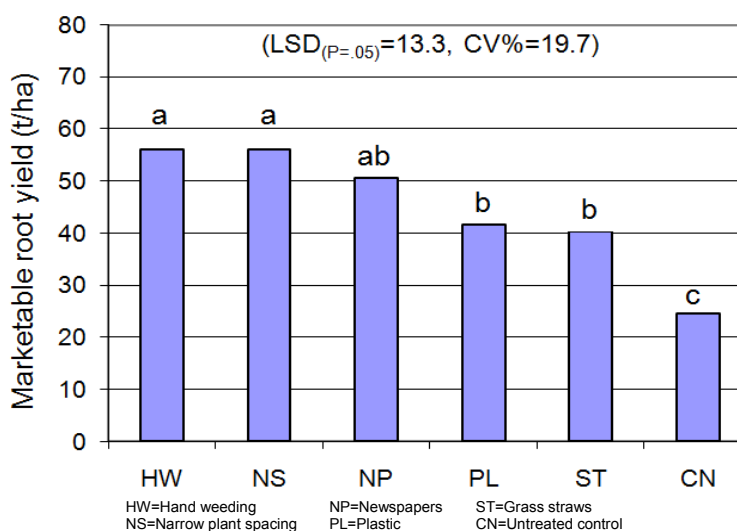


Fig. 6. Marketable root yield of sweet potato at different weed control treatments for Trial 2 Bars marked by different letters differ significantly at the $P=0.05$ significance level

3.3 Size Classes of Roots

There were no significant difference detected in Trial 2 for percentage roots per marketable size class among 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, the untreated control showed a tendency of higher percentage for small-sized roots and smaller percentage large-sized roots (Table 1).

4. DISCUSSION

There is a paucity of research of weed control of sweet potato, compared to other major staple crop, and more so in terms of methods of control related to small-holder farming. The present study established that narrow row spacing (NS), newspaper mulch (NP) and plastic mulch (PL) are good options for weed control in sweet potato. These treatments reduce the cost of labour to execute hand weeding and should be useful for small-scale production.

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	0.714	0.332	0.147	0.020*
CV %	21.2	21.1	30.8	2.44
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

Most reported weed management research in sweet potato were based on large scale agriculture. Chemical weed control is generally considered to be effective in crop production, but has constraints such as the cost of chemicals and the application thereof, phytotoxic effects on the crop and environmental sustainability. For example, in a study by Steven and coworkers [19] at nine days after transplanting sweet potato, 20% injury was observed of the application of flumioxazin. Lewthwaite and coworkers [20] tested application of a number of herbicides (i.e. acetochlor, dimethenamid and alachlor) for weed control in sweet potato due to occurrence of paraquat-resistant black nightshade. In that experiment none of the chemicals tested could be justified by improved economic returns and, in addition, herbicide phytotoxicity was detected. In the present study, herbicide application combinations did not provide advantages in terms of canopy cover and weed control efficiency above narrow row spacing (NS) and mulching with newspaper (NP) or plastic (PL). The present study reports novel results of the effectiveness of the use of newspaper mulch for control of weeds in sweet potato. Some research on the use of mulch for control of weeds in sweet potato has been conducted by Ossom and coworkers, who found grass mulch 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. These authors furthermore reported a decrease in soil temperature due to mulching but found non-significant effect on dry matter yield. In another study by Gawronski [21] newspaper mulch was tested on silver beet, and the authors

found the mulch to be potentially useful. However, there were confounding effects in the experiment causing the results to be inconclusive. Sangakkara and coworkers [22] found that rice straw and grass mulch increased root yield, leaf area and crop growth rates of sweet potato and reduced the time for storage root initiation significantly. Management aspects of mulching should also be taken into account. Organic mulch, e.g. grass mulch, allows some flexibility in fertilization and irrigation, since the water can infiltrate and the mulch can be raked back from the plants, and organic mulch decomposes naturally. Inorganic mulches, e.g. plastic, do not decompose and the plastic need to be removed by hand after the growing season, and as seen in the present study, may need management of soil moisture to avoid sprouting. Newspaper mulch (Fig. 7) provides an option similar to plastic mulch but has the advantage of decomposing naturally.

The use of narrow row spacing (NS) is also an attractive option for weed control in sweet potato. Most studies have shown the benefits of reducing row spacing on early canopy closure that increases the capability of crops to compete with weeds for sunlight, nutrients and water [16]. In this regard it will be important to consider the effect of plant population in relation to the cultivar. Blesbok, the cultivar used in the present study, did not show significant yield reduction with narrow spacing (NS). The case may be different for other cultivars, e.g. those which are slow maturing or more reactive to plant population. Du Plooy and coworkers found that closer spacing between plants influenced size class achieved in certain cultivars while not influencing others [23].



Fig. 7. Newspaper mulch plot at four weeks after planting showing the effective weed control

5. 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 and narrow spacing particularly, seems to be a viable option for small holder farmers to control weeds in sweet potato plantings and resulted in high marketable root yield, similar to hand weeding. Future research may further investigate the influence of mulching and narrow spacing on root size and should be tested specifically per cultivar before making production recommendations.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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