BUREAU OF SUGAR EXPERIMENT STATIONS
QUEENSLAND, AUSTRALIA

# FINAL REPORT
## SRDC PROJECT BS31S

# PHYTOTOXIC SUBSTANCES ASSOCIATED WITH THE DECOMPOSITION OF SUGARCANE TRASH RESIDUES

by

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## SUMMARY

Ratooning through trash blankets is generally effective with minor exceptions for certain varieties and in cold or waterlogged soils. Information was required to determine whether these effects are normal reactions of slow ratooning varieties to the cold conditions or poor aeration, or whether there are toxic effects attributable to trash residues, ie allelopathy.

The project was a preliminary investigation to assess potential allelopathic effects from trash residues on the growth of sugarcane. It was concentrated mainly on north Queensland soils and varieties due to the high percentage of trash retention in that area. A smaller test program was carried out at Bundaberg to take into account a wider suite of varieties and soils.

The experimental approach involved glasshouse studies to determine if the decomposition products or leachates from trash residues have an adverse effect on germination and early plant growth. Treatments focussed on environmental conditions known to produce an adverse reaction from trash retention under field conditions, including wet soil for prolonged periods and cool temperatures.

Results from these experiments indicated that trash blanketing had a negative effect on germination and root growth, but it was only temporary and disappeared with time. Varieties showed differential sensitivity to trash blanketing and the trash blankets from certain varieties had a greater effect on germination than others. The inhibitory effect on germination was more pronounced on poorly drained soil types, possibly due to leaching of chemicals from the trash residue.

Yields were generally unaffected by the decomposing trash residues. An important result was the deleterious effect on plant growth from waterlogging soil prior to planting. This adversely affected both root and shoot growth, particularly on a soil type with poorer drainage. Chemical and/or biological activity in the wet soil may result in accumulation of by-products which are toxic to plant growth. This may be significant in the yield decline problem.

Researchers from the University of New England attempted to identify allelochemicals in extracts from leaf and trash of different cane varieties. Several phenolic acids were identified and some of these are known to have allelopathic effects in other plant species.

Future research should test the phytotoxic effects of the phenolic acids identified, then concentrate on potential phytotoxic effects of root and stubble residues on ratoon growth, particularly under conditions of high soil moisture.

## OBJECTIVES

To determine if phytotoxic substances are produced during the decomposition of trash residues from sugarcane.

## BACKGROUND

Allelopathy - biochemical interactions between plants of all levels of complexity - has been identified with secondary metabolites released by plants during life and from their residues after death. In agricultural situations, allelochemicals may be washed from foliage or plant residues by rainfall or irrigation, or released into the rhizosphere. For the most part, their destination is the soil where they may accumulate to concentrations not found in the plant material itself. Ultimately, these biologically active compounds break down but at varying rates according to ambient conditions.

Interest in potential allelopathic effects from sugarcane trash residue was prompted by the success of trash residues in suppressing weeds, and by reports from Taiwan of allelopathic effects following waterlogging of soils.

Green cane harvesting in Queensland expanded by 1990 to reach 34% overall and 75% in north Queensland. Trash residues are mainly left in situ with minimum or zero cultivation, the changeover occurring mainly because of its cost effectiveness. There are indications that the green-cane-harvesting/trash-conservation system also increases productivity. Acceptance has been limited in some areas because of concern over adverse effects on crop growth, particularly under wet conditions or at low soil temperatures. This raised the question of whether it is purely an environmental effect or due to the release of phytotoxic substances associated with the decomposition of plant residues (allelochemicals). The answer to this question could have a significant influence on the adoption of trash conservation. It would also have an impact on the profitability of growers.

## METHODOLOGY

The study was undertaken in controlled environment conditions and included genotypes such as Q124 and Q136 which were reported to be affected adversely by trash blanketing.

A bioassay system used germinating cane setts or very young cane plants to detect the presence of phytotoxic substances emanating from trash residues. The study was restricted to the germination and early growth phases of plant development, and presence of phytotoxic substances was determined from the presence of visual symptoms on roots and the dry weights of assay plants. The bioassays were carried out under different temperatures as well as under waterlogged and well-drained conditions. Chemical assays were carried out on extracts of trash residues to identify allelochemicals.

Detailed experimental methods are given in Attachments 1 and 2, which are BSES Project Reports on the research.

## RESULTS

Detailed results of the experiments are provided in Attachments 1 and 2. The main conclusions were as follows:

- Trash blanketing produced negative effects on germination and sett root growth, particularly where tests were carried out with trash blankets from a range of varieties.
- Varieties showed differential sensitivity to trash blanketing in germination trials.
- Trash blankets from some varieties had a greater effect on germination than from others.
- The negative effect on germination appeared to be more pronounced on soils with poorer internal drainage.
- The negative effect on germination decreased or disappeared with time.
- Trash blanketing adversely affected root growth, but the effect on shoot growth was less pronounced or non-existent.
- Storing or incubating the soil in a wet condition before planting adversely affected shoot and root growth.
- Chemical or biological effects of 'waterlogging' on plant growth were of greater significance than those due to trash blanketing.
- Several phenolic acids were identified in extracts from leaf and trash of different cane varieties and some of these are known to have allelopathic effects in other plant species.

## ACHIEVEMENTS

This study achieved its objective by determining that substances phytotoxic to sugarcane are produced during the decomposition of trash residues. However, the main effect of these substances was to slow down germination although the effects generally were not permanent. Several of these chemicals were identified and require testing.

The project also identified other potential problems, possibly allelopathic, that can occur under waterlogged conditions.

## RECOMMENDATIONS

- Test the identified phenolic acids to determine whether they produce the toxic effects noted in this project.

- Examine the potential phytotoxic effects of root and stubble residues on ratoon growth, particularly under waterlogged soil conditions.

ATTACHMENT 1

**BUREAU OF SUGAR EXPERIMENT STATIONS**
**QUEENSLAND, AUSTRALIA**

**PROJECT REPORT**
**SRDC PROJECT BS31S**

# PHYTOTOXIC SUBSTANCES ASSOCIATED WITH THE DECOMPOSITION OF SUGARCANE TRASH RESIDUES

## 1. Tully studies

by

A P Hurney

## INTRODUCTION

There have been major changes in the cultivation methods utilised in the growing of sugarcane in recent years. Previously the crop was burnt, trash residues left after harvest were raked and burnt, and the field was cultivated mechanically. Currently, particularly in north Queensland, a high percentage of the crop is harvested green and the trash residues are left in situ with minimum or zero cultivation practices being employed.

These changes have occurred mainly because they are cost effective and increase profitability. There are indications that the green cane harvesting and trash conservation system can also increase productivity. Acceptance has been limited in some areas because of concern over adverse effects on crop growth, particularly under wet conditions or at low temperatures. This has raised the question of whether it is purely an environmental effect or due to the release of phytotoxic substances associated with the decomposition of plant residues (allelochemicals).

This project was intended as a preliminary investigation to assess potential allelopathic effects from trash residues on the growth of sugarcane. The study was undertaken at Bundaberg and Tully to obtain data from a wider suite of commercial canes and soils. Data from the Tully experiments are presented in this report.

## METHODOLOGY

The experimental approach involved glasshouse trials to determine if auto toxic chemicals derived from decomposing trash residues restrict plant growth. Treatments focussed on environmental conditions known to produce an adverse reaction from trash retention under field conditions. These included wet soil, particularly for prolonged periods, and cool temperatures. These were short term studies and investigated trash effects on germination and early shoot and root growth. Several factors were common to all experiments.

**Soils:** The two soil types used in these experiments were the Bulgun and Tully soil series, which are representative of poor and well drained soils which may be trash blanketed in the Tully area. Details of the soils are given in Table 1. Fresh soil was collected for each experiment from a non-trash blanket field and sieved through a 12.5 mm sieve prior to use.

**Varieties:** Four varieties (Q78, Q117, Q124, Q138) were used in all experiments. Q117 and Q124 have been associated with ratoon failures under trash blanket in the field, Q138 is a known good ratooner, and Q78 has shown possible allelopathic effects on weed growth. Chemical composition of leaf material from these varieties is given in Table 2.

**Trash mulch:** Fresh leaf material was collected from the same location for each trial. The material was shredded in a Jeffco cutter-grinder prior to use to produce a fine material which would have accelerated decomposition and from which chemicals could be leached more rapidly. The trash mulch was applied at a rate of 30 t/ha (fresh weight) which was approximately 20% higher than the quantity of trash in a field situation. A surface mulch of vermiculite was used as a control for comparative purposes to provide similar effects (shading, reduced evaporation) as the trash mulch. Application rate was adjusted to provide a similar depth of cover as the trash mulch.

**Germination experiments**

Two separate trials were carried out to investigate trash residue effects on germination.

**Trial 1:** A germination trial was carried out with four varieties and two surface mulches during February-March, 1990. Two separate experiments were carried out within the main trial on the Bulgun and Tully soil types. A split plot experimental design with four replicates was used, main effects being the surface mulch of trash and vermiculite with varieties as the split treatment.

Five single eye setts per replicate were planted in soil in trays, and the soil surface covered with the mulch. The setts were hot water treated for 30 minutes at 50°C and dipped in fungicide prior to planting to control diseases that might affect germination. The trays were spray irrigated through the surface mulch. Initially a five minute watering time three times daily was used, but the time had to be reduced to two minutes because of excessive waterlogging. Number of setts germinating was recorded daily. Root growth was not assessed to avoid damage to the plants, since the germinated setts were used to plant Trial 3.

**Trial 2:** This was conducted in the glasshouse during July-August, 1990 when temperatures were lower. Treatments, trial design and methods were the same as in Trial 1 except that 10 setts were used per replicate. Setts were taken from 10 upper nodes of a stalk, and position on the stalk was recorded at planting to enable assessment of effect of physiological age of the sett on germination. Setts were watered with overhead sprays three times daily for two minute time intervals. The following variables were recorded for each treatment: number of shoots per replicate on a daily basis, final shoot length, a visual fine root rating for sett roots (scale 0-10).

**Growth experiments**

**Trial 3:** This investigated the possible effect of trash residues on root and shoot growth and yield, and possible interactions with soil moisture, and was carried out during March-April, 1990. Treatments included two soils, four varieties, two mulches and two moisture regimes in a factorial design with four replicates. Pre-germinated one-eye setts from Trial 1 were transplanted into 150 mm clay pots. Mulch treatments and soils were consistent between both trials except for Q78 in the Tully soil, which required additional plants to be pre-germinated because of poor germination in Trial 1.

Each pot contained the equivalent of 1.5 kg of oven dry soil, to which had been added a basal nutrient application of 0.15 g ammonium nitrate plus 0.34 g di-potassium hydrogen orthophosphate per pot to supply normal N, P, K requirements. The plants were given a side dressing of urea (0.27 g/pot) after three weeks growth. The pots were placed in air-conditioned benches which maintained soil temperature between 22-28°C, but plant tops were at ambient temperatures.

The two moisture regimes were drained and waterlogged. Pots were free draining in the former and water was applied via surface sprays through the surface mulch. Watering cycle was for two minutes three times daily, which applied approximately 200 mL per pot; surface misting was also used. The same treatments were used in the waterlogged series, but pots also were sub-irrigated through the saucers which were kept filled with water using a drip system. This resulted in saturated soil conditions and watering regimes had to be adjusted occasionally to dry the soil particularly during early growth. Plants were harvested at 6.5 weeks of age. Plant height, shoot and root dry weight and a visual fine root rating (0-10 scale) for shoot roots were recorded at harvest.

**Trial 4:** Another trial to investigate the effects of trash residues on cane shoot growth was carried out in September-October 1990. Two separate experiments were run concurrently in this trial to assess temperature effects. Soil temperature was controlled in one half of the trial by placing the pots in air-conditioned benches, and temperature fluctuated between 22-28°C. Soil temperature fluctuated with ambient temperature in the other half of the trial. Treatments in each section of the trial included two soils, four varieties, two mulches and two incubation treatments, with four replicates set out in a factorial design.

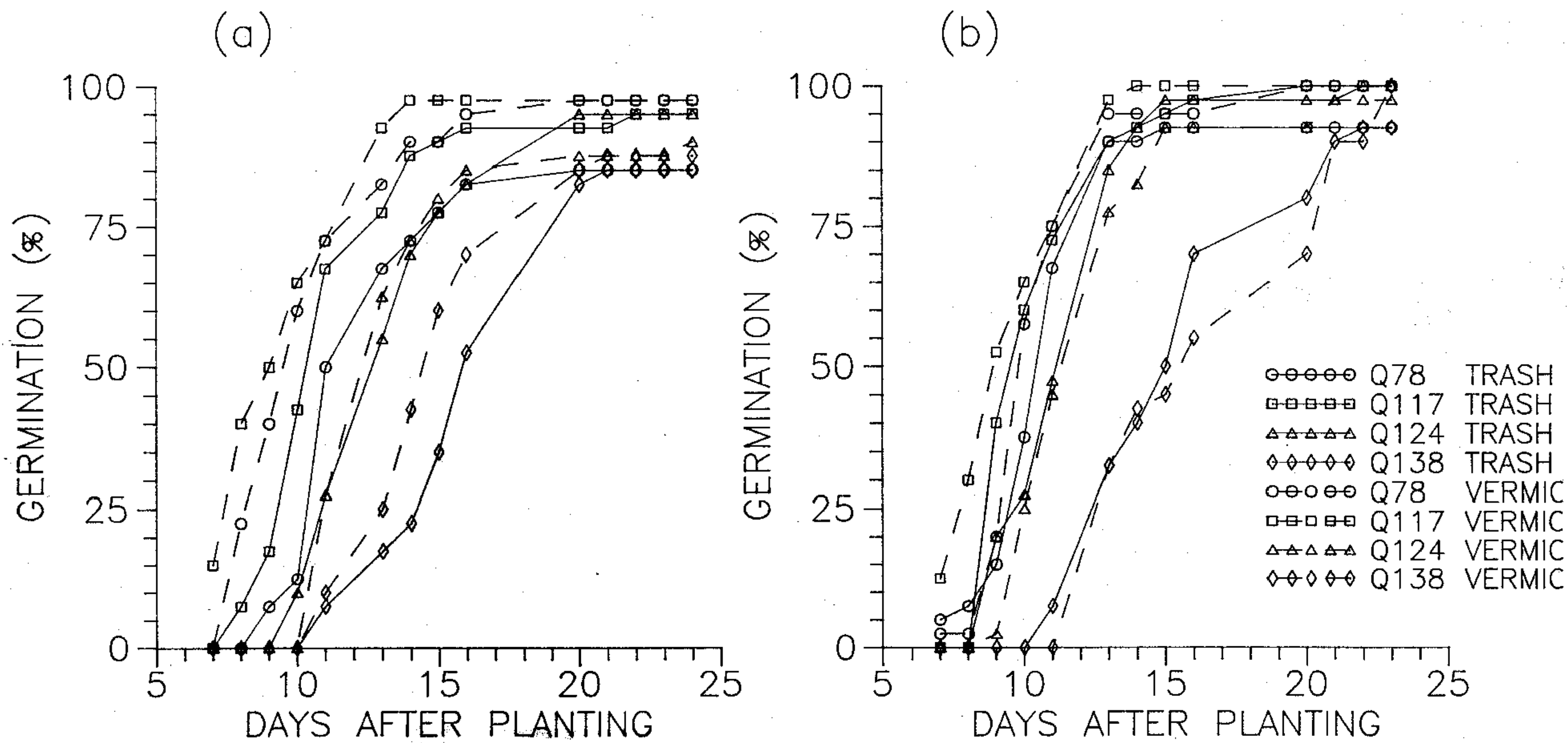
The incubation treatment was intended to increase the reaction time between the trash and soil, and provide more time for chemicals to leach from the trash and accumulate in the soil. Pots were filled with soil (1.5 kg OD) and the surface covered with trash or vermiculite. They were placed on the benches (air-conditioned or ambient) and left to incubate for three weeks. Soil was kept wet by overhead sprays and sub-irrigation, and was only dried at the end of incubation period to enable them to be planted. Surface mulches were returned to the same pot after planting. In the non-incubated treatments, soil was added to the pots immediately before planting. Watering during plant growth was by overhead sprays as per Trial 3. Fertiliser and rates were the same as in Trial 3 with basal applications being made at planting. The trial was harvested at seven weeks of age and data collected as for Trial 3.

## RESULTS AND DISCUSSION

### Germination experiments

Germination of sugarcane was reduced in both soils in Trial 1 by a surface mulch of decomposing trash residues (Fig. 1, Table 3). The effect was most apparent with the Tully soil and in Q78. The only exception was Q124 in the Tully soil where germination was enhanced by the trash residues.

Fig. 2 Effect of a trash and vermiculite surface mulch on germination of four cane varieties on two soils in Trial 2. (a) Bulgun soil (b) Tully soil



ATTACHMENT 2

BUREAU OF SUGAR EXPERIMENT STATIONS
QUEENSLAND, AUSTRALIA

PROJECT REPORT
SRDC PROJECT BS31S

# PHYTOTOXIC SUBSTANCES ASSOCIATED WITH THE DECOMPOSITION OF SUGARCANE TRASH RESIDUES

## 2. Bundaberg Studies

by

D R Ridge

## INTRODUCTION

Interest in potential allelopathic effects from sugarcane trash residues was prompted by the success of trash residues in suppressing weeds and by reports from Taiwan of allelopathic effects following waterlogging of soils. Green cane harvesting in Queensland has expanded to reach 34% overall in 1990 and approximately 75% in north Queensland, with leaf, tops and trash residues of up to 15 tonnes/hectare retained on the soil surface after harvest.

In general, ratooning through trash blankets is effective with minor exceptions for certain varieties and in cold waterlogged soils. Information is required to determine whether these effects are normal reactions of slow ratooning varieties to the combination of cold conditions/poor aeration, or whether there is a toxic effect attributable to trash residues. Sugarcane is known to have high levels of phenolics and amino acids, with considerable variation between varieties. It is also known that biological activity in trash residues produces a range of volatile fatty acids.

Apart from allelopathic effects of a cane variety on itself, there is significant mixing of trash residues from different varieties in small plot variety trials and this is a potential concern in the variety selection program.

The investigation of allelopathic effects from sugarcane trash residues was concentrated mainly at Tully on north Queensland soils and varieties due to the high percentage of trash retention in that area. A smaller test program was carried out at Bundaberg to take into account a wider range of cane varietal characteristics, and these results are present herein.

## METHODOLOGY

Three types of trials were carried out to investigate trash effects on germination, the combined effect on germination and shoot and root growth, and the effect on shoot growth alone. Trash extracts were also analysed both qualitatively and quantitatively for phenolic acids.

### Germination experiments

Two separate trials were carried out to investigate trash residue effects on germination.

**Trial 1:** Cane setts from seven varieties were planted in vermiculite in duplicate trays in August-September 1988. Each set of duplicate trays was covered with trash residues from one of the seven varieties giving a total of 14 germination trays. This gave a complete crossover effect of seven varieties under seven trash blanket covers. The trash was obtained from harvester trials with the same seven varieties and was typical of residues in the field. The trays were spray irrigated with town water through the trash blanket. The following variables were recorded for each variety : number of shoots produced per eight one-eye setts, height of shoots, number of setts producing roots, a visual fine root rating for sett roots (scale 0-10) and a visual rating for root stubbing effects (scale 0-10, 10 = nil root stubbing). These indices were combined to give an overall ranking of varietal reaction to trash blanketing. A high ranking infers a low reaction to trash blanketing.

**Trial 2:** Germination was carried out in September-October 1989 in a gley podzolic soil rather than vermiculite, but methodology otherwise was similar to above. Four varieties were tested, again with crossover between trash covers. Watering was carried out through the trash cover using deionised water rather than the town water used for the first trial. This eliminated possible confounding effects caused by salt buildup from the town water supply (E.C. 0.3-0.4 mS/cm). Germination of each replicate of 10 setts was recorded at two dates, final shoot length was measured and root stubbing was rated on the scale 0-10.

**Germination/growth experiment**

A germination/growth experiment was carried out with six varieties and two soil types in August-December, 1989. Four one-eye setts were planted in 250 mm black polythene pots filled with either krasnozem or humic gley soil, covered with approximately 50 mm of soil, then a cover of trash or vermiculite was applied to the surface of the pot. The setts were thinned to two per pot after germination. Each variety received a surface mulch of its own leaf and trash. Pots were watered with town water using one button dripper per pot. Watering time each day was adjusted for pot size. Pots were weighed periodically to check on effectiveness of watering. Pots were fertilised initially with di-hydrogen orthophosphate and urea and later with urea to supply normal N, P, K requirements. Each soil x variety combination was replicated eight times. Four replicates were assessed for germination (number of shoots), progressive growth (shoot vigour rating 0-10), and root stubbing symptoms at an intermediate harvest in October. Final shoot and root dry weights were recorded at harvest in December on the remaining four replicates.

**Growth experiment**

A trial to assess the possible effect of trash residues on cane shoot growth was carried out from August to December 1990. One-eye setts of four varieties were pre-germinated in vermiculite and transplanted into 200 mm clay pots after excision of the sett, with two shoots per pot. Three soil types were used as growing media : krasnozem, gley podzolic and humic gley, representing typical well to poorly drained soils which may be trash blanketed by Bundaberg growers. Each soil type was surface mulched with trash of the particular variety and with vermiculite. Treatments were replicated five times. Fertiliser was applied as indicated above.

Pots were watered by sub-irrigating through the saucers which were kept filled with water using a drip system and by regular hand watering or overhead misting. The misting was used for daily watering with supplementary hand watering with deionised water to minimise salt accumulation. Shoot dry matter was recorded at trial harvest and in the absence of any visible stubbing symptoms, no root weights were recorded.

**Analysis of cane extracts for phenolic acids**

Two separate series of leaf and trash extracts for phenolic acid analysis were prepared in 1990 and 1991, respectively. These were analysed at University of New England using a HPLC C18 column after centrifuging and passage through a Sep-Pak cartridge.

In 1990 extracts were prepared from four varieties: Q123, Q141, H56-752 and CP51-21. Leaf and trash were prepared in a cutter grinder, then shaken for 24 hours at 5 g/200 mL of extractant in water, 0.1% $NH_4OH$ and 40% methanol. The following 12 phenolic acid standards were used for identifying phenolic peaks in the cane extracts : gallic, protocatechuic, p-OH benzoic, chlorogenic, vanillic, caffeic, syringic, gentisic, ferulic, salicylic, p-coumaric and sinapic acids.

In 1991 four north Queensland (Q78, Q117, Q124, Q138) and four south Queensland varieties (Q136, Q141, H56-752, CP51-21) were tested. Water extracts were prepared from fresh cutter ground leaf and trash in the ratios 5 g/100 mL and 5 g/50 mL of extractant. The following 15 phenolic acids were used as standards for HPLC analyses: gallic, protocatechuic, gentisic, p-OH benzoic, chlorogenic, vanillic, caffeic, syringic, p-coumaric, ferulic, sindpic, salicylic, o-coumaric, transcinnamic and m-cinnamic acids.

## RESULTS AND DISCUSSION

**Germination trials**

**Trial 1:** Results are summarised in Tables 1 and 2.

The growth index rankings for the overall effect of each variety's trash cover on early growth of the range of varieties were as follows (in descending order from good to poor growth) Q136 > CP44-101 > Q124, Q135, Q110, Q142 > Q123.

Similar rankings for growth of varieties under the full range of trash covers are: Q123 > Q135, Q142 > CP44-101, Q136, Q110 > Q124.

Field rankings obtained from BSES extension staff for ease of ratooning under trash blanketing are as follows: CP44-101 > Q123, Q135, Q142 > Q136, Q124. No ranking is available for Q110 as it is rarely cut green.

These rankings from Tables 1 and 2 show trends only, as no statistical tests were carried out. However they suggest that there is one link between the inhibitory effect of trash from a given variety on other varieties and its own reaction to trash blanketing. For example, Q123 grows well under trash blanketing but appears to have a significant adverse effect on other varieties; Q136 reacts adversely to trash blanketing but has little effect on other varieties. If these results can be transferred to ratoon growth in the field, the interaction between varieties could affect selection in variety trials which are harvested green.

**Trial 2:** Results are summarised in Tables 3, 4 and 5.

From Table 3 it is evident that trash effects on germination are more pronounced at 3 weeks than at 4.3 weeks. At the initial assessment, trash from the different varieties gave the following order of germination percentages Q141 > CP51-21 > Q123 > H56-752. At the final assessment only H56-752 trash gave a relative depression in germination percentage. Similarly, varietal growth under the range of trash blankets followed the order initially of CP51-21 > H56-752 > Q123 > Q141. The final order was CP51-21 > Q123 > Q141 > H56-752.

These results show similar trends to Trial 1 with Q141 being relatively sensitive to the trash blanket of other varieties, but its trash having least effect on other varieties. Q123 behaved as in the first trial, germinating quite well under trash but its trash having a moderately severe effect on other varieties. Trash from the variety H56-752 produced the strongest negative effect on all varieties except CP51-21, but it did not germinate as well as other varieties. CP51-21 germinated best under the range of trash blanket types.

Shoot length data in Table 4 again suggest that trash from H56-752 had a negative effect relative to other varieties. Q141 grew less under trash covers from the other three varieties than under its own trash.

The data on root stubbing in Table 5 show some consistency with germination and shoot length data, as Q141 and H56-752 showed the greatest root stubbing. Trash from CP51-21 produced the greatest root stubbing.

**Germination/growth experiment**

The early assessment of germination and root growth in Table 6 showed slightly better growth under trash blanketing than under vermiculite, so there was no apparent negative effect from trash blanketing. Only slight to moderate root stubbing was evident and this was generally similar under both trash and vermiculite mulches.

Final harvest data for root and shoot oven dry weights are given in Table 7. For the krasnozem soil type, root weights were similar under trash and vermiculite mulches for four varieties but the latter was superior for CP51-21 and Q141. In the humic gley soil type, five of the six varieties showed greater root weights under the vermiculite mulch and the most significant differences again occurred for CP51-21 and Q141.

Shoot weights showed no consistent differences between trash and vermiculite mulches in the krasnozem soil, but five of the six varieties had higher shoot weights under vermiculite mulch in the humic gley soil. The largest shoot weight differences occurred with CP44-101, Q136, Q124 and Q141.

In general, apparent reductions in growth under variety trash blankets were more pronounced in the poorly drained humic gley soil than in the well drained krasnozem.

### Growth experiment

Results of the shoot growth assessment trial on three soil types are summarised in Table 8. There was considerable variability in yield but no apparent negative effect from trash blanketing. Trash blanket mulching generally gave higher shoot weights than the vermiculite mulch. There is no obvious reason for this except for better water penetration with the overhead spray watering system.

### Analysis of cane extracts

Results for the 1990 series of extracts were qualitative only, and identified the presence of six phenolic acids with chromatograph peaks corresponding to six of the 12 phenolic acid standards used for comparison. These were protocatechuic, vanillic and caffeic (similar retention times), ferulic, chlorogenic, gallic and p-OH benzoic acids. Most of these acids have been previously identified as having some allelopathic activity.

For the 1991 samples, 15 phenolic acids were used as standards and seven of these acids were identified as present in Bundaberg and north Queensland varieties. Quantitative assessments were obtained for four of these seven phenolics and one unknown phenolic peak. Levels of protocatechuic, p-OH benzoic, vanillic and syringic acids and the unknown peak (retention time 13.57) are given in Tables 9 and 10 for Bundaberg and north Queensland varieties respectively.

In general the southern Queensland varieties had higher levels of phenolics than the north Queensland varieties did. Protocatechuic acid was the dominant phenolic, but in H56-752 vanillic acid was the main phenolic. As pointed out earlier, several phenolics are known to have allelopathic effects in other plant species and in some cases these are synergistic.

## CONCLUSIONS

The following conclusions can be drawn from the Bundaberg trials:

- Trash blanketing produced negative effects on germination and sett root growth, particularly where tests were carried out with trash blankets from a range of varieties.
- Varieties showed differential sensitivity to trash blanketing in germination trials.
- Trash blankets from some varieties had a greater effect on sett germination.
- The negative effect of trash blanketing on sett germination decreased with time.

- Where trash blankets were compared with a vermiculite mulch, there was an apparent negative effect of trash blanketing on root growth, particularly in a poorly drained humic gley soil type. The negative effect on shoot growth was less pronounced.

- Several phenolic acids were identified in extracts from leaf and trash of different cane varieties, and some of these are known to have allelopathic effects in other plant species.

- Further testing is required to determine whether any or all of the phenolic acids identified have specific allelopathic effects on cane at the levels found in water extracts from trash.

## RECOMMENDATIONS

- Specific testing for phytotoxic effects should be carried out with phenolic acids identified in cane extracts, to determine whether they are the causal agents of toxic effects noted in this project.

- Future research should concentrate on potential phytoxic effects of trash or root residues on ratoon growth, rather than on cane sett germination and sett-shoot growth.

**Table 1**

**Effect of different trash covers on one-eye sett development averaged over the seven varieties, Trial 1**

| Measurement | Variety trash cover | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Q124** | **Q123** | **Q142** | **Q110** | **Q135** | **CP44-101** | **Q136** |
| Shoot number | 5.0 | 4.7 | 5.6 | 4.4 | 5.3 | 6.0 | 5.3 |
| Shoot height* | 7.0 | 6.9 | 6.7 | 6.0 | 6.1 | 6.8 | 7.1 |
| Presence of sett roots | 7.9 | 6.9 | 7.1 | 7.9 | 7.4 | 7.4 | 7.4 |
| Fine root rating | 5.6 | 5.6 | 6.4 | 6.3 | 6.7 | 6.3 | 8.1 |
| Root stubbing rating | 4.6 | 3.4 | 4.0 | 6.3 | 4.6 | 6.6 | 8.3 |
| Growth index | 30.1 | 27.5 | 29.8 | 30.9 | 30.1 | 33.1 | 36.2 |

* Actual shoot height was divided by 15 to reduce it to the 0-10 range used for ranking other measurements.

**Table 2**

**Effect of trash cover on one-eye sett development of individual varieties, Trial 1**

| Measurement | Variety (all trash covers) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Q124** | **Q123** | **Q142** | **Q110** | **Q135** | **CP44-101** | **Q136** |
| Shoot number | 2.7 | 7.3 | 4.4 | 4.3 | 4.9 | 6.3 | 4.6 |
| Shoot height* | 5.6 | 7.3 | 8.5 | 5.4 | 7.2 | 6.1 | 6.6 |
| Presence of sett roots | 7.9 | 7.7 | 6.1 | 7.3 | 8.0 | 7.3 | 7.6 |
| Fine root rating | 5.0 | 7.9 | 7.0 | 5.7 | 7.1 | 5.4 | 6.0 |
| Root stubbing rating | 3.7 | 6.9 | 6.9 | 4.9 | 6.0 | 5.1 | 4.3 |
| Growth index | 24.9 | 37.1 | 32.9 | 38.6 | 33.2 | 30.2 | 29.1 |

* Actual shoot height was divided by 15 to reduce it to the 0-10 range used for ranking other measurements.

In Trial 2, germination was slower under a trash than a vermiculite mulch during the first 10 days (Fig. 2, Table 4). The differences were more pronounced on the Bulgun soil which tends to have poorer internal drainage. Varietal differences occurred with Q138 affected more than Q117 or Q78; although germination of Q124 was faster under the trash mulch. The differences in germination between mulches had disappeared by 20 days after planting, and final germination percentage exceeded 90% in nearly all treatments.

Plant height and sett root growth were significantly better under the trash mulch on the Tully soil, although sett root development was poor in all treatments on this soil. Treatment differences were not evident on the Bulgun soil (Table 5).

The variable results obtained in the first trial are considered to be associated with immaturity of the setts coupled with waterlogged soil conditions due to excessive watering during the early stages. Q78 is normally a reliable germinator but performed poorly in this trial, with a high percentage of setts affected by fungal rot. All varieties were affected by rotting setts but it was more evident in Q78. The incidence of sett rots was more pronounced under the trash mulch, possibly increased by chemicals leaching from the trash.

Data on soils effects are conflicting. Adverse effects from decomposing trash were more pronounced on the Tully soil in Trial 1, but trash enhanced germination on this soil in Trial 2. The converse applied to the Bulgun soil. No explanation is offered for this phenomena.

The initial differences in germination in Trial 2 could not be attributed to lower temperatures under the trash mulch. Unfortunately full temperature data were not available because of a malfunction in the datalogger. Temperatures were recorded manually at 9 am daily, and ranged from 11 to 21°C during the trial period; but no differences occurred between soils or type of mulch.

Initial differences in germination in Trial 2 could have been associated with adverse effects from chemicals leached from the decomposing trash mulch. However this effect was temporary. The physiological age of the buds did not affect final germination, although initially it was quicker from the younger or more immature buds.

These results are more applicable to ratoon crops because trash blanketing is not generally practised in plant crops. The conditions in the trial were extreme to simulate conditions where ratoon mortality has been observed in the field. The results indicate that germination may be slower under wet conditions, but failure is unlikely to result from the presence of a trash mulch. However under extreme or prolonged wet weather, leachates from a trash mulch may increase germination failure. The situation could be exacerbated where stubble has been damaged during harvest.

**Growth experiments**

**Trial 3:** Varietal differences were the only significant effects obtained with the Bulgun soil type, and there were no interactions with other treatments. There was a significant interaction between varieties and the type of surface mulch on the Tully soil type (Table 6). The trash mulch had an adverse effect on shoot height and weight and root weight in Q78 and Q124, but a positive influence on these yield components with Q117 and Q138.

No responses in growth were recorded under the different moisture regimes, although there may have been insufficient differentiation in soil moisture contents. However, the results tended to be variable in this trial and this may have restricted responses.

**Trial 4:** The major factor influencing growth in this experiment was incubation of the soil in a wet condition for three weeks prior to planting. This resulted in a reduction in shoot height and weight, root weight and fine root rating (Table 7), irrespective of the type of surface mulch or temperature conditions of the soil. The influence of incubation on plant growth was more pronounced on the Bulgun soil type, with similar results being obtained under both temperature regimes (Table 8).

There was a significant interaction between varieties and the type of surface mulch, but this was recorded only where soil temperature was controlled (Table 9). Shoot weights of Q78 and Q138 were reduced by the presence of decomposing trash but were increased for Q117 and Q124. These results were reversed under ambient temperatures although the responses were not significant. The trash blanket reduced root growth under both temperature regimes (Table 10) but there was no interaction apparent with soils, variety or method of incubation.

The major outcome from both of these growth experiments was the adverse effect on plant growth that occurred if soil was stored in a wet condition prior to planting. Since there were no significant interactions apparent with decomposing trash, it is assumed that the adverse effects are related to chemical reactions within the soil rather than the effects of chemicals released from decomposing trash.

This does not eliminate allelopathy as a factor affecting plant growth, however. Decomposition products from roots and other organic material in the soil could still be an influencing factor. The pre-conditioning treatments provided in this experiment may have provided an ideal environment for enhanced chemical or biological activity. These results merely suggest that leachates from trash per se may not be an adverse contributing factor to shoot growth.

There are some indications in the data that chemicals leaching from the trash blanket may have had an adverse effect on root growth. The effects were not consistent across all trials and were not reflected in a corresponding effect on shoot growth. However these were short term trials. These results do suggest that leachates, presumably containing chemicals, from trash have the potential to influence root growth.

Conclusions regarding varietal sensitivity to the effect of trash blankets are difficult because the data is conflicting. The only consistent result appeared to relate to adverse effects on the growth of Q78. Results with the other three varieties were inconsistent and tended to be at variance with known field reactions.

### Analysis of cane extracts

Water extracts from the trash were analysed for the presence of phenolic acids (see Bundaberg report). Five acids were detected in these extracts: protocatechuic, p-OH benzoic, vanillic and syringic acids, and an unknown acid. Several of these phenolics are known to have allelopathic effects in other plant species and in some cases these are synergistic. The effects of these phenolics on sugarcane growth were not tested in this study.

## CONCLUSIONS

The following conclusions can be drawn from these trials:

- Varieties showed differential sensitivity to trash blanketing in germination trials.
- Trash blanketing produced negative effects on germination and sett root growth.
- The negative effects of trash blanketing on sett germination varied with soil type but appeared to be more pronounced on poorly drained soils.
- The negative effect of trash blanketing on germination disappeared with time.
- Trash blanketing had an apparent negative effect on root growth when compared with a vermiculite mulch. There was no apparent temperature effect.
- Data on the effect of trash blanketing on shoot growth of different varieties were conflicting.
- Storing (or incubating) soil in a wet condition before planting adversely affected shoot and root growth.
- Chemical or biological effects from waterlogging on plant growth were of greater significance than those due to trash blanketing.
- Several phenolic acids have been identified in extracts from leaf and trash of different cane varieties.

## RECOMMENDATIONS

- Test phenolic acids identified in cane extracts for phytotoxic effects, to determine if they are the causal factor in toxic effects noted in these studies.

- Future research should concentrate on possible autotoxicity on ratoon growth from chemicals released from decomposing stubble and root residues, particularly under wet soil conditions.

## ACKNOWLEDGMENTS

The able technical assistance of Mr M Ronkainen is gratefully acknowledged. Funds for this study were provided by the Sugar Research and Development Corporation.

**Table 1**

**Physical and chemical properties of Bulgun and Tully soil series**

| Soil | Clay % | Silt % | Sand % | pH | C % | Ca me/100g | Mg me/100g | K me/100g | P mg/kg |
|---|---|---|---|---|---|---|---|---|---|
| Bulgun | 49 | 33 | 18 | 5.3 | 2.3 | 2.5 | 0.4 | 0.07 | 39 |
| Tully | 50 | 35 | 15 | 5.5 | 1.1 | 3.1 | 0.6 | 0.14 | 32 |

**Table 2**

**Chemical composition of leaf tissue from the four varieties used in trash mulch**

| Variety | Percent dry matter | | | | | |
|---|---|---|---|---|---|---|
| | N | Ca | Mg | P | K | S |
| Q78 | 1.13 | 0.17 | 0.11 | 0.17 | 2.2 | 0.15 |
| Q117 | 1.15 | 0.28 | 0.15 | 0.18 | 2.4 | 0.18 |
| Q124 | 1.10 | 0.21 | 0.10 | 0.15 | 1.8 | 0.11 |
| Q138 | 1.13 | 0.28 | 0.10 | 0.17 | 1.9 | 0.14 |

**Table 3**

**Standard errors and levels of significance for germination (%) of four varieties grown on two soils with different surface mulches. The values refer to data in Fig. 1.**

| Treatment | Bulgun soil | | Tully soil | |
|---|---|---|---|---|
| | se ± | P | se ± | P |
| Mulch effect | 2.2 | ** | 8.8 | ns |
| Variety effect | 8.1 | ns | 7.3 | ** |
| Interaction | 11.4 | ns | 10.3 | ns |

** significant at $P < 0.01$, ns not significant at $P = 0.05$

**Table 4**

**Standard errors and levels of significance of main effects and interactions for germination (%) of four varieties grown under different surface mulch on two soils. The values refer to data in Fig. 2.**

| Days after planting | Mulch effect | | Variety effect | | Interaction | |
|---|---|---|---|---|---|---|
| | se ± | P | se ± | P | se ± | P |
| **Bulgun soil** | | | | | | |
| 7 | 1.1 | ns | 1.6 | ** | 2.3 | ** |
| 8 | 2.1 | * | 2.9 | ** | 4.1 | ** |
| 9 | 2.6 | * | 3.2 | ** | 4.5 | ** |
| 10 | 4.5 | ns | 3.9 | ** | 5.5 | ** |
| 11 | 3.2 | ns | 4.4 | ** | 6.3 | ns |
| 13 | 2.3 | * | 4.4 | ** | 6.3 | ns |
| 14 | 3.2 | ns | 3.4 | ** | 4.8 | ns |
| 15 | 2.0 | * | 3.2 | ** | 4.5 | ns |
| 16 | 0.8 | ** | 3.7 | ** | 5.3 | ns |
| 20 | 2.1 | ns | 3.5 | ns | 5.0 | ns |
| 21 | 2.2 | ns | 3.5 | ns | 5.0 | ns |
| 22 | 1.9 | ns | 3.7 | ns | 5.3 | ns |
| 23 | 1.9 | ns | 3.7 | ns | 5.3 | ns |
| **Tully soil** | | | | | | |
| 7 | 1.3 | ns | 1.4 | * | 2.0 | ** |
| 8 | 2.2 | ns | 2.9 | ** | 4.2 | ** |
| 9 | 2.2 | ns | 3.0 | ** | 4.2 | * |
| 10 | 1.9 | ns | 3.4 | ** | 4.8 | ns |
| 11 | 2.2 | ns | 3.9 | ** | 5.6 | ns |
| 13 | 2.7 | ns | 2.8 | ** | 4.0 | ns |
| 14 | 2.1 | ns | 3.0 | ** | 4.3 | ns |
| 15 | 1.7 | ns | 3.3 | ** | 4.7 | ns |
| 16 | 0.5 | * | 2.9 | ** | 4.1 | ns |
| 20 | 1.3 | ns | 2.7 | ** | 3.8 | ns |
| 21 | 1.5 | ns | 1.8 | ** | 2.5 | ns |
| 22 | 0.8 | ns | 1.8 | * | 2.6 | ns |
| 23 | 1.1 | ns | 1.5 | ns | 2.1 | ns |

** significant at $P < 0.01$     * significant at $P < 0.05$

ns not significant at $P = 0.05$

## Table 5

**Effect of trash and vermiculite mulch on sett root growth and shoot height (all varieties) in two soils in Trial 2**

| Type of Mulch | Bulgun soil | | Tully soil | |
|---|---|---|---|---|
| | Root rating | Shoot height (mm) | Root rating | Shoot height (mm) |
| Trash | 12.7 | 80 | 2.7 | 70 |
| Vermiculite | 11.4 | 81 | 2.2 | 65 |
| se ± | 0.92 | 1.35 | 0.05 | 0.16 |
| | ns | ns | ** | ** |

** significant at $P < 0.01$, ns not significant at $P = 0.05$

## Table 6

**Interaction between variety and type of mulch on plant height, root and shoot oven dry weights on the Tully soil type in Trial 3**

| Variety | Plant height (mm) | | Shoot weight (g/pot) | | Root weight (g/pot) | |
|---|---|---|---|---|---|---|
| | T[a] | V[a] | T | V | T | V |
| Q78 | 185 | 218 | 1.7 | 3.0 | 1.2 | 2.1 |
| Q117 | 302 | 281 | 5.9 | 4.9 | 2.6 | 2.4 |
| Q124 | 314 | 325 | 4.5 | 5.9 | 2.3 | 2.6 |
| Q138 | 312 | 289 | 6.8 | 6.3 | 3.1 | 2.4 |
| se ± | 11.0 * | | 0.3 ** | | 0.2 ** | |

** significant at $P < 0.01$ * significant at $P < 0.05$

(a) T = Trash mulch, V = Vermiculite mulch

## Table 7

**Influence of incubating soil at high moisture on plant growth under the different temperature conditions in Trial 4**

| Treatment[a] | Ambient temperature | | | | Controlled temperature | | | |
|---|---|---|---|---|---|---|---|---|
| | Shoot height (mm) | Root rating | Shoot weight (g) | Root weight (g) | Shoot height (mm) | Root rating | Shoot weight (g) | Root weight (g) |
| Incubated | 187 | 8.3 | 5.5 | 3.5 | 189 | 9.4 | 5.2 | 3.6 |
| Non-incubated | 208 | 9.5 | 6.7 | 4.1 | 202 | 10.9 | 6.4 | 4.0 |
| se ± | 276 ** | 0.27 ** | 0.12 ** | 0.10 ** | 3.32 ** | 0.27 ** | 0.10 ** | 0.09 ** |

** significant at P < 0.01 (a) all surface mulches, varieties and soils

## Table 8

**Influence on shoot weight (g/pot) of the interaction of soils to pre-planting storage methods under two temperature regimes in Trial 4**

| Treatment[a] | Ambient temperature | | Controlled temperature | |
|---|---|---|---|---|
| | Bulgun soil | Tully soil | Bulgun soil | Tully soil |
| Incubated | 6.1 | 5.0 | 5.5 | 5.0 |
| non-incubated | 7.7 | 5.7 | 7.2 | 5.6 |
| se ± | ** 0.18 | | ** 0.15 | |

** significant at P < 0.01 (a) all varieties and surface mulches

**Table 9**

**Effect of two surface mulches on oven dry shoot weight of four varieties grown under controlled soil temperatures (Trial 4)**

| Variety[a] | Shoot weight (g/pot) | |
|---|---|---|
| | Trash | Vermiculite |
| Q78 | 4.7 | 5.3 |
| Q117 | 6.6 | 6.0 |
| Q124 | 6.3 | 6.1 |
| Q138 | 5.5 | 6.2 |
| se ± | 0.21 * | |

* significant at $P < 0.05$
(a) both soils and incubation methods

**Table 10**

**Effect of trash and vermiculite surface mulch on root weights at harvest of Trial 4**

| Type of mulch[a] | Root weight (g/pot) | |
|---|---|---|
| | Ambient temperature | Controlled temperature |
| Trash | 3.7 | 3.6 |
| Vermiculite | 4.0 | 3.9 |
| se ± | 0.10 * | 0.09 * |

* significant at $P < 0.05$

(a) all varieties, soils and incubation methods

**Fig. 1 Effect of a trash and vermiculite surface mulch on germination of four cane varieties on two soils in Trial 1. (a) Bulgun soil (b) Tully soil**

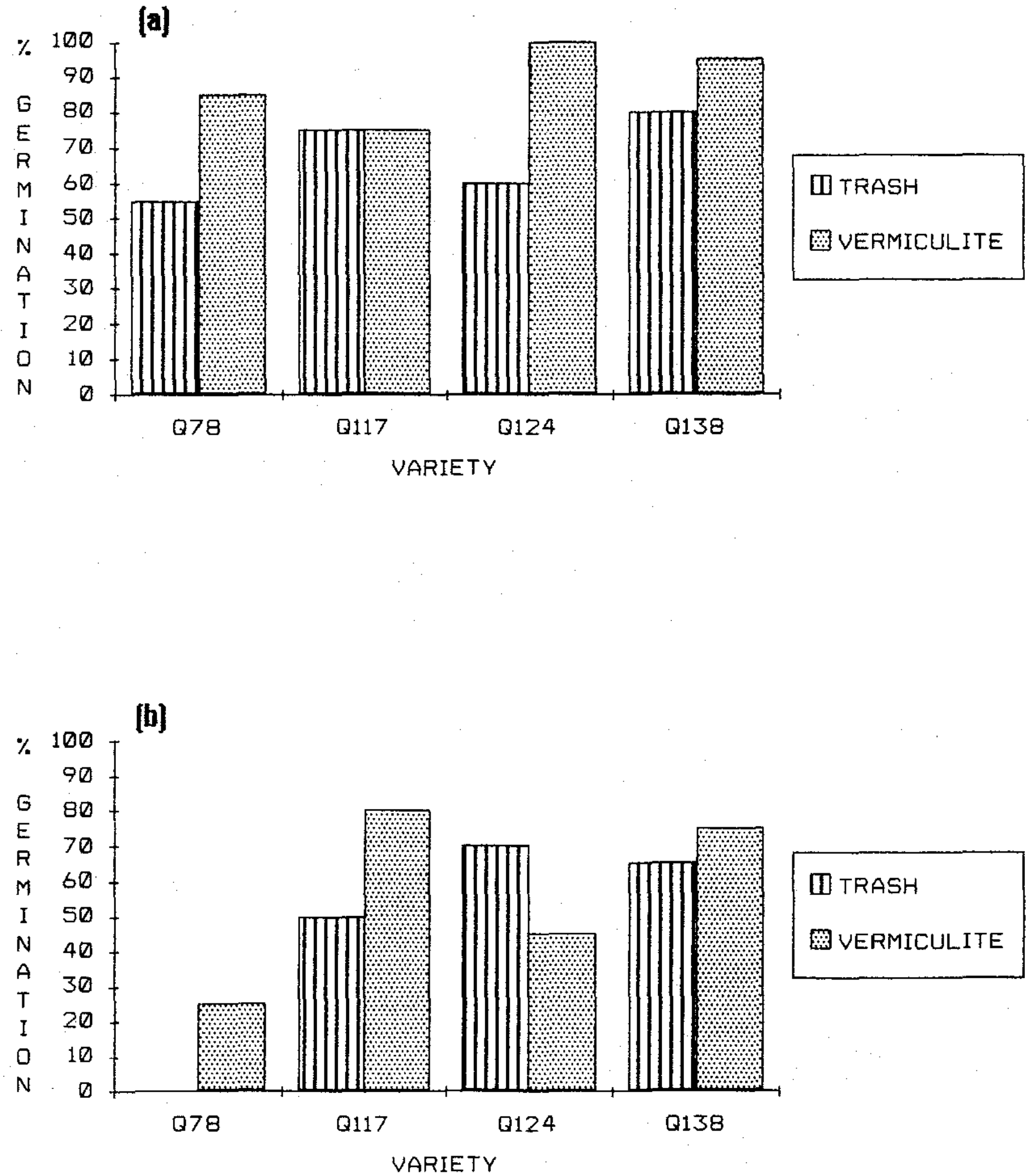


**Table 3**

**Percentage of one-eye setts germinating for four varieties x four trash covers, Trial 2**

| Variety planted/ varietal trash cover | Germination percentage* | | | | |
|---|---|---|---|---|---|
| | Q141 | CP51-21 | H56-752 | Q123 | Mean |
| Q141 | 100 (100) | 65 ( 85) | 50 ( 70) | 25 ( 85) | 60 (95) |
| CP51-21 | 90 ( 90) | 90 ( 90) | 90 (100) | 95 (100) | 91 (95) |
| H56-752 | 80 ( 80) | 80 ( 90) | 70 ( 70) | 80 ( 85) | 78 (81) |
| Q123 | 81 ( 88) | 94 (100) | 38 ( 75) | 63 ( 88) | 69 (88) |
| Mean | 88 ( 90) | 82 ( 91) | 62 ( 79) | 66 ( 90) | |

* Shown as % @ 3 weeks (final % @ 4.3 weeks)

**Table 4**

**Mean shoot lengths at harvest for one-eye setts from four varieties x four trash covers, Trial 2**

| Variety planted/ varietal trash cover | Mean shoot length mm | | | | |
|---|---|---|---|---|---|
| | Q141 | CP51-21 | H56-752 | Q123 | Mean |
| Q141 | 102 | 70 | 78 | 86 | 84 |
| CP51-21 | 132 | 122 | 123 | 155 | 133 |
| H56-752 | 94 | 82 | 86 | 113 | 94 |
| Q123 | 113 | 124 | 100 | 109 | 111 |
| Mean | 110 | 100 | 97 | 116 | |

**Table 5**

**Rating for root stubbing (scale 0-10) for one-eye setts from four varieties x four trash covers, Trial 2**

| Variety planted/ varietal trash cover | Mean root stubbing rating* | | | | |
|---|---|---|---|---|---|
| | Q141 | CP51-21 | H56-752 | Q123 | Mean |
| Q141 | 5.6 | 3.2 | 3.0 | 5.0 | 4.2 |
| CP51-21 | 5.8 | 4.8 | 7.6 | 6.8 | 6.2 |
| H56-752 | 4.6 | 3.2 | 3.2 | 3.2 | 3.6 |
| Q123 | 6.2 | 6.8 | 7.2 | 9.4 | 7.4 |
| Mean | 5.6 | 4.5 | 5.2 | 6.0 | |

* 0 = severe stubbing, 10 = no stubbing

**Table 6**

**Results of intermediate harvest of germination/growth experiment at Bundaberg, 1989**

| Soil[a] | Variety | Treatment | Number of shoots/pot | Well developed shoots/pot | Sett fine root rating[b] | Sett root stubbing[c] |
|---|---|---|---|---|---|---|
| K | CP44-101 | Trash | 4.9 | 2.9 | 5.7 | S |
| | | Vermiculite | 4.3 | 2.3 | 4.8 | S |
| HG | CP44-101 | Trash | 3.8 | 1.9 | 2.0 | S-M |
| | | Vermiculite | 4.2 | 2.2 | 2.1 | S-M |
| K | CP51-21 | Trash | 3.6 | 1.8 | 4.0 | S |
| | | Vermiculite | 3.6 | 1.5 | 3.3 | S |
| HG | CP51-21 | Trash | 3.0 | 1.4 | 1.0 | S |
| | | Vermiculite | 4.0 | 1.9 | 1.9 | S |
| K | Q123 | Trash | 4.6 | 2.8 | 5.8 | S |
| | | Vermiculite | 5.0 | 2.6 | 5.6 | S |
| HG | Q123 | Trash | 5.0 | 2.9 | 3.8 | S |
| | | Vermiculite | 4.8 | 2.9 | 2.9 | S |
| K | Q124 | Trash | 3.9 | 1.9 | 2.3 | N-S |
| | | Vermiculite | 3.9 | 1.9 | 2.4 | N-S |
| HG | Q124 | Trash | 4.8 | 2.8 | 2.1 | N-S |
| | | Vermiculite | 4.3 | 2.3 | 1.5 | N-S |
| K | Q136 | Trash | 3.7 | 1.7 | 3.2 | S |
| | | Vermiculite | 4.3 | 2.3 | 3.2 | S |
| HG | Q136 | Trash | 3.7 | 1.3 | 0.8 | S-M |
| | | Vermiculite | 3.2 | 2.0 | 1.4 | S-M |
| K | Q141 | Trash | 4.0 | 2.0 | 3.0 | S |
| | | Vermiculite | 4.3 | 2.3 | 2.8 | S |
| HG | Q141 | Trash | 4.5 | 2.5 | 1.0 | S-M |
| | | Vermiculite | 3.3 | 1.3 | 0.8 | S-M |
| Mean | | | | | | |
| K | | Trash | 4.1 | 2.1 | 4.0 | N-S |
| | | Vermiculite | 4.2 | 2.2 | 3.7 | N-S |
| HG | | Trash | 4.1 | 2.1 | 1.8 | N-M |
| | | Vermiculite | 4.0 | 2.1 | 1.8 | N-M |

[a] K = krasnozem, HG = humic gley
[b] sett fine root rating 0-10
[c] root stubbing N = none, S = slight, M = moderate

Table 7

**Root and shoot oven dry weights for December harvest of germination/growth experiment at Bundaberg, 1989**

| Variety/soil type | Oven dry root weight g/pot | | Oven dry shoot weight g/pot | |
|---|---|---|---|---|
| | Trash | Vermiculite | Trash | Vermiculite |
| CP44-101 | | | | |
| krasnozem | 33.0 | 35.7 | 89.3 | 69.9 |
| humic gley | 22.7 | 26.1 | 84.4 | 97.5 |
| CP51-21 | | | | |
| krasnozem | 24.2 | 33.1 | 53.5 | 60.1 |
| humic gley | 21.7 | 28.2 | 102.7 | 97.8 |
| Q123 | | | | |
| krasnozem | 20.7 | 22.3 | 37.8 | 35.8 |
| humic gley | 21.6 | 20.5 | 60.3 | 63.2 |
| Q124 | | | | |
| krasnozem | 24.8 | 25.4 | 40.6 | 40.7 |
| humic gley | 25.5 | 28.8 | 47.8 | 53.8 |
| Q136 | | | | |
| krasnozem | 24.7 | 22.2 | 70.3 | 57.8 |
| humic gley | 18.0 | 20.7 | 55.6 | 60.5 |
| Q141 | | | | |
| krasnozem | 28.6 | 38.9 | 62.7 | 59.0 |
| humic gley | 18.2 | 25.3 | 44.9 | 50.0 |

Table 8

**Shoot dry matter (g/pot) at harvest for four varieties grown under trash and vermiculite mulches on three Bundaberg soils**

| Cane variety | Soil type | Shoot dry matter g/pot | | | |
|---|---|---|---|---|---|
| | | Gley podzolic | Humic gley | Krasnozem | Mean |
| CP51-21 | Trash | 72.1 | 91.4 | 76.1 | 80.0 |
| | Vermiculite | 77.6 | 63.5 | 57.8 | 66.3 |
| H56-752 | Trash | 50.4 | 77.5 | 93.8 | 73.9 |
| | Vermiculite | 72.6 | 43.9 | 50.7 | 55.7 |
| Q123 | Trash | 46.3 | 56.3 | 55.3 | 52.6 |
| | Vermiculite | 46.2 | 56.6 | 45.5 | 49.4 |
| Q141 | Trash | 47.6 | 45.9 | 52.7 | 48.7 |
| | Vermiculite | 41.9 | 55.9 | 41.4 | 46.4 |