EFFECTS OF SEED ADJUVANTS ON GERMINATION AND DEVELOPMENT OF ONIONS

BY

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Dissertation submitted in fulfilment of the requirements for the degree of Magister Technologiae in Agriculture (M. Tech)

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Short title: Treatment of onion seeds with adjuvants

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Abstract

Onion seeds (cultivar Caledon Globe), and soil into which the seedlings were planted, were treated with various adjuvants including fungicides, a seed disinfectant and a soil sterilant, as well as soil-applied growth stimulants to determine the effect of these on germination of seed, the growth of plants and the storage life of onions obtained. Three sets of germination trials were undertaken in petri dishes, and sets of seed was also sown in deep seed trays. A trial planting was made and the crop graded and stored. Seed was also sown in pots in soil obtained from a commercial undertaking where poor germination had been obtained. A portion of this soil was pasteurised and a portion inoculated with *Fusarium spp.* Growth of these seedlings was then followed by re-sowing in the same pots using seed of additional cultivars.

Declaration

I, the undersigned, declare herewith that the dissertation contains all my original work and that it has never before been submitted, in part or as a whole, to any other tertiary institution to obtain an academic qualification.

E Allison
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E ALLISON

14/2/2001
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DATE

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2. Prof. Dirk van Schalkwyk for the statistical evaluations.

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15. To our Heavenly Father for the strength needed to undertake the project.

INTRODUCTION

Onions (*Allium capa*: Liliaceae) are native to middle Asia, with secondary centres of development *inter alia* the Mediterranian area. It is unknown in the wild state, having been cultivated since pre-historic times. The onion is now grown the world over, chiefly in the temporate zones (Encyclopedia Britanica, 1995). In South Africa onions were first planted at the Cape by the survivors of the Haarlem shipwreck (1647). The onions grew so well that it was later recommended to the Lords of the Dutch East India Company (V.O.C.) in Holland that a colony should be established at the Cape to provide vegetables to combat scurvy among the sailors of the V.O.C. fleet. (Agricultural News, 1998).

Onion production in the Republic of South Africa in 1996/97 amounted to 284 000 tons. The 12 major fresh produce markets sold 190 000 tons of this crop to the value R202m at an average price of R1063 per ton (Anon. 1997). Production of any crop is influenced by seasonal variations, as is illustrated by the onion production during the 1998/99 season with 224 000 tons worth R200m (Anon 1999).

The above figures indicated that onion production in South Africa ranks third as the most important vegetable grown, following after potatoes and tomatoes (Anon 1999).

Although the production potential of onions is in excess of 100 ton per hectare, the average production obtained in South Africa is only slightly over 20 tons per hectare (van Rooyen and Comrie, 1997). Most onions are grown from seedling transplants. Among the establishment problems identified is poor seedling stands in the seedbed, partially due to the fact that certain diseases cannot currently be controlled economically in the seedbed. Seed costs can vary dramatically, from under R250 to well in excess of R10 000 per hectare depending on cultivar, supplier, and quantity purchased. Where hybrid seed is used it is therefor of the utmost importance that an excellent plant stand of high quality seedlings be obtained in the seedbed. In practice producers have found that not only is there often a poor germination from seed having a high percentage germination power, but that the quality of the seedlings available also leaves much to be desired. Disease problems on the land after planting are also a cause for concern and often cause a less than satisfactory stand, with a resultant poor and disappointing yield (Fugler 1989 and LNR-Roodeplaat 1998).

Commercially, 550 000 to 650 000 seedlings are planted per hectare (Swart *et al* 1998). An increase in the number of plants obtained per seed mass, or in bulb size when lifted, will obviously increase profitability. Currently an average of only approximately 135 000 plants are planted per kilogram of seed (approximately 270 000 seeds) sown, even though the commercial germination rate of fresh seed is in excess of 90%. Possible reasons for this poor plant-out rate include diseases on the seed, and poor life expectancy of the seed could possibly be due in part to seed harvested at the incorrect stage of ripeness. Apart from cultural implications, strong good quality seedlings are a pre-requisite for optimum size and quality of bulbs harvested.

Two new adjuvant products have become available in South Africa, but have apparently not yet been tested on germination or resultant growth of onions, or in soil from badly infected onion seedbeds in onion producing areas. It has been found that seedling growth is enhanced by mycorrhizae, certain beneficial fungi growing in symbiotic relationship in root cells of higher plants. Root diseases should be inhibited and phosphate uptake increased with a resultant improvement in plant growth. The use of mycorrhizae and other biological products are being promoted as major developments in the agricultural industry for the future (Anon. 1995; Nelson & Safir 1982). The local emphasis is on usage of mycorrhizae on vegetables as an additive to seedtray medium mixes. As onion seedlings are grown in seedbeds where there are inherently many variable conditions, germination trials need to be carried out under controlled conditions in eg petri dishes and trays and the effect monitored on the land, followed by a period of storage, to evaluate some adjuvants on the local markets.

The other new product, Sporekill (Schreuder, 1996), which acts against fungi, bacteria and virusses by a disinfection action, thus controlling pro-actively whilst being a safe product to use. This product, as with the mycorrhiza material mentioned above, needs to be similarly tested and compared.

This study was therefor undertaken in an attempt to determine the effect of some adjuvants on onion seed germination, production and final yield, and effectivity of seed treatments.

MATERIALS and METHODS

Seed Cultivar.

Caledon Globe was chosen as it is one of the most important late onion cultivars commercially used in the major onion producing areas of the RSA. Seed was obtained from the following five commercial seed firms to give a representative sample of the seed available to the average producer, viz. Agricol (Pty) Ltd., Greengrow Seed (Ltd)., Hygrotech Seed, Straathof's Group (Pty) Ltd., and Starke Ayres (Pty) Ltd.

The raw seed, as well as the Sporekill treated seed, was tested for fungal infection by Dr. Terry Aveling of the Faculty of Biological Agricultural Sciences of the University of Pretoria. The method used and results are given in Table 1. Samples 1 to 5 represent the seed of the different suppliers, as received, and samples 6 to 10 samples from the same suppliers pre-treated with Sporekill by Mr. Andrew Comrie of Hygrotech Seed. The seed was soaked in 1000ppm (1ml/litre distilled water) for 30 seconds, rinsed in distilled water and dried.

Table 1. Percentage fungal infection of onion seed samples.

Percentage Infection										
Sample	1	2	3	4	5	6	7	8	9	10
Fungus species										
Stemphylium vesicarium [1]	10	0	3,5	0.5	7	1,5	0	1,5	0,5	1,5
Alternaria porri[1]	0	0	0.5	0	0,5	0,5	0	0,5	0	0,5
Fusarium sp.[2]	0	0	8	0	3,5	0	0	3	0	6,5
Botrytis sp.[2]	0	0	0	0	0,5	0	0	0	0	0
Penicillium sp[3]	0	0	4	1	3	0,5	1,5	4,5	0	2
Aspergillus sp.[3]	0	0	0	4	0,5	0,5	1,5	7,5	8	11,5
Rhizopus sp.[3]	0	0	0	0	0	0	1,5	4	2	2
Acremonium[3]	0	0,5	0	0	0,5	0	0	0	0	0

Samples 1 to 5 were surface sterilised with sodium hypochloride, hence less saprophytes.

Samples 6 to 10 were plated out as is to determine the effect of the fungicides.

Key:

[1] Serious seed -borne pathogens of onion.

[2] Occasionally pathogens of onion but usually saprophytes.

[3] Usually saprophytes but may reduce percentage germination.

In an attempt to emulate the normal situation which would be experienced by the producer all germination trials were carried out at room temperature in conditions as near to the commercial situation as possible. The germination test does not indicate vigour as expressed by speed of germination, but this is also indicated in the results of the trials.

Seed treatments:

The following seed treatments were used:

1. Sporekill^{TM} - supplied and seed treated by Mr. Andy Comrie of Hygrotech. The active ingredient in this agricultural disinfectant is polymethyl ammonium chloride at a concentration of 120g/l . Sporekill was applied to the seed at the rate of 1 000ppm in distilled water. The seed was soaked for 30 seconds after which it was rinsed in distilled water and dried.
2. Mycorrhiza - in ready to use vermiculite base was supplied by Dr. Marianne Venter of Myco Greengro.
3. Apron C^{TM} - supplied by Mr. Chris Theron of Novartis. The active ingredient of this product is captab/metalaxyl. The concentration used was 50g/100kg seed, applied dry to the small quantities of seed.
4. Thiram^{TM} - with active ingredient thiram was supplied by Agricura and used at the concentration of 150g/100kg seed, applied dry to the small quantities of seed.
5. Biostart^{R} - supplied by Mr. G. Limerick of Microbial Solutions. Biostart^{R} CM135-2 (*Bacillus chitinosporus, Bacillus uniflagillatus, Bacillus subtilis, Bacillus licheniformis)* was used at a rate of 100ml together with 60g Biostart^{R} CM microbial soil inoculant and was

dissolved in 12 litre warm water. The mixture was held for 24 hours at room temperature before being added at the rate of 10ml per deep seed tray.

6. Herbifume.

First sowing

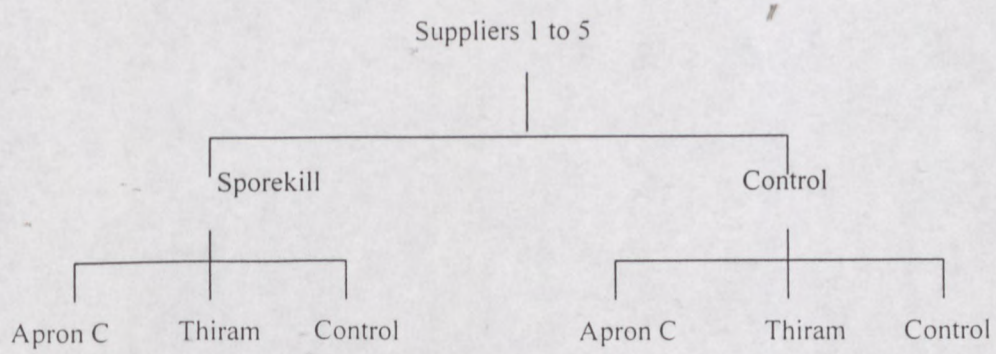
The first sowing was made during autumn which approximates the normal sowing time for onions, both in petri dishes to determine germination percentage and in deep seed trays (30 x 22 x 10cm) to simulate the conditions for obtaining seedlings later in the season for planting out on the land.

In view of the fact that mycorrhiza was to be included in the soil mix for the seed that was to be planted out on the land, a trial was included here to determine the effect that mycorrhiza might have on germination. Seed from all the suppliers was mixed, and treated as above, with mycorrhiza being added to one treatment. This meant that vermiculite was also applied on the filter paper in the petri dishes, and to eliminate any effect that this might have on germination a treatment where only vermiculite was added was included.

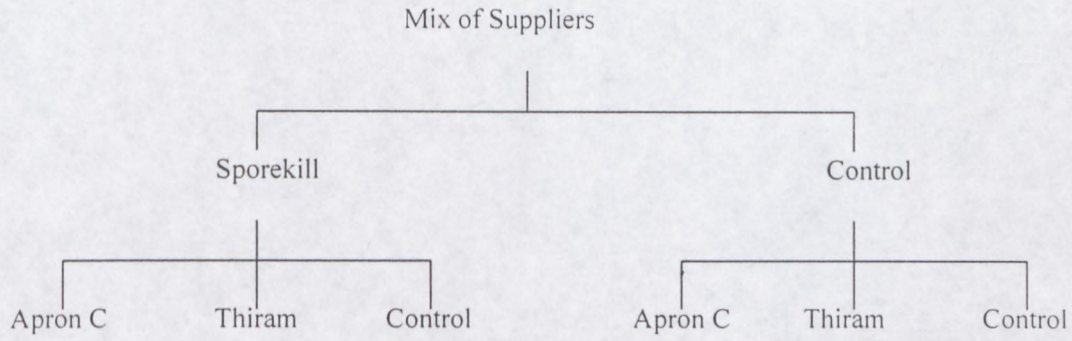
Trial 1 Petri dish germination.

One hundred seeds were sown per dish lined with a sheet of filter paper, with 14 counts being made on alternate days over a four week period, although the majority had germinated within 10 days. The dishes were held at room temperature. A total of 84 dishes was sown, as follows:

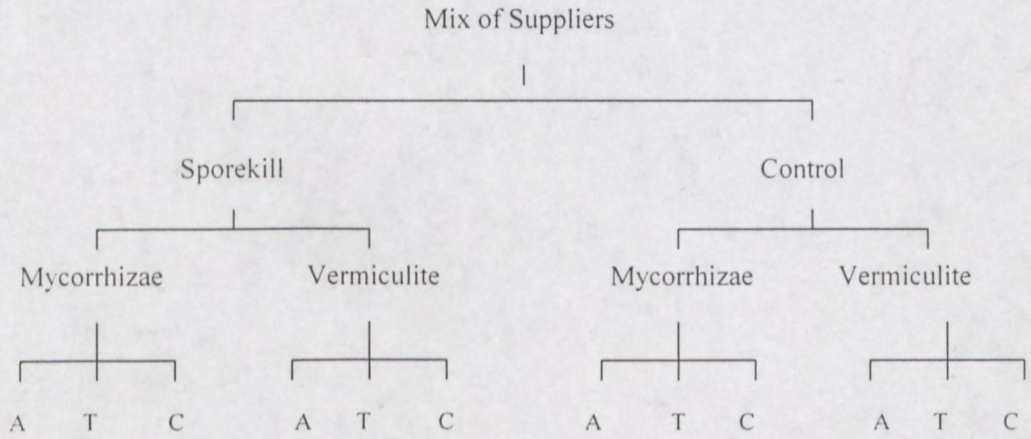
1.1 Seed from each of the five suppliers was sown separately, with six treatments for each supplier, giving a total of 30 dishes.



1.2 As above, but seed of all suppliers mixed into one treatment. Three replicates of each treatment were sown, giving a total of 18 dishes.



1.3 As above (1.1.2), but including Mycorrhiza/vermiculite and vermiculite-only treatments. Three replicates of each treatment were sown, giving a total of 36 dishes.



A = Apron C T = Thiram C = Control

Trial 2. Deep seed trays

The motivation behind producing seedlings in trays instead of in seedbeds as is the commercially accepted practice was that all the treatments were to be given exactly the same conditions, excluding the variable outside factors such as weed growth, mole tunnels, excessive rainfall, etc, and at the same time obtain good seedlings from a large number of differently treated seed samples.

Thirty five seeds from each supplier, giving a total of 175 seeds were sown per tray in seven rows (replicates) of twenty five seeds each. The trays were filled with five litre light sandy soil. The soil was analysed by the Department of

Agriculture, Western Cape Production Technology Laboratory at Elsenburg, and the analysis appears in Table 2.

Table 2. Analysis of soil used in deep seed trays.

Soil texture	Sand	
pH (KCl)	5,8	High
Resistance (ohms)	3200	High
Sodium (Na) (mg/kg)	31	
Phosphate (P) (mg/kg)	21	Low
Potassium (K) (mg/kg)	27	Low
Calcium (Ca) (me%)	0,82	Satisfactory
Magnesium (Mg) (me%)	0,20	Low
Copper (Cu) (mg/kg)	0,21	Low
Zinc (Zn) (mg/kg)	0,78	Satisfactory
Manganese (Mn) (mg/kg)	0,10	Low
Boron (B) (mg/kg)	0,13	Low
Clay (%)	2,0	
Silt (%)	2,0	
Coarse sand (%)	52,5	
Medium sand (%)	26,8	
Fine sand (%)	16,7	

The following additions were made to the soil:

1. 1 litre wetted Mycorrhiza/vermiculite mix or 1 litre wetted vermiculite as control was added to and mixed to the soil in each tray.
2. The seed was covered with 0,5 litre Consol dry grade one silicate sand.
3. The soil used for the Herbifume treatments was pre-treated with 800ml Herbifume/m^3 soil dissolved in 40 litre water. The soil was covered with a plastic sheet for three days to prevent the escape of gases.

Seed treatments were applied as described for petri dishes.

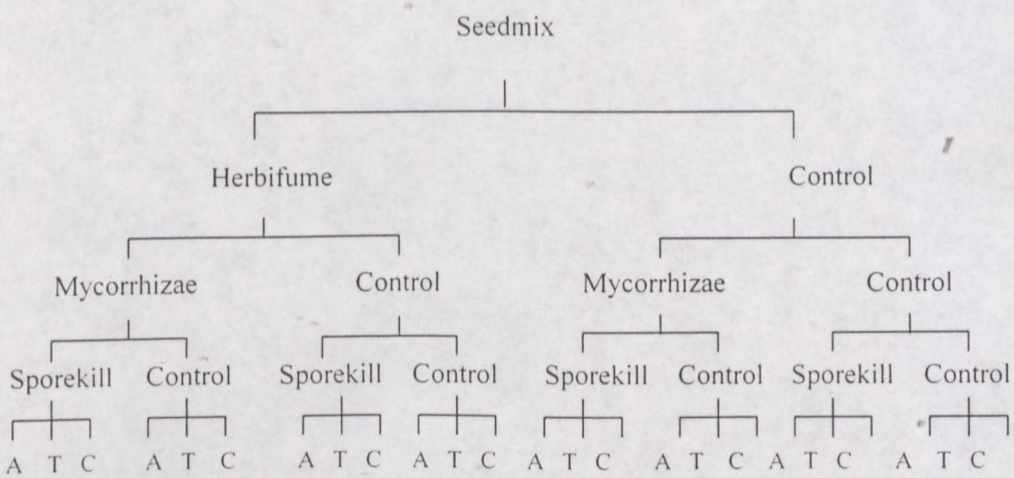
Hygrofert fertiliser was applied weekly from three weeks post sowing as follows. The chemical composition of Hygrotech fertilisers is given in Table 3. Hygrofert B and Hygrofert C at the rate of 0,5g each in 0,25l water per tray for

three weeks, followed by 1gm/l of both per week for the duration of the trial. As a precautionary measure a regular fungicidal spray programme was followed commencing four weeks after sowing. Mancozeb at the rate of 300gm/100l water was alternated weekly with Iprodione at 200ml/100l water to ensure that the seedlings remained healthy and thus to eliminate any possible effect of disease on the results.

Table 3. Chemical composition of Hygrofert mixtures.

Element	Hygrofert A	Hygrofert B	Hygrofert C
Nitrogen (N)	139gm/kg	156g/kg	98g/kg
Phosphate (P)	70gm/kg	70g/kg	0g/kg
Potassium (K)	214gm/kg	187g/kg	88g/kg
Iron (Fe)	1871mg/kg	1885mg/kg	1254mg/kg
Copper (Cu)	33mg/kg	34mg/kg	22mg/kg
Zinc (Zn)	223mg/kg	224mg/kg	149mg/kg
Manganese (Mn)	446mg/kg	449mg/kg	299mg/kg
Boron (B)	557mg/kg	561mg/kg	373mg/kg
Molybdenum (Mo)	56mg/kg	56mg/kg	37mg/kg
Sulphur (S)	13g/kg	14g/kg	23g/kg
Magnesium (Mg)	10g\kg	11g/kg	17g/kg
Calcium (Ca)			120g/kg
Chloride (Cl)			60mg/kg

1.2 24 treatments with 2 replicates were sown, giving 48 trays, as follows:



A = Apron C T = Thiram C = Control

Seedling counts were made two weeks after sowing, when all seedling emergence should have taken place, and four weeks after sowing to coincide with the last petri dish count. The seedlings were then allowed to develop for four months. Total wet and dry root and shoot mass for the various treatments was then determined. For this purpose 10 random plants were taken per sample from each tray. Shoot lengths were measured from the top of the root system to the tip of the longest and shortest leaves from each sample.

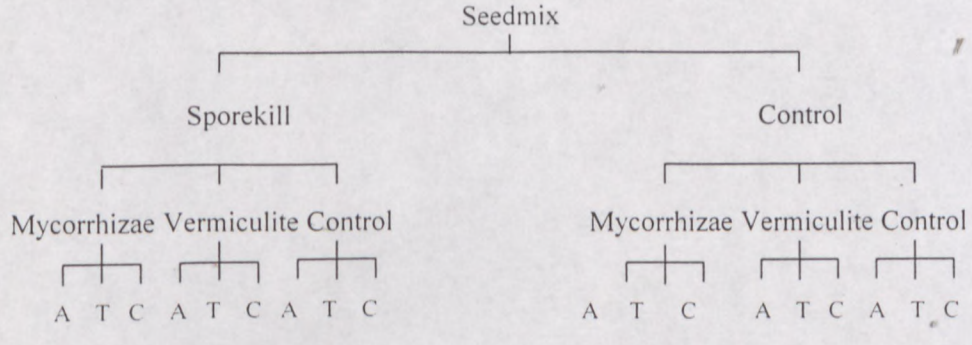
Second sowing

The second sowing was made in winter, but as seed sown in trays under protection can germinate during a time of the year not conducive to development in seedbeds, and seedlings developing in trays reach the stage where they have to be transplanted more rapidly than those developing in seedbeds, the seedlings from this sowing were used for the planting trials. Seedlings grown in seedbeds need five or six months between sowing and planting out on the land.

Trial 3 Petri dish germination

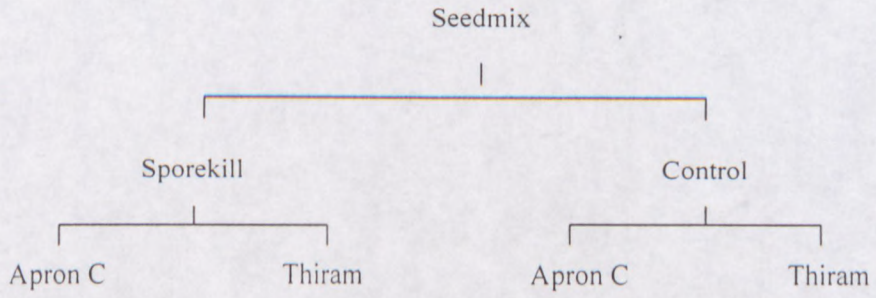
A total of 122 dishes were sown, with 14 counts being made over a period of four weeks. The dishes were again held at room temperature.

3.1 Seed from only the three best Suppliers (Results, Table 5) was used in a mix. Apart from a plain filter paper treatment, layers of mycorrhiza/vermiculite and plain vermiculite were again included. Five replicates were sown, giving a total of 90 dishes.

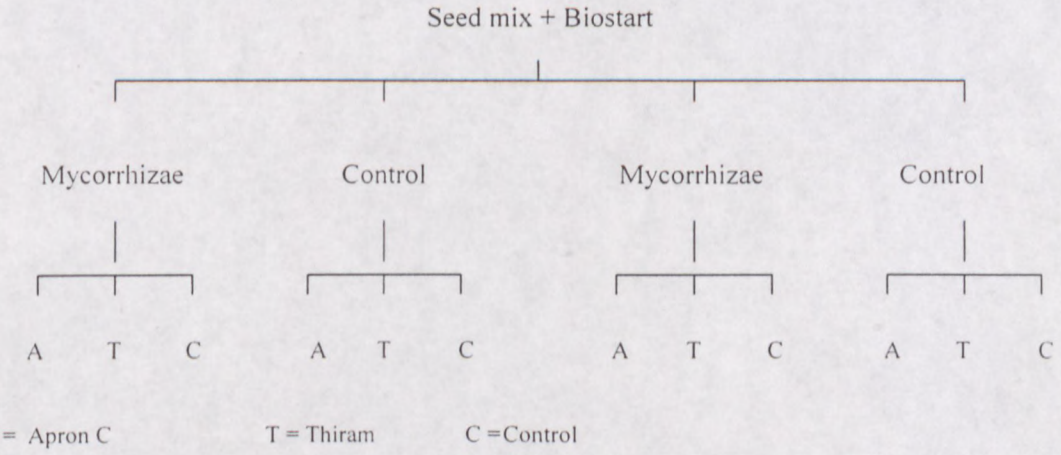


A = Apron C T = Thiram C = Control

3.2 As a comparison, a small trial was included where the two fungicides, Thiram and Apron C were applied as a seed coating at a random rate - the seed being placed and shaken in dishes containing the fungicide being applied, this being done to determine any possible effect on germination of incorrect excessive dosages of fungicides. Four treatments with five replicates were included, giving 20 dishes.



3.3 Biostart was added to 12 treatments to determine the effect of this material on germination.



Trial 4 Deep seed trays

A total of 120 trays were sown with 175 seeds per tray and spacing as for April. Germination data was taken twice, after two and six weeks; shoot and root data were taken, and 100 plants per tray planted out in a block randomised by drawing markers from a container. The plan of the block is shown in Figure 1. An analysis of the soil used is given in Table 4. Normal cultural practices as applied at Elsenburg were applied to the trial. The onions were planted a month later than would normally have been the case due to abnormal rainfall resulting in very wet soil conditions (669mm fell during the months June to October

which is a good 10% above our average annual rainfall). 100 plants were planted per block, in two rows of 50 plants each, spaced at 20cm x 7.5cm, giving approximately 650 000 plants per hectare. The crop of all blocks was lifted during January and graded, and all marketable onions stored for six months. During storage six counts were made.

Figure 1 Plan of experimental block.

CCCB	HCSB	HCSA
CCCB	HCSB	HCC
CCSB	HCCB	CCSA
CCSB	HCCB	CCSA
CMCB	HMCB	CMC
CMCB	HMCB	CMC
CMSB	HMSB	HMC
CMSB	HMSB	HMC

	HCCC	CCCC	CCST	CCSA
	12.1	24.4	19.4	20.1
	HCSA	CCCA	HCST	CCCT
	8.4	23.3	7.3	22.2
CCST	CCCC	HCCT	CCSC	HCC
19.2	24.3	10.1	21.4	10.2
HCSA	HCST	CCSA	CCST	HCSA
8.2	7.2	20.2	19.3	8.1
CCCA	HCCC	CCSC	HCCA	CCCT
23.2	12.3	21.2	11.4	22.1
HCCC	HCSC	CCCA	HCST	HCC
12.4	9.1	23.1	7.4	11.3
CCCT	HCCA	HCCT	HCCA	HCSC
22.4	11.1	10.3	11.2	9.3
CCSC	CCCT	CCSC	CCSA	CCC
21.3	22.3	21.1	20.3	24.2
CCSA	CCCC	HCSA	CCCA	HCSC
20.4	24.1	8.3	23.4	9.4
HCCC	HCSC	HCST	HCCT	CCST
12.2	9.2	7.1	10.4	19.1

	HMCC	CMCC	CMST	CMS
	6.1	18.4	13.4	14.1
	HMSA	CMCA	HMST	CMC
	2.4	17.3	1.3	16.2
CMST	CMCC	HMCT	CMSC	HMC
13.2	18.3	4.1	15.4	4.2
HMSA	HMST	CMSA	CMST	HMS
2.2	1.2	14.2	13.3	2.1
CMCA	HMCC	CMSC	HMCA	CMC
17.2	6.3	15.2	5.4	16.1
HMCC	HMSC	CMCA	HMST	HMC
6.4	3.1	17.1	1.4	5.3
CMCT	HMCA	HMCT	HMCA	HMS
16.4	5.1	4.3	5.2	3.3
CMSC	CMCT	CMSC	CMSA	CMC
15.3	16.3	15.1	14.3	18.2
CMSA	CMCC	HMSA	CMCA	HMS
14.4	18.1	2.3	17.4	3.4
HMCC	HMSC	HMST	HMCT	CMS
6.2	3.2	1.1	4.4	13.1

Each Block = 100 Plants Plant Spacing = 7.5 cm 4 Replicate Blocks of each main Treatment

Each Block = 2 rows of 50 plants Plant spacing = 20 cm 2 Replicate Blocks of Bio-Start and Random Treatments

|| = Edge Row of Rion 3 Plants

Table 4. Analysis of soil on which onion trial was planted.

Soil texture	Sand	
PH (Kcl)	6,3	High
Resistance (ohms)	610	High
Sodium (Na) (mg/kg)	106	
Phosphate (P) (mg/kg)	463	High
Potassium (K) (mg/kg)	243	High
Calcium (Ca) (me%)	6,93	High
Magnesium (Mg) (me%)	1,57	High
Copper (Cu) (mg/kg)	12,71	High
Zinc (Zn) (mg/kg)	18,07	High
Manganese (Mn) (mg/kg)	34,90	High
Boron (B) (mg/kg)	0,61	Satisfactory

The following recommendations for were made by the Production Technology Laboratory at Elsenburg regarding the analysis given in Table 4:

i) pH, although slightly high for vegetables is not a problem.

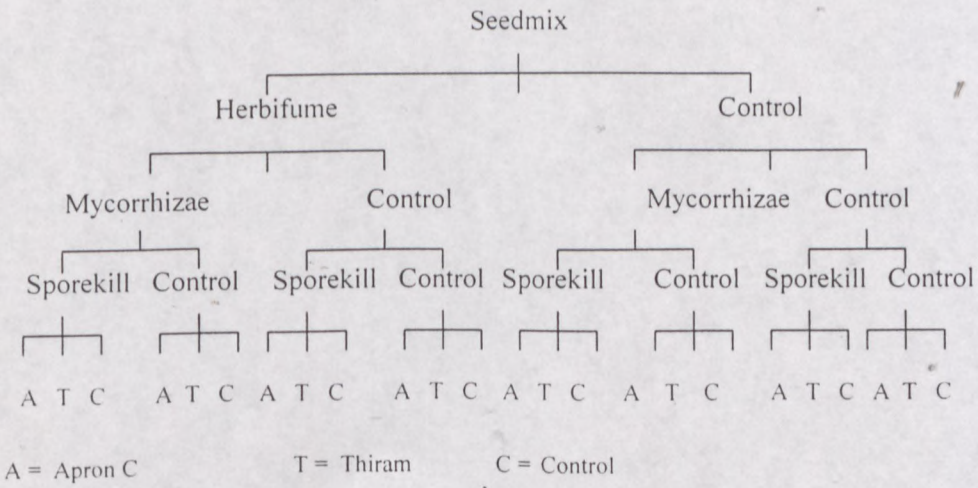
ii) addition of phosphate or potassium is not recommended so as not to reduce the resistance.

iii) no zinc or copper should be applied as the levels are on the high side.

iv) 115kg per hectare limestone ammonium nitrate to be applied at 2, 4, 6 and 8 weeks post planting.

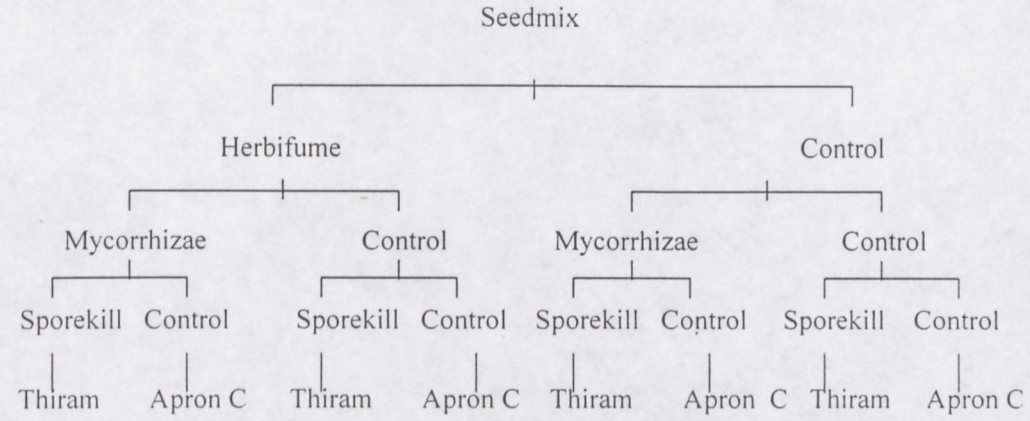
Treatments sown:

4.1 24 treatments with 4 replicates, giving 96 trays, as follows:



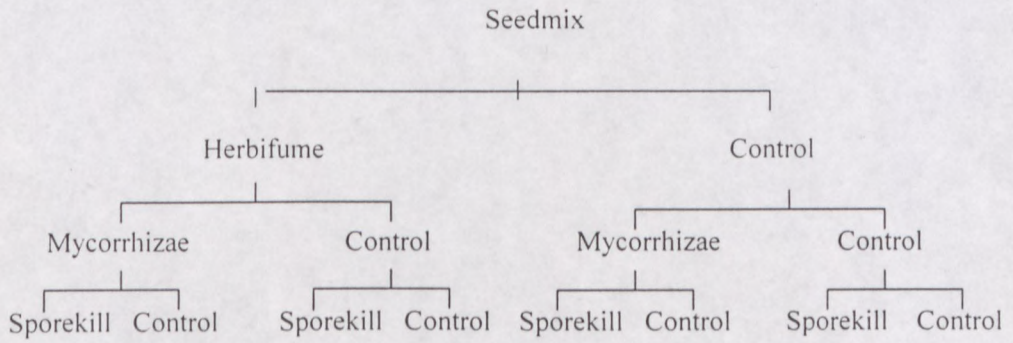
A = Apron C T = Thiram C = Control

4.2 8 trays with random rate fungicide



A = Apron C T = Thiram C = Control

4.3 8 treatments with added Biostart with 2 replicates, giving 16 trays.



Third sowing

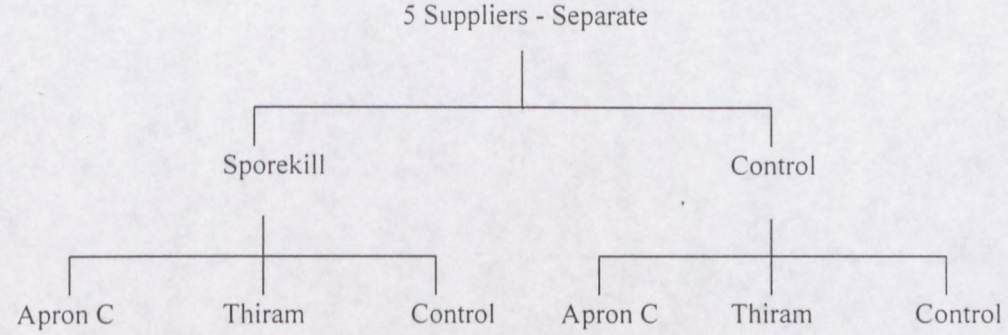
The third sowing was made in summer, both in petri dishes to establish germination, and in foam cups again under protection so that the seedlings were not exposed to too hot conditions.

Trial 5 Petri Dish Germination

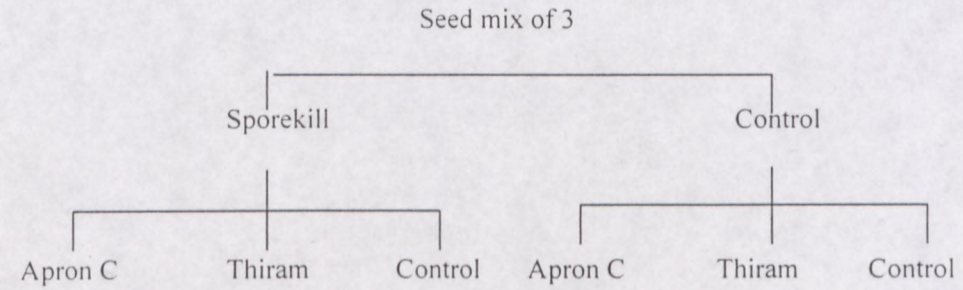
These trials were carried out basically to see if there were any differences between seed freshly treated with Sporekill as against seed that had previously been treated, to see if the addition of a wetter to the fungicidal treatment made any difference and also to check on the germination of seed of other cultivars included in the cup trials.

168 dishes of 100 seeds each were used, with counts again being made on alternate days for four weeks.

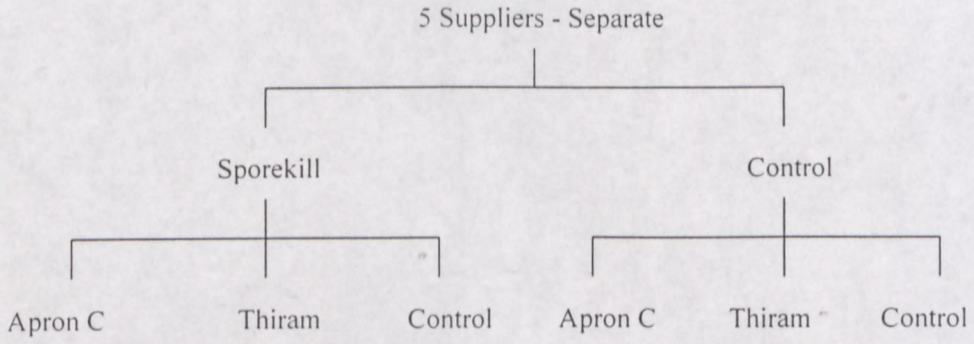
5.1 Seed treated with Sporekill prior to first sowing - 30 dishes



5.2 Seed treated with Sporekill prior to second sowing - 6 dishes

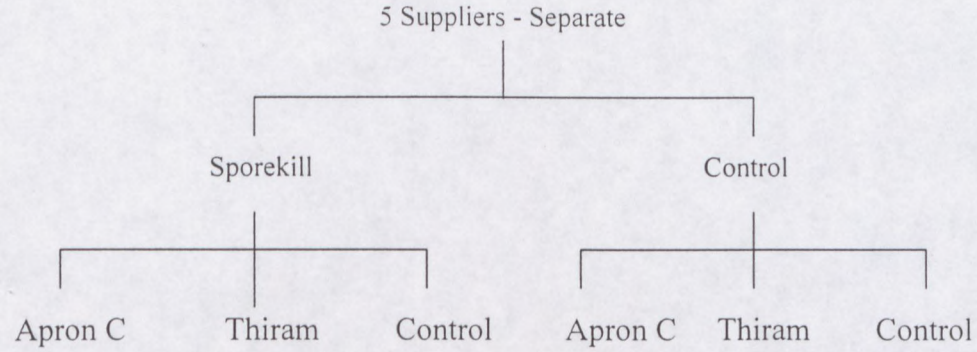


5.3 Seed freshly treated, 5 suppliers separate, 30 dishes

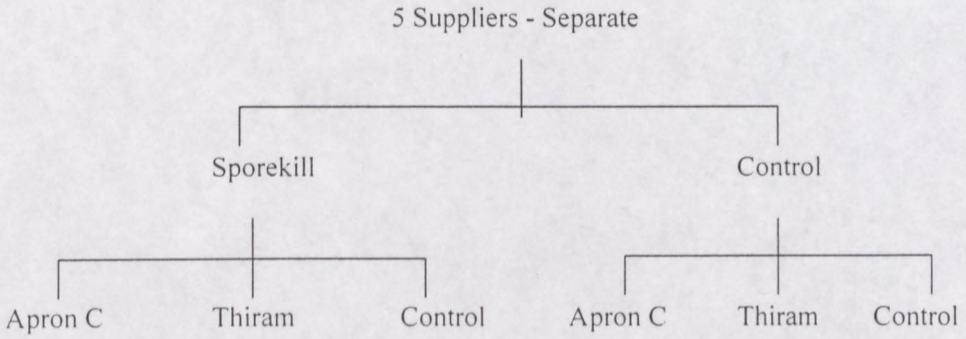


5.4 Seed freshly treated, 5 suppliers separate plus Biostart, 30 dishes

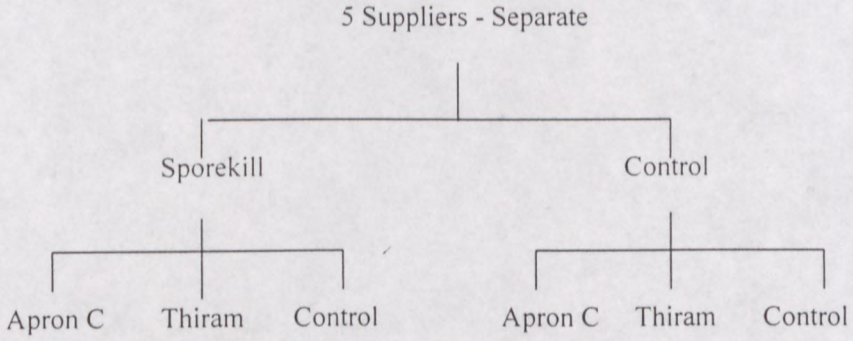
Biostart, a microbial product being launched onto the market (Microbial Solutions 1996), is another product introduced during the course of the trials.



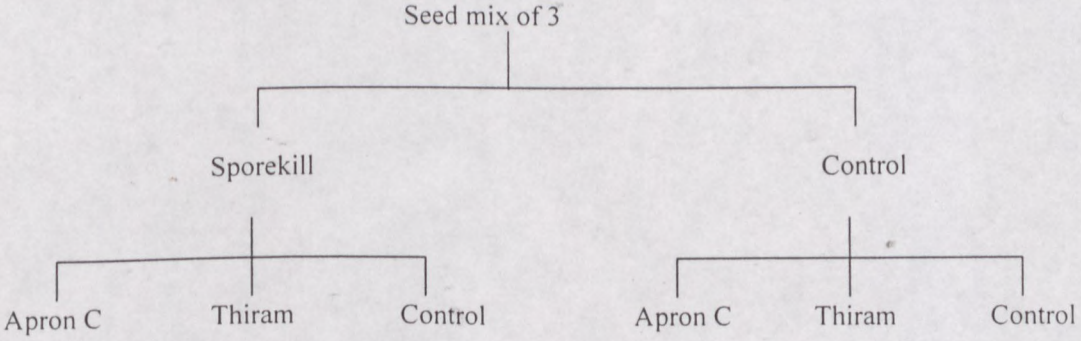
5.5 Seed freshly treated, 5 suppliers separate plus fungicidal overdose, 30 dishes



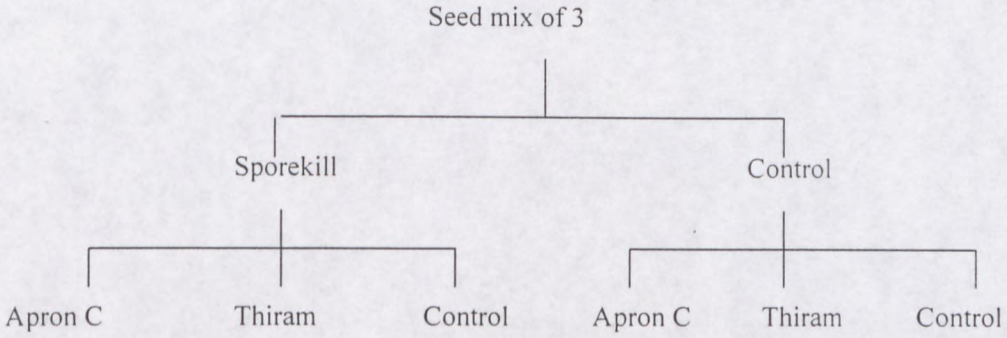
5.6 Seed freshly treated, 5 suppliers separate plus wetter, 30 dishes



5.7 Cultivar Eytan - to determine germination and compare with Caledon Globe seed - 6 dishes



5.8 Cultivar Ben Shemen - to determine germination and compare with Caledon Globe seed - 6 dishes



Trial 6 Germination of seed, growth to bulblet stage and re-sow using Eytan seed in 250ml Insulkups™.

These tests were carried out to compare the germination of seed using the same soil source as previously used, but pasteurised or innoculated with Fusarium isolates, and soil from a farm in the Caledon area where germination problems with onions had occurred in the spring. This soil was used both as it was received from the farm as well as pasteurised. The four Fusarium isolates were prepared by Mr. Dirk Uys then of the ARC Roodeplaat (Elsenburg), now Bayer (Pty) Ltd. These isolates were *Fusarium oxysporum* Strain 1 and 2, under the codes 11, 16, 21 and 25. The soil of source previously used, and for one treatment of the soil from Caledon was pasteurised by the Production Technology Department at Elsenburg, treating the soil for 60 minutes at a temperature of 83,6°C.

The Insulkups were filled with 150g dry weight of whichever soil used for the specific treatment plus 30g Mycorrhiza/vermiculite or plain vermiculite, mixed with a further 30g of the applicable soil and applied to the top of the 150g soil and the seed was covered with Consol sand.

Biostart, prepared as previously described, was added where applicable at the rate of 1ml per insulkup to both the pasteurised and raw soil.

Twenty seeds were sown per cup. Two germination counts, at two and four weeks after sowing were made as for the previous sowing.

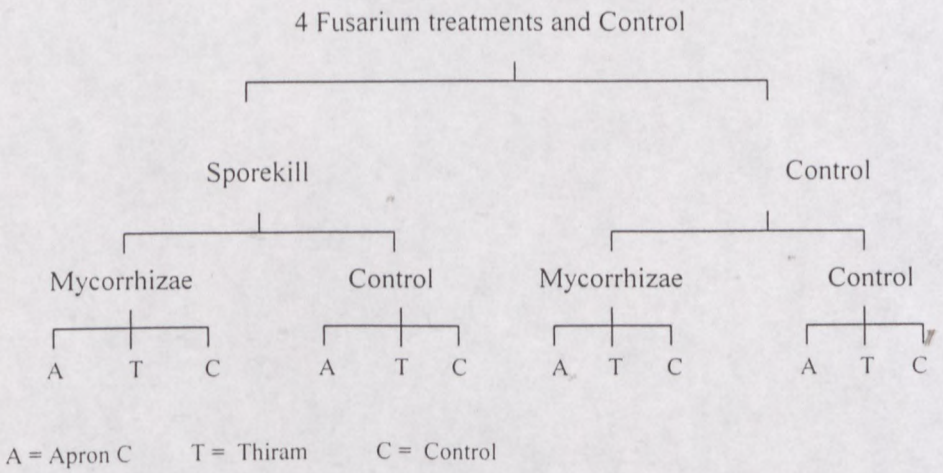
Two different levels of fertilisation were used to determine what effect, if any, a too high level of fertiliser would have on the seedling growth. Hygrotech A fertiliser (refer to Table 3 for composition) at the rate of 0.25g/litre water was applied weekly to the normal strength treatment, and at the rate of 0,5g/litre water to the double strength treatment from three weeks after sowing until the seedlings stopped growing.

The seedlings were then allowed to develop and after six months the bulbs were lifted, with counts being made of visibly viable bulblets, visibly non-viable bulblets and undeveloped growth. To determine the effect of sowing on soil previously infected with fusarium, all cups were resown with seed of the cultivar Eytan, a cultivar which had previously performed poorly on seedbed soil. Two counts were made of germination and growth up to two months after sowing.

6.1 Elsenburg soil

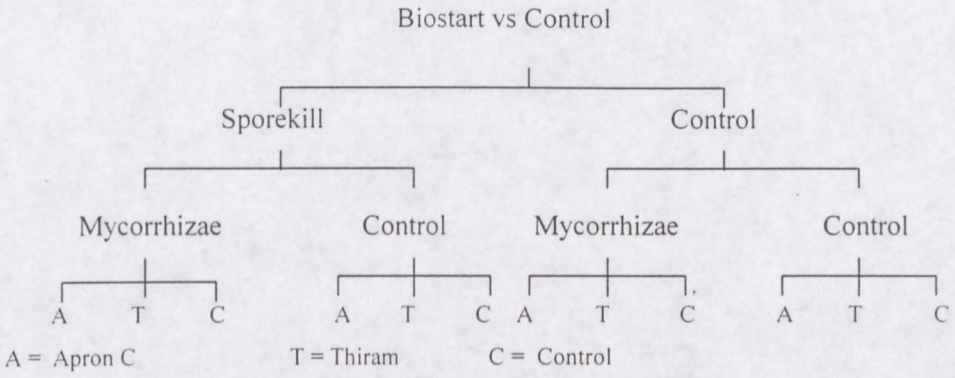
Two sets at normal and double strength fertilisation levels, each with five replicates (four fusarium treatments and a control) giving a total of 600 cups

Key - A = Apron C, T = thiram and C = Control.

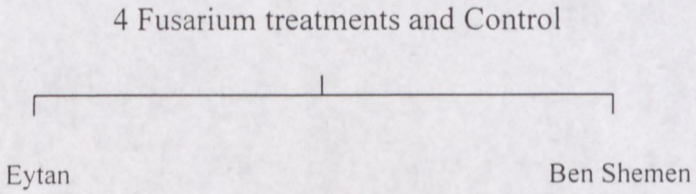


6.2. Pasteurised Caledon soil.

6.2.1 Five replicates

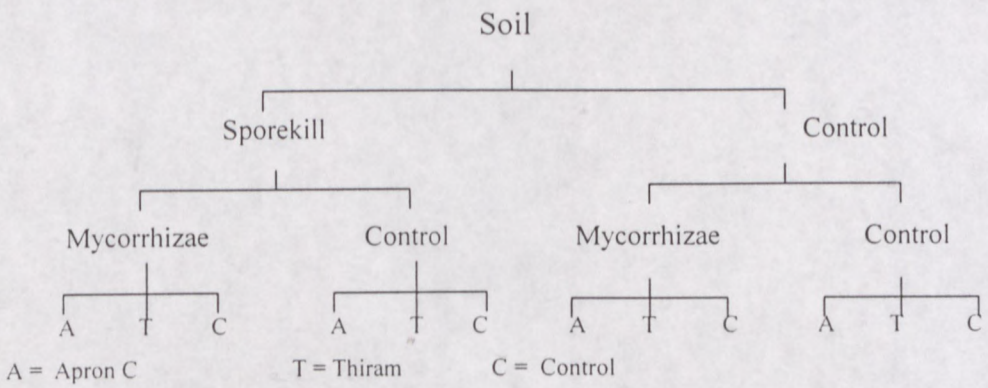


6.2.2 Five replicates each of four Fusarium treatments plus control

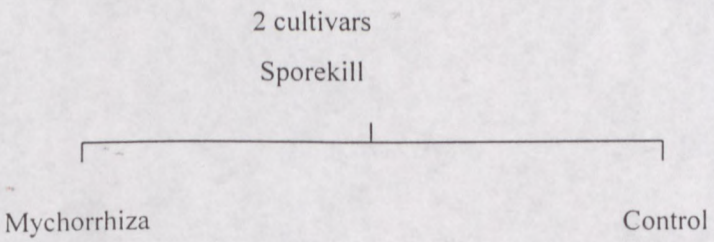


6.3 Untreated Caledon soil.

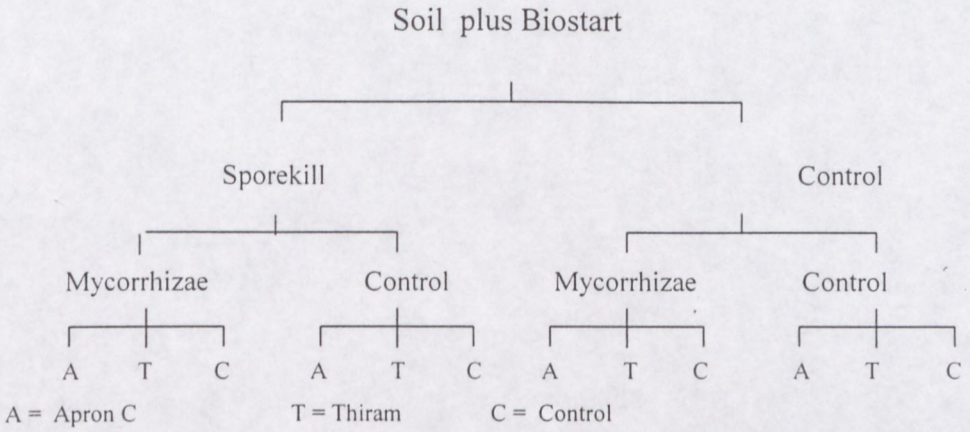
6.3.1 Five replicates



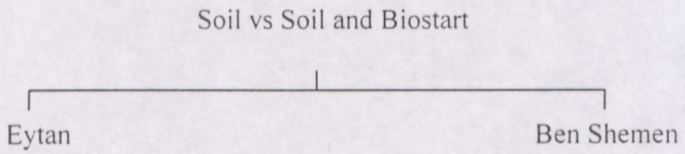
6.3.2 Five replicates



6.3.3 Five replicates



6.3.4 Five replicates



RESULTS

Only the results of which there are statistical differences at the 15% level, and which can thus be used in the discussion are tabled below. The analysis of variance results were carried according to the Number Cruncher Statistical System by Prof. D.van Schalkwyk of the Cape Technikon and the applicable plots sections are tabled in Annexure 1.

First sowing

Trial 1 Petri dish germination.

Table 5 Seed germination percentage of different suppliers after 15 and 29 days, for a variety of different treatments (p5; 1.1).

Treatment	Supl 1		Supl 2		Supl 3		Supl 4		Supl 5	
Days	15	29	15	29	15	29	15	29	15	29
ST	91	93	91	92	33	42	81	89	35	42
SA	72	75	90	93	41	48	82	90	53	65
SC	87	88	94	96	34	44	85	93	25	38
CT	94	95	90	92	75	78	94	95	67	69
CA	90	90	96	96	60	65	87	91	64	68
CC	92	92	100	100	70	70	90	94	62	62

Key - A = Apron C C = Control S = Sporekill T = Thiram
Supl = Supplier

Table 6 Seed germination percentage of mix of suppliers after 15 and 29 days, for a variety of different treatments, average of three replicates (p6; 1.2).

Treatment	Rep 1		Rep 2		Rep 3		Av. of Reps	
Days	15	29	15	29	15	29	15	29
ST	58	66	69	71	66	75	64	71
SA	70	80	58	63	74	78	67	74
SC	56	64	66	74	68	75	63	71
CT	81	84	88	89	82	84	84	86
CA	78	79	78	80	79	80	78	80
CC	90	90	82	83	97	97	90	90

Key - A = Apron C C = Control S = Sporekill T = Thiram

Table 7 **Seed germination percentage of mix of suppliers after 15 and 29 days, for a variety of different treatments, including mycorrhiza, and average of three replicates (p6; 1.3).**

Treatment	Rep 1		Rep 2		Rep 3		Av. of Reps	
Days	15	29	15	29	15	29	15	29
MST	74	76	79	82	47	50	67	69
MSA	62	68	65	66	63	65	63	66
MSC	60	61	71	75	65	66	65	67
MCT	71	72	75	77	85	85	77	78
MCA	75	75	87	87	75	76	79	79
MCC	86	86	55	55	84	84	75	75

Key - A = Apron C C = Control M = Mycorrhiza plus vermiculite
S = Sporekill T = Thiram

Table 8 **Seed germination percentage of mix of suppliers after 15 and 29 days, for a variety of different treatments, including vermiculite, and average of three replicates (p6; 1.3).**

Treatment	Rep 1		Rep 2		Rep 3		Av. of Reps	
Days	15	29	15	29	15	29	15	29
VST	76	78	78	81	74	77	76	79
VSA	60	66	75	81	78	81	71	76
VSC	66	71	81	81	73	73	73	75
VCT	89	89	84	86	81	81	85	85
VCA	88	88	77	78	75	76	80	81
VCC	77	79	86	87	80	80	81	82

Key - A = Apron C C = Control V = Vermiculite S = Sporekill
T = Thiram

Table 9 **Statistical analysis of petri dish germination after 29 days, according to source of seed (refer Figure 2; p67).**

Term	Degrees of freedom	F-Ratio	Probability level
A (s)	4	3.40	<0.01
B (sc)	1	8.13	<0.01
AB	4	4.92	0.27
C (tac)	2	0.07	0.93
AC	8	1.75	0.22
BC	2	0.77	0.49
S	8		
Total (Adjusted)	29		
Total	30		

- Term significant at alpha = 0,15

Key - s = source sc = sporekill vs control tac = thiram vs Apron C vs control

Table 10 Statistical analysis of petri dish germination after 29 days according to replications (refer Figure 3; p68).

Term	Degrees of freedom	F-Ratio	Probability level
A (rep)	2	0.43	0.65
B (mvc)	2	3.73	0.04
AB	4	0.42	0.79
C (sc)	1	18.55	<0.01
AC	2	0.97	0.39
BC	2	0.85	0.44
D (tac)	2	0.27	0.77
AD	4	0.45	0.77
BD	4	0.29	0.88
CD	2	0.19	0.83
S	28		
Total (Adjusted)	53		
Total	54		

- Term significant at alpha = 0,15

Key - rep = replicates cmv = mycorrhiza vs vermiculite vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Trial 2 Deep seed trays.

2.1 Seed germination

Table 11 Seed germination of mix of suppliers after 28 days, for a variety of different treatments (p7; 2.1).

Treatment				Rep 1	Rep 2	Avr	%
H	M	S	T	138	131	134.5	77
H	M	S	C	137	143	140.0	80
H	M	S	A	120	134	127.0	73
H	M	C	T	148	154	151.0	86
H	M	C	A	141	150	145.5	83
H	M	C	C	143	133	138.0	79
H	C	S	T	148	137	142.5	81
H	C	S	A	143	141	142.0	81
H	C	S	C	139	149	144.0	82
H	C	C	T	146	141	143.5	82
H	C	C	A	146	149	147.5	84
H	C	C	C	143	144	143.5	82
C	M	S	T	142	149	145.5	83
C	M	S	A	140	140	140.0	80
C	M	S	C	132	137	134.5	77
C	M	C	T	146	143	144.5	83
C	M	C	A	147	141	144.0	82
C	M	C	C	144	132	138.0	79
C	C	S	T	140	142	141.0	81
C	C	S	A	139	133	136.0	78
C	C	S	C	149	143	146.0	83
C	C	C	T	151	143	147.0	84
C	C	C	A	132	138	135.0	77
C	C	C	C	133	140	136.5	78

Key - A = Apron C C = control H =Herbifume S = Sporekill T= Thiram

Table 12 Statistical analysis of seedtray germination after 28 days according to replications.

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	0,18	0.68
B (mc)	1	0.85	0.38
AB	1	2.04	0.19
C (sc)	1	3.73	0.09
AC	1	3.11	0.11
BC	1	3.11	0.11
D (tac)	2	2.30	0.16
AD	2	0.73	0.51
BD	2	0.68	0.53
CD	2	2.16	0.17
S	9		
Total (Adjusted)	23		
Total	24		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

2.2 Shoot and root measurements:

Table 13 **Shoot and root averages and mass for both wet and dry treatments (p8; 2.1).**

Treatment	Wet mass (gm)		Length in cm		Total	Total stem	Wet mass tray (gm)		Dry mass tray (gm)		% Dry/wet mass	
	Root	Shoot	Max	Min	Leaves	Width (mm)	Root	Shoot	Root	Shoot	Root	Shoot
HMST	0.8	5.9	34.9	21.9	25.5	2.1	15.8	73.8	2.2	4.6	13.7	6.2
HMSA	0.7	4.7	33.3	22.7	25.0	1.9	11.2	59.0	1.4	3.8	12.0	6.5
HMSC	0.9	6.9	36.6	24.6	24.3	2.2	17.3	93.5	2.5	5.8	14.6	6.2
HMCT	1.0	6.3	35.9	26.2	25.2	2.0	17.2	78.6	2.4	4.7	13.7	5.9
HMCA	1.0	6.5	37.9	27.5	26.5	2.1	22.3	81.1	2.7	5.1	12.1	6.3
HMCC	0.9	5.1	32.7	22.7	23.7	1.9	14.1	65.3	2.0	4.1	13.9	6.3
HCST	1.0	5.9	36.3	24.8	25.3	2.0	13.3	69.6	1.9	4.3	14.0	6.2
HCSA	0.9	6.5	37.4	22.1	27.0	2.0	15.9	79.7	2.1	4.8	13.4	6.1
HCSC	1.1	7.0	38.2	27.1	26.3	2.1	18.9	90.2	2.8	5.3	14.8	5.9
HCCT	1.1	6.7	42.0	30.0	26.8	2.0	15.1	82.6	1.9	4.7	12.9	5.7
HCCA	1.1	5.4	34.8	23.6	25.5	1.9	18.9	64.1	2.6	4.0	13.7	6.2
HCCC	0.9	5.4	34.5	24.9	24.8	2.0	15.5	69.1	2.0	4.8	12.7	7.0
CMST	1.0	4.7	34.6	24.3	24.3	2.0	20.3	63.3	3.1	3.9	15.4	6.1
CMSA	1.1	6.1	36.8	26.6	26.0	2.0	20.9	71.3	3.5	4.5	16.6	6.2
CMSC	1.1	6.8	38.6	25.6	26.2	2.0	20.2	75.1	3.6	4.3	18.0	5.7
CMCT	0.8	6.0	35.7	27.5	26.5	2.1	16.3	77.0	2.1	4.8	13.0	6.2
CMCA	0.8	4.9	33.9	23.9	26.3	1.9	17.1	69.5	2.2	4.4	13.0	6.3
CMCC	1.3	6.4	37.1	27.4	27.2	2.1	18.5	75.1	3.2	4.7	17.0	6.2
CCST	1.4	6.8	36.9	27.8	25.5	2.1	25.4	85.8	4.2	4.8	16.7	5.6
CCSA	1.1	5.7	37.5	25.8	25.8	2.1	16.7	67.8	2.3	4.1	13.9	6.0
CCSC	1.0	6.1	38.6	28.0	26.3	2.1	20.3	83.6	2.4	4.8	11.6	5.8
CCCT	1.2	6.0	35.7	25.0	26.7	2.1	18.7	78.4	3.2	4.4	17.1	5.6
CCCA	1.0	5.5	35.9	23.6	25.5	2.0	20.6	71.4	3.2	4.2	15.6	5.9
CCCC	0.9	4.0	29.9	21.6	22.0	1.8	17.9	58.1	2.8	3.7	15.8	6.4

Key - A = Apron C C = control H =Herbifume S = Sporekill T= Thiram

Table 14 Statistical analysis of dry root mass.

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	13.99	0.06
B (mc)	1	0.08	0.81
AB	1	0.01	0.95
C (sc)	1	0.45	0.57
AC	1	1.53	0.34
BC	1	0.47	0.57
ABC	1	2.86	0.23
D (tac)	2	0.20	0.84
AD	2	0.48	0.68
BD	2	0.97	0.51
ABD	2	2.88	0.26
CD	2	1.45	0.41
ACD	2	2.00	0.33
BCD	2	0.22	0.82
S	2		
Total (Adjusted)	23		
Total	24		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 15 Statistical analysis of percentage dry root mass.

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	89.89	0.01
B (mc)	1	0.07	0.82
AB	1	2.69	0.24
C (sc)	1	3.25	0.21
AC	1	1.58	0.34
BC	1	22.15	0.04
ABC	1	45.19	0.02
D (tac)	2	9.82	0.09
AD	2	0.40	0.71
BD	2	29.79	0.03
ABD	2	22.10	0.04
CD	2	1.72	0.37
ACD	2	10.55	0.09
BCD	2	1.83	0.35
S	2		
Total (Adjusted)	23		
Total	24		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 16 Statistical analysis of percentage dry shoot mass.

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	6.86	0.12
B (mc)	1	4.66	0.16
AB	1	1.53	0.34
C (sc)	1	2.59	0.25
AC	1	1.08	0.41
BC	1	1.22	0.38
ABC	1	1.70	0.32
D (tac)	2	4.38	0.19
AD	2	0.89	0.53
BD	2	4.33	0.19
ABD	2	0.91	0.53
CD	2	8.78	0.10
ACD	2	0.72	0.58
BCD	2	1.76	0.36
S	2		
Total (Adjusted)	23		
Total	24		

• Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Second sowing

Trial 3. Petri dish germination.

Table 17 Seed germination percentages for a series of treatments in petri dishes (p9&10; 3.1-3.3).

Treatment	%	Treatment	%
C S T	94.6	C S T F	86.0
C S A	92.4	C S A F	42.2
C S C	91.6	C C T F	92.0
C C T	94.8	C C A F	55.4
C C A	93.6	C S T B	66.0
C C C	96.0	C S A B	67.0
M S T	91.0	C S C B	28.0
M S A	84.0	M S T B	64.0
M S C	81.4	M S A B	59.0
M C T	93.8	M S C B	67.0
M C A	89.4	C C T B	61.0
M C C	87.6	C C A B	48.0
V S T	89.8	C C C B	51.0
V S A	91.0	M C T B	83.0
V S C	94.6	M C A B	75.0
V C T	91.4	M C C B	72.0
V C A	88.8		
V C C	92.0		

Key – A = Apron C, B = Biostart, C = Control, F = Fungicide coated,
M= Mycorrhiza, S = Sporekill, T = Thiram V = Vermiculite

Table 18 Statistical analysis of petri dish germination using four variables

Term	Degrees of freedom	F-Ratio	Probability level
A (mvc)	2	4.44	0.04
B (sc)	1	0.99	0.34
AB	2	0.84	0.46
C (tac)	2	1.30	0.31
AC	4	0.40	0.80
BC	2	0.41	0.67
D (bc)	1	13.22	<0.01
AD	2	5.23	0.03
BD	1	0.20	0.66
CD	2	0.68	0.53
S	10		
Total (Adjusted)	29		
Total	30		

- Term significant at alpha = 0,15

Key – mvc = mycorrhiza vs vermiculite vs control bc = bioostart vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 19 Statistical analysis of petri dish germination using three variables

Term	Degrees of freedom	F-Ratio	Probability level
A (mvc)	2	17.94	0.01
B (sc)	1	5.36	0.08
AB	2	4.31	0.10
C (tac)	2	3.96	0.11
AC	4	4.89	0.08
BC	2	0.23	0.80
S	4		
Total (Adjusted)	17		
Total	18		

- Term significant at alpha = 0,15

Key – mvc = mycorrhiza vs vermiculite vs control sc = sporekill vs control
tac = thiram vs Apron C vs control

Table 20 Statistical analysis of petri dish germination using two variables

Term	Degrees of freedom	F-Ratio	Probability level
A (sc)	1	0.27	0.63
B (tac)	1	4.42	0.10
C (fc)	1	6.27	0.07
S	4		
Total (Adjusted)	7		
Total	8		

- Term significant at alpha = 0,15

Key – sc = sporekill vs control fc = fungicide coated vs control

Trial 4. **Deep seed trays.**

Table 21 **Seed germination percentages for a series of treatments in deep seed trays (p12-13; 4.1-4.3).**

Treatment	%
HMST	91.1
HMSA	86.7
HMSC	88.0
HMCT	85.4
HMCA	89.6
HMCC	90.9
HCST	90.6
HCSA	88.4
HCSC	89.3
HCCT	91.0
HCCA	92.4
HCCC	88.1

Treatment	%
CMST	89.6
CMSA	87.0
CMSC	92.9
CMCT	92.4
CMCA	91.0
CMCC	90.1
CCST	92.6
CCSA	87.4
CCSC	90.7
CCCT	91.1
CCCA	90.6
CCCC	91.7

Treatment	%
HMSTF	93.7
HMCAF	91.4
HCSAF	90.0
HCCTF	90.0
CMSTF	92.0
CMCTF	88.0
CCSAF	92.6
CCCAF	90.3
HMSB	80.9
HMCB	88.9
HCSB	80.6
HCCB	68.0
CMSB	85.7
CMCB	88.0
CCSB	75.1
CCCB	80.0

Key – A = Apron C, B = Biostart, C = Control, F = Fungicide coated,
H = herbifume M = Mycorrhiza, S = Sporekill, T = Thiram

Table 22 **Statistical analysis of percentage germination for four variables after 28 days.**

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	0.03	0.87
B (mc)	1	0.04	0.85
AB	1	0.00	0.99
C (sc)	1	0.43	0.53
AC	1	0.29	0.60
BC	1	0.25	0.63
ABC	1	0.37	0.56
D (tac)	3	0.64	0.61
AD	3	0.32	0.81
BD	3	0.37	0.78
ABD	3	0.28	0.84
CD	3	0.13	0.94
ACD	3	0.16	0.92
BCD	3	0.20	0.90
S	11		
Total (Adjusted)	39		
Total	40		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 23 Statistical analysis of percentage germination for three variables after 28 days.

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	0.72	0.43
B (sc)	1	0.03	0.86
AB	1	0.22	0.65
C (tac)	2	0.46	0.65
AC	2	0.12	0.89
BC	2	2.63	0.15
S	6		
Total (Adjusted)	15		
Total	16		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control sc = sporekill vs control
tac = thiram vs Apron C vs control

Table 24 Statistical analysis of percentage germination for three variables after 28 days.

Term	Degrees of freedom	F-Ratio	Probability level
A (mc)	1	0.72	0.55
B (sc)	1	0.05	0.86
AB	1	2.61	0.35
C (f)	1	4.98	0.27
AC	1	28.17	0.12
BC	1	89.52	0.67
S	1		
Total (Adjusted)	7		
Total	8		

- Term significant at alpha = 0,15

Key – mc = mycorrhiza vs control sc = sporekill vs control
f = fungicide coated

No statistical analysis was done on the root and shoot data as there was no difference in the first sowing, and there was no apparent difference in the measurements taken.

The following results were obtained from the grading data:

Table 25 **Grading data of all treatments giving numbers and mass of bulbs for each size grade as well as percentage marketable (p12-13; 4.1-4.3).**

Treatment	Medium		Small		Split bulb		Under size		Total		% Marketable	
	No	Kg	No	Kg	No	Kg	No	Kg	No	Kg	No	Kg
HMST	18.3	1.2	48.3	2.0	8.8	0.5	11.0	0.2	86.3	3.9	76.7	81.3
HMSA	12.8	1.0	59.5	2.6	8.8	0.6	8.0	0.3	89.0	4.4	81.3	81.9
HMSC	35.5	2.0	33.8	1.4	7.0	0.4	11.5	0.2	87.8	4.0	78.9	84.3
HMCT	16.8	1.2	50.3	2.0	10.5	0.4	10.3	0.2	87.8	3.8	76.8	83.3
HMCA	27.8	1.9	47.0	1.6	8.8	0.5	5.0	0.1	88.5	4.0	84.5	85.1
HMCC	33.3	2.0	34.8	1.3	6.3	0.3	8.5	0.1	82.8	3.8	82.4	87.3
HCST	22.5	1.5	46.0	1.9	5.3	0.3	12.0	0.2	85.8	3.9	78.4	87.2
HCSA	28.5	2.0	39.3	1.7	9.3	0.6	6.3	0.1	83.3	4.3	81.1	84.0
HCSC	25.8	1.7	30.3	1.2	6.8	0.4	15.8	0.3	78.5	3.6	71.2	80.3
HCCT	28.3	2.0	42.0	1.6	6.0	0.4	7.5	0.1	83.8	4.1	83.3	86.5
HCCA	23.3	1.6	45.0	1.9	4.8	0.4	8.0	0.1	81.0	4.0	84.1	88.3
HCCC	28.5	2.1	44.0	1.9	6.0	0.3	6.8	0.1	85.3	4.4	85.0	90.1
CMST	15.0	1.1	51.8	2.2	4.3	0.2	14.3	0.3	85.3	3.7	77.7	85.4
CMSA	19.3	1.4	55.0	2.3	12.3	0.6	7.8	0.1	94.3	4.4	78.8	83.9
CMSC	33.5	2.1	42.5	1.8	8.5	0.5	7.0	0.1	91.5	4.4	83.1	87.4
CMCT	43.0	2.6	35.0	1.4	6.8	0.4	4.8	0.1	89.5	4.4	87.2	89.5
CMCA	13.5	1.2	57.0	2.5	8.8	0.5	7.3	0.3	86.5	4.5	81.6	82.5
CMCC	28.0	1.6	48.5	1.9	6.3	0.3	7.5	0.1	90.3	4.0	84.8	88.2
CCST	34.0	2.4	40.0	1.7	6.5	0.4	9.5	0.2	90.0	4.7	82.0	87.5
CCSA	38.3	2.3	39.8	1.6	8.0	0.5	4.8	0.1	90.8	4.4	86.0	87.1
CCSC	24.5	1.6	47.5	2.1	12.0	0.7	5.3	0.1	89.3	4.5	80.8	82.9
CCCT	25.0	1.8	49.5	2.2	7.0	0.4	7.0	0.1	88.5	4.5	84.4	87.4
CCCA	22.3	1.7	52.3	2.2	6.0	0.5	4.0	0.1	84.5	4.4	87.8	88.5
CCCC	22.0	1.2	49.3	2.0	10.3	0.6	7.5	0.1	89.0	3.9	79.5	81.5
HMSTF	22.0	1.7	54.0	2.7	6.0	0.4	6.0	0.1	88.0	4.9	86.4	89.1
HMCAF	13.0	1.0	38.0	1.5	7.0	0.5	44.0	1.2	102.0	4.2	50.0	60.2
HCSAF	48.0	3.7	33.0	1.4	11.0	0.8	3.0	0.0	95.0	5.9	85.3	85.9
HCCTF	55.0	4.7	14.0	0.7	8.0	1.0	11.0	0.3	88.0	6.7	78.4	81.2
CMSTF	40.0	3.2	49.0	2.3	3.0	0.2	5.0	0.1	97.0	5.7	91.8	95.1
CMCTF	22.0	1.8	64.0	2.9	2.0	0.1	7.0	0.2	95.0	5.0	90.5	93.9
CCSAF	73.0	5.4	10.0	0.4	14.0	1.3	0.0	0.0	97.0	7.0	85.6	82.0
CCCAF	60.0	4.8	18.0	0.9	9.0	1.0	5.0	0.1	92.0	6.7	84.8	84.6
HMSB	26.5	2.0	41.5	1.7	11.5	0.7	8.0	0.2	87.5	4.6	77.7	80.2
HMCB	21.0	1.7	52.5	2.4	4.0	0.3	11.0	0.2	88.5	4.6	83.7	88.3
HCSB	47.5	3.5	21.5	1.0	8.0	0.7	4.5	0.1	81.5	5.2	84.9	85.6
HCCB	35.0	2.7	24.5	1.2	11.5	0.9	9.5	0.3	80.5	5.1	73.6	77.1
CMSB	34.5	2.2	39.5	1.8	9.5	0.6	7.0	0.2	90.5	4.7	81.6	84.6
CMCB	29.5	2.3	49.5	2.3	9.5	0.7	0.5	0.0	89.0	5.3	88.7	86.0
CCSB	42.0	3.1	33.0	1.4	10.5	0.9	5.0	0.1	90.5	5.4	83.0	82.7
CCCB	44.0	3.4	27.5	1.3	14.0	1.1	8.5	0.2	94.0	6.0	76.1	78.6

Key – A = Apron C, B = Biostart, C = Control, F = Fungicide coated,
H = herbifume M = Mycorrhiza, S = Sporekill, T = Thiram

Table 26 **Statistical analysis of the percentage marketable bulbs obtained (refer Figure 4; p69).**

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	2.73	0.12
B (mc)	1	0.03	0.86
AB	1	0.02	0.89
C (sc)	1	2.81	0.12
AC	1	0.06	0.81
BC	1	1.30	0.27
D (tac)	3	0.58	0.64
AD	3	0.20	0.90
BD	3	1.43	0.28
CD	3	0.77	0.53
S	13		
Total (Adjusted)	31		
Total	32		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 27 **Statistical analysis of the total mass of bulbs harvested (refer Figure 5; p70).**

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	10.19	0.01
B (mc)	1	5.44	0.04
AB	1	0.16	0.70
C (sc)	1	0.21	0.66
AC	1	0.43	0.53
BC	1	0.03	0.84
D (tac)	3	21.13	<0.01
AD	3	0.38	0.77
BD	3	2.04	0.16
CD	3	0.99	0.43
S	13		
Total (Adjusted)	31		
Total	32		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 28 **Statistical analysis of the total number of bulbs harvested (refer Figure 6; p71).**

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	26.96	<0.01
B (mc)	1	7.05	0.02
AB	1	6.87	0.02
C (sc)	1	0.70	0.42
AC	1	0.40	0.54
BC	1	0.18	0.68
D (tac)	3	0.20	0.90
AD	3	1.27	0.33
BD	3	1.02	0.42
CD	3	1.58	0.24
S	13		
Total (Adjusted)	31		
Total	32		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 29 **Statistical analysis of the number of medium bulbs harvested (refer Figure 7; p72).**

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	0.81	0.38
B (mc)	1	4.05	0.07
AB	1	0.08	0.78
C (sc)	1	0.17	0.68
AC	1	0.06	0.81
BC	1	1.60	0.23
D (tac)	3	3.99	0.03
AD	3	0.98	0.43
BD	3	3.26	0.06
CD	3	0.86	0.48
S	13		
Total (Adjusted)	31		
Total	32		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 30 **Statistical analysis of the mass of medium bulbs harvested (refer Figure 8; p73).**

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	0.53	0.48
B (mc)	1	9.47	0.01
AB	1	0.28	0.61
C (sc)	1	0.00	1.00
AC	1	0.11	0.74
BC	1	1.68	0.22
D (tac)	3	9.54	<0.01
AD	3	1.27	0.33
BD	3	3.69	0.04
CD	3	0.59	0.63
S	13		
Total (Adjusted)	31		
Total	32		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

There were a few differences after a six month storage period, showing that the state of seed planted has an effect on the quality of the stored product. These differences are illustrated below.

Table 31 **Statistical analysis of the percentage of bulbs marketable after six months, over the same four variables as above (refer Figure 9; p74).**

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	2.79	0.12
B (mc)	1	3.08	0.10
AB	1	0.70	0.42
C (sc)	1	0.57	0.47
AC	1	6.28	0.03
BC	1	0.84	0.37
D (tac)	3	10.58	<0.01
AD	3	1.59	0.24
BD	3	5.61	0.10
CD	3	0.51	0.68
S	13		
Total (Adjusted)	31		
Total	32		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control tac = thiram vs Apron C vs control

Table 32 **Statistical analysis of the percentage of bulbs marketable after six months, over different variables including the fungicide coated treatment.**

Term	Degrees of freedom	F-Ratio	Probability level
A (hc)	1	0.24	0.64
B (mc)	1	0.13	0.72
C (sc)	1	0.00	1.00
D (ta)	1	0.01	0.91
E (fc)	1	5.27	0.04
S	10		
Total (Adjusted)	15		
Total	16		

- Term significant at alpha = 0,15

Key – hc = herbifume vs control mc = mycorrhiza vs control
sc = sporekill vs control ta = thiram vs Apron C
fc = fungicide coated vs control

Third sowing

Trial 5. **Petri dish germination.**

Table 33.1 **Seed germination percentages for a series of treatments in petri dishes (p14-16; 5.1-5.8).**

		Seed treated prior to first sowing	Seed treated prior to third sowing			
Cultivar	Supplier	12 treatments	12 treatments	SB	SF	SW
CG	I	85.0	77.8	61.8	66.8	20.7
CG	II	84.7	93.2	70.0	73.0	18.8
CG	III	43.2	57.0	46.3	38.5	11.8
CG	IV	81.2	70.0	58.0	69.8	17.0
CG	V	38.2	49.2	38.0	31.7	14.2
Eytan			84.0			
B.S			43.0			

Key – BS = Ben Shemen CG = Caledon Globe SB = with added Biostart
SF = fungicide coated SW = with wetter added

Table 33.2 Seed germination percentages for seed of best three suppliers seed germinated at different times after treatment with Sporekill (p14; 5.1-5.3).

Cultivar	First sowing	Second sowing	Third sowing
Caledon Globe	83.6	86	80.3

Table 34 Statistical analysis of the percentage germination after 28 days over two variables (refer Figure 10; p75).

Term	Degrees of freedom	F-Ratio	Probability level
A (ad)	1	0.34	0.59
B (source)	4	12.29	0.02
S	4		
Total (Adjusted)	9		
Total	10		

- Term significant at alpha = 0,15

Key – ad = previously treated vs freshly treated seed
source = supplier

Table 35 Statistical analysis of the percentage germination after 28 days over different variables (refer Figure 11; p75).

Term	Degrees of freedom	F-Ratio	Probability level
A (cbfw)	3	12.25	<0.01
S	16		
Total (Adjusted)	19		
Total	20		

- Term significant at alpha = 0,15

Key – cbrw = control vs Biostart vs fungicide coated vs wetter

Trial 6. Sowing in 250ml Insulkups™.

Differences were obtained between the soils, where in general, the untreated Caledon soil gave the poorest results. This indicates that where there are problems, they can be improved by taking the necessary measures. Germination results for two months after sowing are given as it was felt that there could be a higher initial germination followed by a dying-off of seedlings due to the effect of the various fusarium treatments.

6.1 Germination

Refer to Material/Method for detail on Fusarium and other treatments.

6.1.1 Elsenburg soil

Table 36 Seed germination percentages for a series of treatments in Insulkups™ (p17; 6.1).

Fer	Fun	Control		Fusarium 1		Fusarium 2		Fusarium 3		Fusarium 4	
		1 month	2 months	1 month	2 months	1 month	2 months	1 month	2 months	1 month	2 months
N	CMST	83.0	82.0	78.0	69.0	74.0	46.0	82.0	80.0	85.0	84.0
N	CMSA	86.0	90.0	51.0	46.0	85.0	84.0	79.0	78.0	82.0	87.0
N	CMSC	80.0	81.0	58.0	54.0	67.0	65.0	74.0	58.0	81.0	74.0
N	CMCT	79.0	78.0	64.0	52.0	59.0	57.0	82.0	82.0	82.0	79.0
N	CMCA	73.0	74.0	67.0	61.0	80.0	73.0	82.0	81.0	81.0	76.0
N	CMCC	92.0	93.0	69.0	56.0	75.0	65.0	78.0	73.0	79.0	77.0
N	CCST	78.0	64.0	32.0	21.0	17.0	13.0	82.0	78.0	90.0	91.0
N	CCSA	94.0	91.0	37.0	32.0	17.0	2.0	86.0	82.0	83.0	78.0
N	CCSC	90.0	85.0	47.0	33.0	29.0	17.0	86.0	82.0	76.0	77.0
N	CCCT	93.0	83.0	59.0	46.0	52.0	40.0	89.0	81.0	91.0	85.0
N	CCCA	95.0	88.0	42.0	33.0	37.0	32.0	91.0	92.0	89.0	88.0
N	CCCC	80.0	78.0	44.0	25.0	36.0	27.0	83.0	79.0	88.0	83.0
D	CMST	84.0	86.0	61.0	58.0	70.0	65.0	82.0	81.0	85.0	81.0
D	CMSA	77.0	80.0	56.0	51.0	75.0	69.0	86.0	83.0	75.0	75.0
D	CMSC	76.0	61.0	46.0	36.0	68.0	63.0	82.0	81.0	84.0	84.0
D	CMCT	82.0	75.0	77.0	79.0	87.0	87.0	90.0	85.0	91.0	85.0
D	CMCA	89.0	85.0	70.0	68.0	70.0	69.0	75.0	76.0	83.0	81.0
D	CMCC	79.0	81.0	78.0	70.0	79.0	81.0	79.0	75.0	79.0	74.0
D	CCST	90.0	86.0	34.0	27.0	23.0	13.0	86.0	83.0	82.0	76.0
D	CCSA	85.0	80.0	29.0	14.0	25.0	16.0	82.0	80.0	78.0	71.0
D	CCSC	77.0	80.0	16.0	7.0	29.0	21.0	82.0	81.0	80.0	84.0
D	CCCT	97.0	87.0	65.0	49.0	28.0	24.0	86.0	85.0	86.0	85.0
D	CCCA	89.0	86.0	50.0	42.0	37.0	23.0	85.0	85.0	84.0	75.0
D	CCCC	83.0	76.0	35.0	31.0	26.0	14.0	88.0	82.0	82.0	78.0

Key – A = Apron C C = Control D = Double fertiliser dosage
M = Mycorrhiza N = Normal fertiliser dosage S =Sporekill
T=Thiram

Table 37 **Statistical analysis of germination percentages for four variables after 2 months (refer Figure 12; p76).**

Term	Degrees of freedom	F-Ratio	Probability level
A (sup)	4	147.37	<0.01
B (fert)	1	0.00	0.95
AB	4	0.49	0.74
C (mc)	1	89.89	<0.01
AC	4	51.71	<0.01
BC	1	2.36	0.13
D (sc)	1	14.36	<0.01
AD	4	3.21	0.02
BD	1	1.48	0.23
CD	1	1.32	0.25
S	97		
Total (Adjusted)	119		
Total	120		

- Term significant at alpha = 0,15

Key –sup = fusarium treatment vs control mycor = mycorrhiza vs control
fert = normal vs double applications sc = sporekill vs control

Table 38 **Statistical analysis of germination percentages for three other variables after 2 months (refer Figure 13; p77).**

Term	Degrees of freedom	F-Ratio	Probability level
A (fus)	4	131.29	<0.01
B (fer)	1	0.00	0.96
AB	4	0.44	0.02
C (fun)	11	9.73	<0.01
AC	44	4.96	<0.01
BC	11	0.92	0.53
S	44		
Total (Adjusted)	119		
Total	120		

- Term significant at alpha = 0,15

Key – fus = fusarium treatment vs control fun = fungicide vs control
fer = normal vs double applications

6.1.2 Pasteurised Caledon soil

Table 39.1 Seed germination percentages for a series of treatments in Insulkups™ (p18; 6.2.1).

Fer	Fun	Control		Biostart	
		1 month	2 months	1 month	2 months
N	CMST	71.0	70.0	82.0	71.0
N	CMSA	79.0	70.0	83.0	83.0
N	CMSC	82.0	75.0	82.0	79.0
N	CMCT	89.0	89.0	83.0	80.0
N	CMCA	84.0	82.0	82.0	81.0
N	CMCC	87.0	72.0	66.0	64.0
N	CCST	82.0	83.0	91.0	93.0
N	CCSA	72.0	72.0	88.0	83.0
N	CCSC	86.0	83.0	80.0	79.0
N	CCCT	92.0	87.0	82.0	80.0
N	CCCA	85.0	90.0	86.0	80.0
N	CCCC	81.0	80.0	87.0	90.0

Key – A = Apron C C = Control M = Mycorrhiza
N = Normal fertiliser dosage S = Sporekill T = Thiram

Table 39.2 Seed germination percentages for two cultivars in Insulkups™ using normal fertiliser application, no fungicidal, mycorrhiza or Sporekill treatments and no fusarium treatments (p18; 6.2.2).

Fer	Fun	Cultivar	1 month	2 months
N	CCCC	E	75.0	75.0
N	CCCC	B S	55.0	48.0
N	CCCC	E	33.0	28.0
N	CCCC	B S	7.0	6.0
N	CCCC	E	38.0	30.0
N	CCCC	BS	30.0	18.0
N	CCCC	E	77.0	77.0
N	CCCC	BS	50.0	43.0
N	CCCC	E	82.0	77.0
N	CCCC	BS	40.0	37.0

Key – B = Ben Shemen C = Control E = Eytan
N = Normal fertiliser dosage

Table 40 **Statistical analysis of germination percentages for two variables after 2 months (refer Figure 14; p77).**

Term	Degrees of freedom	F-Ratio	Probability level
A (fus)	4	15.90	0.01
B (cul)	1	31.15	<0.01
S	4		
Total (Adjusted)	9		
Total	10		

- Term significant at alpha = 0,15

Key – fus = fusarium treatment vs control cul = cultivar

6.1.3 Untreated Caledon soil.

Table 41.1 **Seed germination percentages for a series of treatments in Insulkups™ (p18; 6.3.1 & 6.3.3).**

Fer	Fun	Control		Biostart	
		1 month	2 months	1 month	2 months
N	CMST	78.0	79.0	70.0	67.0
N	CMSA	70.0	73.0	67.0	73.0
N	CMSC	81.0	84.0	85.0	85.0
N	CMCT	73.0	72.0	81.0	83.0
N	CMCA	68.0	68.0	65.0	69.0
N	CMCC	74.0	75.0	72.0	72.0
N	CCST	82.0	80.0	83.0	78.0
N	CCSA	75.0	79.0	80.0	77.0
N	CCSC	84.0	86.0	81.0	83.0
N	CCCT	87.0	84.0	80.0	64.0
N	CCCA	81.0	85.0	82.0	81.0
N	CCCC	81.0	77.0	70.0	73.0

Key – A = Apron C C = Control D = Double fertiliser dosage M = Mycorrhiza N = Normal fertiliser dosage S =Sporekill T=Thiram

Table 41.2 **Seed germination percentages for two cultivars in Insulkups™ using normal fertiliser application, no fungicidal, mycorrhiza or Sporekill treatments and no fusarium treatments (p18-19; 6.3.2 & 6.3.4).**

Fer	Fun	Cultivar	Control		Biostart	
			1 month	2 months	1 month	2 months
N	CMSC	E	75.0	75.0		
N	CCSC	E	71.0	70.0		
N	CCCC	E	72.0	74.0	79.0	78.0
N	CMSC	BS	27.0	21.0		
N	CCSC	BS	31.0	27.0		
N	CCCC	BS	52.0	44.0	56.0	60.0

Key – BS = Ben Shemen C = Control E = Eytan M = Mycorrhiza N = Normal fertiliser dosage S = Sporekill

Table 42 **Statistical analysis of germination percentages for two variables after 2 months.**

Term	Degrees of freedom	F-Ratio	Probability level
A (cul)	1	37.25	0.03
B (fun)	2	1.07	0.48
S	2		
Total (Adjusted)	5		
Total	6		

- Term significant at alpha = 0,15

Key – cul = cultivar fun = fungicide vs control

6.1.4 Comparison between Elsenburg, Caledon treated and untreated seed (refer Tables 36, 39.1, 41.1).

Table 43 **Statistical analysis of comparison of germination percentages between the Elsenburg, Caledon treated, and Caledon untreated soils.**

Term	Degrees of freedom	F-Ratio	Probability level
A (soil)	2	1.02	0.03
B (mc)	1	2.85	0.03
AB	2	1.40	0.38
C (bio)	1	0.48	0.27
AC	2	2.17	0.19
BC	1	0.56	0.53
D (fun)	2	0.15	0.47
AD	4	1.44	0.51
BD	2	0.89	0.40
CD	2	1.36	0.30
S	16		
Total (Adjusted)	35		
Total	36		

- Term significant at alpha = 0,15

Key – soil = Elsenburg vs Caledon treated vs Caledon untreated
mycor = mycorrhiza vs control bio = Biostart vs control
fun = fungicide vs control

6.2 Bulblets lifted

6.2.1 Elsenburg soil

Table 44 Percentages of bulblets lifted six months after sowing of the seed sown in Insulkups™ (p17; 6.1).

Fer	Fun	Control	Fusarium1	Fusarium 2	Fusarium 3	Fusarium 4
N	CMST	52.0	35.0	25.0	60.0	45.0
N	CMSA	69.0	24.0	48.0	62.0	65.0
N	CMSC	49.0	21.0	38.0	34.0	58.0
N	CMCT	49.0	31.0	33.0	57.0	51.0
N	CMCA	57.0	36.0	45.0	64.0	48.0
N	CMCC	60.0	29.0	42.0	38.0	59.0
N	CCST	46.0	12.0	6.0	60.0	69.0
N	CCSA	59.0	19.0	1.0	62.0	66.0
N	CCSC	49.0	19.0	11.0	65.0	60.0
N	CCCT	56.0	23.0	18.0	66.0	45.0
N	CCCA	61.0	19.0	16.0	42.0	45.0
N	CCCC	49.0	11.0	17.0	21.0	68.0
D	CMST	39.0	19.0	10.0	27.0	51.0
D	CMSA	42.0	18.0	16.0	7.0	45.0
D	CMSC	37.0	15.0	11.0	5.0	50.0
D	CMCT	50.0	32.0	17.0	64.0	46.0
D	CMCA	46.0	26.0	27.0	49.0	34.0
D	CMCC	61.0	7.0	44.0	33.0	22.0
D	CCST	49.0	9.0	5.0	45.0	33.0
D	CCSA	55.0	4.0	7.0	26.0	24.0
D	CCSC	45.0	4.0	10.0	10.0	34.0
D	CCCT	57.0	18.0	9.0	9.0	19.0
D	CCCA	58.0	14.0	10.0	13.0	42.0
D	CCCC	51.0	12.0	10.0	30.0	38.0

Key – A = Apron C C = Control D = Double fertiliser dosage
M – Mycorrhiza N = Normal fertiliser dosage S = Sporekill
T = Thiram

Table 45 Statistical analysis for three variables of percentages of bulblets lifted six months after sowing (refer Figure 15; p78).

Term	Degrees of freedom	F-Ratio	Probability level
A (fus)	4	56.77	<0.01
B (fer)	1	60.93	<0.01
AB	4	4.61	<0.01
C (fun)	11	2.31	0.02
AC	44	1.69	0.04
BC	11	1.26	0.28
S	44		
Total (Adjusted)	119		
Total	120		

- Term significant at alpha = 0,15

Key – fus = fusarium treatment vs control fun = fungicide vs control
fer = fertiliser vs control

Table 46 **Statistical analysis for four variables of percentages of bulblets lifted six months after sowing (refer Figure 16; p79).**

Term	Degrees of freedom	F-Ratio	Probability level
A (fus)	4	51.80	<0.01
B (fert)	1	55.59	<0.01
AB	4	4.20	<0.01
C (mc)	1	13.93	<0.01
AC	4	3.96	<0.01
BC	1	0.04	0.84
D (sk)	1	2.07	0.15
AD	4	1.92	0.11
BD	1	4.08	0.05
CD	1	3.02	0.09
S	97		
Total (Adjusted)	119		
Total	120		

- Term significant at alpha = 0,15

Key – fus = fusarium vs control fert = fertiliser double vs single
mycor = mycorrhiza vs control sk = sporekill vs control

6.2.2 Pasteurised Caledon soil

Table 47.1 **Percentages of bulblets lifted six months after sowing of the seed in Insulkups™ (p18; 6.2.1).**

Fer	Fun	Control	Biostart
N	CMST	40.0	43.0
N	CMSA	45.0	45.0
N	CMSC	50.0	46.0
N	CMCT	55.0	46.0
N	CMCA	49.0	59.0
N	CMCC	46.0	45.0
N	CCST	52.0	65.0
N	CCSA	44.0	52.0
N	CCSC	45.0	52.0
N	CCCT	60.0	30.0
N	CCCA	57.0	58.0
N	CCCC	55.0	68.0

Key – A = Apron C C = Control M = Mycorrhiza
N = Normal fertiliser dosage S = Sporekill T = Thiram

Table 47.2 **Percentages of bulblets lifted after six months for two cultivars in Insulkups™ using normal fertiliser application, no fungicidal, mycorrhiza or Sporekill treatments and no fusarium treatments (p18; 6.2.2).**

Fer	Fun	Cultivar	%
N	CCCC	E	16.0
N	CCCC	BS	9.0
N	CCCC	E	3.0
N	CCCC	BS	0.0
N	CCCC	E	3.0
N	CCCC	BS	3.0
N	CCCC	E	8.0
N	CCCC	BS	4.0
N	CCCC	E	7.0
N	CCCC	BS	6.0

Key – BS = Ben Shemen C = Control
E = Eytan N = Normal fertiliser dosage

Table 48 **Statistical analysis for two variables of percentages of bulblets lifted six months after sowing (refer Figure 17; p80).**

Term	Degrees of freedom	F-Ratio	Probability level
A (fus)	4	9.56	0.03
B (cul)	1	6.00	0.07
S	4		
Total (Adjusted)	9		
Total	10		

- Term significant at alpha = 0.15

Key – fus = fusarium treatment vs control cul = cultivar

6.2.3 Untreated Caledon soil.

Table 49.1 Percentages of Caledon Globe bulblets lifted six months after sowing of the seed in Insulkups™ (p18; 6.3.1 & 6.3.2).

Treatment		Control	Biostart
N	CMST	24.0	17.0
N	CMSA	20.0	8.0
N	CMSC	44.0	28.0
N	CMCT	45.0	27.0
N	CMCA	41.0	12.0
N	CMCC	46.0	12.0
N	CCST	32.0	22.0
N	CCSA	30.0	33.0
N	CCSC	46.0	28.0
N	CCCT	48.0	31.0
N	CCCA	30.0	50.0
N	CCCC	26.0	31.0

Key – A = Apron C C = Control M = Mycorrhiza
N = Normal fertiliser dosage S = Sporekill T = Thiram

Table 49.2 Percentages for two cultivars in Insulkups™ of bulblets lifted six months after sowing using normal fertiliser application, mycorrhiza, Sporekill and Biostart treatments, but no fungicidal or fusarium treatments (p18-19; 6.3.2 & 6.3.4).

Treatment		Cultivar	Control	Biostart
N	CMSC	E	21.0	
N	CCSC	E	13.0	
N	CCCC	E	14.0	8.0
N	CMSC	BS	9.0	
N	CCSC	BS	15.0	
N	CCCC	BS	16.0	18.0

Key – BS = Ben Shemen C = Control E = Eytan M = Mycorrhiza
N = Normal fertiliser dosage S = Sporekill

Table 50 **Statistical analysis of percentages of bulblets lifted six months after sowing for Biostart and fungicide variables.**

Term	Degrees of freedom	F-Ratio	Probability level
A (bio)	1	6.64	0.03
B (fun)	11	1.12	0.43
S	11		
Total (Adjusted)	23		
Total	24		

- Term significant at alpha = 0,15

Key – bio = Biostart vs control fun = fungicide vs control

Table 51 **Statistical analysis for percentages of bulblets lifted six months after sowing for two cultivars and mycorrhiza and Sporekill variables.**

Term	Degrees of freedom	F-Ratio	Probability level
A (cul)	1	0.33	0.63
B (fun)	2	0.02	0.98
S	2		
Total (Adjusted)	5		
Total	6		

- Term significant at alpha = 0,15

Key – cul = cultivar fun = fungicide vs control

6.2.4 Elsenburg soil, Caledon pasteurised and untreated soil (refer Tables 44, 47.1, 47.2, 49.1, 49.2).

Table 52 Statistical analysis for four variables of percentages of bulblets lifted six months after sowing (refer Figure 18; p80).

Term	Degrees of freedom	F-Ratio	Probability level
A (soil)	2	23.57	<0.01
B (mc)	1	0.01	0.92
AB	2	0.96	0.40
C (sk)	1	5.14	0.04
AC	2	0.73	0.50
BC	1	0.15	0.70
D (fun)	2	0.02	0.98
AD	4	2.73	0.07
BD	2	1.27	0.31
CD	2	2.03	0.16
S	16		
Total (Adjusted)	35		
Total	36		

- Term significant at alpha = 0,15

Key – soil = Elsenburg vs Caledon treated vs Caledon untreated
mycor = mycorrhiza vs control sk = sporekill vs control
fun = fungicide vs control

Table 53 Statistical analysis for Biostart, fungicidal and soil variables, of percentages of bulblets lifted six months after sowing (refer Figure 19; p81).

Term	Degrees of freedom	F-Ratio	Probability level
A (bio)	1	4.37	0.06
B (fun)	11	1.71	0.19
AB	11	1.56	0.24
C (soil)	1	66.48	<0.01
AC	1	6.08	0.03
BC	11	1.14	0.42
S	11		
Total (Adjusted)	47		
Total	48		

- Term significant at alpha = 0,15

Key – bio = Biostart vs control fun = fungicide vs control
soil = Elsenburg vs Caledon treated vs Caledon untreated

6.3 Resowing.

6.3.1 Elsenburg soil

Table 54 **Seed germination percentages for a series of treatments of seed sown as replant in the previously sown Insulkups™ (p17; 6.1).**

Treat		Control			Fusarium 1			Fusarium 2			Fusarium 3			Fusarium 4		
Fer	Fun	Months after sowing														
		1	2	5	1	2	5	1	2	5	1	2	5	1	2	5
N	CMST	25	21	17	48	41	28	16	20	11	34	25	16	62	54	31
N	CMSA	23	24	21	48	34	22	49	36	28	35	32	27	39	35	21
N	CMSC	55	50	37	53	47	31	59	44	32	32	26	22	52	38	24
N	CMCT	53	34	33	46	35	12	34	27	24	54	51	42	55	48	32
N	CMCA	45	34	23	49	38	33	53	40	26	60	58	44	40	33	23
N	CMCC	46	38	35	49	46	26	50	39	29	21	19	18	47	38	32
N	CCST	47	43	36	69	60	33	46	39	37	49	40	31	22	35	11
N	CCSA	53	43	37	57	47	33	56	46	34	55	37	30	66	52	30
N	CCSC	56	55	45	59	54	29	26	20	19	41	74	26	64	55	18
N	CCCT	62	51	29	40	37	22	34	26	19	58	51	35	17	12	7
N	CCCA	37	29	24	37	42	20	51	40	32	59	39	42	46	36	25
N	CCCC	39	34	29	32	27	13	50	36	28	48	39	35	64	53	23
D	CMST	47	41	25	37	34	17	30	24	21	20	15	11	30	27	14
D	CMSA	40	38	32	17	14	13	31	21	15	23	16	14	34	24	19
D	CMSC	26	20	13	28	23	16	28	20	15	25	23	18	28	24	9
D	CMCT	41	38	32	35	33	21	18	16	14	55	53	36	52	44	20
D	CMCA	43	35	25	56	47	18	38	29	26	50	44	39	51	45	32
D	CMCC	33	22	24	34	32	17	15	14	10	32	27	21	30	32	21
D	CCST	63	50	42	12	10	10	50	32	24	48	33	30	47	12	19
D	CCSA	50	35	30	8	5	4	26	22	20	25	20	21	10	8	5
D	CCSC	35	25	23	59	43	30	11	8	5	19	13	13	40	36	21
D	CCCT	54	44	40	26	19	14	18	11	13	27	25	23	21	11	5
D	CCCA	29	33	17	38	29	22	56	54	34	44	32	23	32	26	21
D	CCCC	53	48	37	34	32	20	36	27	24	23	23	15	25	20	17

Key – A = Apron C = Control D = Double fertiliser dosage M = Mycorrhiza N = Normal fertiliser dosage S =Sporekill T=Thiram

Table 55 Statistical analysis for five variables of percentage germination 28 days after sowing (refer Figure 20; p82).

Term	Degrees of freedom	F-Ratio	Probability level
A (fus)	4	1.06	0.38
B (fert)	1	27.82	<0.01
AB	4	1.23	0.30
C (mc)	1	0.53	0.47
AC	4	1.18	0.32
BC	1	0.71	0.40
D (sk)	1	0.92	0.34
AD	4	0.89	0.47
BD	1	1.56	0.22
CD	1	4.44	0.04
E(fun)	2	0.41	0.66
AE	8	1.81	0.09
BE	2	1.44	0.24
CE	2	0.17	0.84
DE	2	1.90	0.16
S	81		
Total (Adjusted)	119		
Total	120		

- Term significant at alpha = 0,15

Key – fus = fusarium vs control fert = normal vs double
mycor = mycorrhiza vs control sk = sporekill vs control
fun = fungicide vs control

Table 56 Statistical analysis for five variables of percentage germination 2 months after sowing (refer Figure 21; p83).

Term	Degrees of freedom	F-Ratio	Probability level
A (fus)	4	1.62	0.18
B (fert)	1	32.92	<0.01
AB	4	1.72	0.15
C (mc)	1	0.32	0.57
AC	4	1.77	0.14
BC	1	4.23	0.40
D (sk)	1	1.41	0.24
AD	4	0.72	0.58
BD	1	6.99	0.01
CD	1	5.25	0.02
E(fun)	2	0.09	0.91
AE	8	1.27	0.27
BE	2	1.36	0.26
CE	2	0.98	0.38
DE	2	2.80	0.07
S	81		
Total (Adjusted)	119		
Total	120		

- Term significant at alpha = 0,15

Key – fus = fusarium vs control fert = normal vs double
mycor = mycorrhiza vs control sk = sporekill vs control
fun = fungicide vs control

Table 57 **Statistical analysis for five variables of percentage germination 5 months after sowing (refer Figure 22; p84).**

Term	Degrees of freedom	F-Ratio	Probability level
A (fus)	4	6.89	<0.01
B (fert)	1	24.97	<0.01
AB	4	0.82	0.52
C (mc)	1	0.33	0.57
AC	4	2.37	0.06
BC	1	0.05	0.82
D (sk)	1	2.61	0.11
AD	4	2.34	0.06
BD	1	2.77	0.10
CD	1	65.6	0.01
E(fun)	2	0.94	0.40
AE	8	1.75	0.10
BE	2	1.37	0.26
CE	2	0.05	0.95
DE	2	0.90	0.41
S	81		
Total (Adjusted)	119		
Total	120		

• Term significant at alpha = 0,15

Key – fus = fusarium vs control fert = normal vs double
mycor = mycorrhiza vs control sk = sporekill vs control
fun = fungicide vs control

6.3.2 Pasteurised Caledon soil

There were no significant differences at the 15% level.

6.3.3 Untreated Caledon soil

Table 58 **Seed germination percentages 28 days and 2 months after sowing for a series of treatments of seed sown as replant in the previously sown Insulkups™ (p17; 6.1).**

Treatment		Cultivar	28 days	2 months
N	CMSC	E	36.0	35.0
N	CCSC	E	62.0	58.0
N	CCCC	E	22.0	20.0
N	CMSC	BS	45.0	47.0
N	CCSC	BS	61.0	55.0
N	CCCC	BS	26.0	24.0

Key – BS = Ben Shemen C = Control E = Eytan M = Mycorrhiza
N = Normal fertiliser dosage S = Sporekill

Table 59 Statistical analysis for two variables of percentage germination 28 days and 2 months after sowing.

Term	Degrees of freedom	F-Ratio		Probability level	
		28 days	2 months	28 days	2 months
A (cul)	1	1.92	1.00	0.30	0.42
B (fun)	2	56.52	21.20	0.02	0.05
S	2				
Total (Adjusted)	5				
Total	6				

• Term significant at alpha = 0,15

Key – cul = cultivar fun = fungicide vs control

6.3.4 Elsenburg soil, Caledon pasteurised and untreated soil

Table 60 Statistical analysis for four variables of percentage germination 28 days after sowing (refer Tables 54, 58).

Term	Degrees of freedom	F-Ratio	Probability level
A (soil)	2	0.09	0.91
B (mc)	1	1.13	0.30
AB	2	0.16	0.86
C (sk)	1	0.11	0.75
AC	2	0.10	0.91
BC	1	0.68	0.42
D (fun)	2	0.39	0.68
AD	4	0.54	0.71
BD	2	0.82	0.46
CD	2	2.38	0.12
S	16		
Total (Adjusted)	35		
Total	36		

• Term significant at alpha = 0,15

Key – soil = Elsenburg vs Caledon treated vs Caledon untreated
mycor = mycorrhiza vs control sk = sporekill vs control
fun = fungicide vs control

Table 61 Statistical analysis for four variables of percentage germination 2 months after sowing.

Term	Degrees of freedom	F-Ratio	Probability level
A (foil)	2	0.11	0.89
B (mc)	1	1.82	0.20
AB	2	0.44	0.65
C (sk)	1	0.00	0.96
AC	2	0.30	0.75
BC	1	1.04	0.32
D (fun)	2	1.57	0.24
AD	4	0.59	0.68
BD	2	0.32	0.73
CD	2	2.45	0.12
S	16		
Total (Adjusted)	35		
Total	36		

- Term significant at alpha = 0,15

Key – soil = Elsenburg vs Caledon treated vs Caledon untreated
mycor = mycorrhiza vs control sk = sporekill vs control
fun = fungicide vs control

Table 62 Statistical analysis for four variables of percentage germination 5 months after sowing (refer Figure 23; p85).

Term	Degrees of freedom	F-Ratio	Probability level
A (soil)	2	0.39	0.70
B (mc)	1	23.46	0.01
AB	2	0.00	1.00
C (sk)	1	0.01	0.93
AC	2	5.47	0.07
BC	1	3.61	0.13
ABC	2	22.33	0.01
D (fun)	2	9.49	0.03
AD	4	8.36	0.03
BD	2	2.98	0.16
ABD	4	6.26	0.05
CD	2	7.82	0.04
ACD	4	4.23	0.10
BCD	2	9.09	0.03
S	4		
Total (Adjusted)	35		
Total	36		

- Term significant at alpha = 0,15

Key – soil = Elsenburg vs Caledon treated vs Caledon untreated
mycor = mycorrhiza vs control sk = sporekill vs control
fun = fungicide vs control

Table 63 **Statistical analysis for the variables soil, Biostart, Mycorrhiza, Sporekill and fungicides of percentage germination 5 months after sowing.**

Term	Degrees of freedom	F-Ratio	Probability level
A (soil)	1	1.15	0.29
B (bio)	1	0.09	0.76
AB	1	1.29	0.27
C (mc)	1	2.61	0.12
AC	1	0.00	0.96
BC	1	0.31	0.58
D (sk)	1	0.19	0.67
AD	1	0.11	0.74
BD	1	1.02	0.32
CD	1	1.68	0.21
E(fun)	2	0.04	0.96
AE	2	1.11	0.34
BE	2	2.10	0.14
CE	2	0.31	0.73
DE	2	2.82	0.08
S	27		
Total (Adjusted)	47		
Total	48		

- Term significant at alpha = 0,15

Key – soil = Caledon treated vs Caledon untreated
bio = Biostart vs control mycor = mycorrhiza vs control
sk = sporekill vs control fun = fungicide vs control

DISCUSSION

First sowing

Trial 1 Petri dish germination

Differences in the actual germination counts between the seed of the five different suppliers was observed, with seed from suppliers three and five performing statistically poorer than the others. This is obvious when the results are compared, and as a result only the seed from the three suppliers which gave better and even germination were used in the later trials. Treating seed with Sporekill had a suppressing effect on germination, and this effect was heightened when the interaction of Sporekill with the various suppliers seed is considered. From these results it is obvious that the suppressing effect Sporekill has is more obvious when the inherent germination of the seed is poor.

Where mycorrhiza and vermiculite were added to the filter paper in the petri dish, it was found that Sporekill still had a suppressing effect on germination but that mycorrhiza also suppressed germination. When vermiculite alone was added there was, however, no effect on germination. Mycorrhiza is not used as a germination additive, and gave no significant difference when added to the soil used in the second sowing. There seems to be no reason why it should be added purely for germination purposes.

There were no significant differences between either the fungicidal treatments or the control, either alone or in interaction with the Sporekill treatments.

Trial 2 Deep seed trays

The same treatments as used in the petri dish trial were used in the deep cutting trays, and results compared after 28 days. Here the control treatments were significantly better that either the Sporekill or mycorrhiza treatments, and in the

interaction treatments the mycorrhiza treatment proved better than the mycorrhiza and Sporekill combined treatment. Again, mycorrhioza is not used as a germination agent, and the effect was only seen after the plants had grown and the crop been harvested.

Data of shoot and root growth as well as mass of both wet and dry root and shoot growth after four months growth in the trays was analysed.

Although no significant differences were found in the above ground portion of the plants, there were differences in the root growth, where Herbifume suppressed root growth. In the interactions, it was found that mycorrhiza treatments gave better results than the Sporekill treatments although there were no differences for either the mycorrhiza and control or Sporekill and control treatments on their own.

When the root and shoot material had been dried, however, the shoot interactions indicated that Sporekill suppressed both the fungicide treatments. However, the Herbifume treatment was superior to the control for the aboveground portion of the plants indicating that the effect of the Herbifume treatment only appears at a later stage and in the quality of the plant. As far as the root growth was concerned, the control gave better results than the Herbifume treatment indicating that the herbifume retards root growth, at any rate initially. The fungicideal treatments also resulted in reduced root dry mass while the interactions indicated that either fungicide was beneficial in combination with both Herbifume and Sporekill, but that Apron C gave poorer results in combination with both Herbifume and mycorrhiza.

Where there is no problem with seed quality it would appear that the addition of mycorrhiza had no affect on the germination of the seed. Similarly there was no advantage gained by treating the seed with fungicides. The Sporekill treatment, however, reduced germination of the seed. However, unless the quality of the seed is known it would still appear to be prudent to treat seed prior to planting, unless the seed has been treated prior to being sold, as there can be no guarantee that seed of other batches would give similar germination results.

Second sowing

In view of the above it was decided that for the second sowing seed from the three sources giving the highest rate of germination in the petri dishes would be mixed and used.

Trial 3. Petri dish germination

The trials done in the first sowing were repeated using mixed seed as described above, with the addition of treatments including Biostart and the random addition of fungicides.

Biostart, Sporekill and the treatments with mycorrhiza all had a suppressing effect on germination, a factor enhanced when used in conjunction with each other. As far as the fungicidal treatments were concerned, Thiram gave the best results, but the interactions indicate that there is no advantage in the fungicidal treatments. In fact, normal applications gave better results than the random applications, indicating that it is essential to adhere to the recommendations given.

Trial 4. Black trays

Germination:

As far as germination was concerned, the only significant differences obtained were from interactions where Thiram proved better than the other treatments when used in conjunction with Sporekill, and, interestingly where the random fungicide applications proved better than the recommended dosage when used in conjunction with mycorrhiza, indicating a possible inhibiting effect of the mycorrhiza on fungicidal application.

Root and shoot data:

No statistical analysis was done on the root and shoot data as there was no difference in the first sowing, and there was no apparent difference in the measurements taken.

Grading:

Due to the prevailing weather conditions of the season during which this trial was undertaken, namely a very wet, cold and late winter, the crop, not only of our trial but also of all onions grown locally was not only light in total mass but also small in size of individual onions. The marketable percentage was reasonable under the circumstances.

Differences on total number and mass of onions revealed that once again the control treatment yielded better results than the Herbifume treatment, but that the mycorrhiza treatment now came into it's own being better than the control.The random rate of fungicide gave better results than either the normal rate or control, and the interaction for number of onions indicated that although no Herbifume gave the best results, the application of mycorrhiza with Herbifume gave improved results to no mycorrhiza.

As far as the medium size alone was concerned, Herbifume again suppressed the yield, while the random fungicidal application was better than the control, this also holding true for the sporekill treatment.

Marketable after storage:

The Herbifume treatments gave a higher percentage of marketable onions after storage, while those treated with mycorrhiza showed a decrease. Biostart treated seed gave onions which stored better than either untreated or fungicide treated seed, while the seed treated with a random amount of fungicide proved better than the normal amount. Sporekill alone had no effect on storage life. The interactions showed that herbifume and Sporekill together gave the best results. The interaction between mycorrhiza and fungicides showed that mycorrhiza and Biostart gave the best results, and mycorrhiza and Apron C the poorest.

It was disappointing that so little improvement could be found using the mycorrhiza or Sporekill treatments. Biostart did not only improve the size of the bulbs but also improved the keeping quality, indicating that a better plant initially results in a better product. It was disappointing that because of the weather conditions the average bulb size was so small, and it would have been interesting to see if the Biostart improvement would also hold good for large and fleshier bulbs.

Third sowing:

Trial 5. Petri dish germination.

There was no significant difference between seed treated with Sporekill before the first or third sowings, that is a difference of eight months. The results of the five different sources of seed were in line with the findings of the first sowing, that is two which gave much poorer germination than the other three. What was very significant, however, was the fact that adding a wetter to the fungicide treated seed prior to sowing very significantly reduced the germination percentage. This is one of the most important results obtained indicating that the seed should, if treating is envisaged, be treated dry.

Trial 6. Sowing in Insulcups.

Three soils were used, the Elsenburg soil which had previously been used, the soil from Caledon and the same soil pasteurised. Differences were obtained between the soils, where in general, the untreated Caledon soil gave the poorest results. This indicates that where there are problems, they can be improved by taking the necessary measures.

6.1 Germination results:

6.1.1 Elsenburg soil

Two fusarium isolates, 11 and 16, gave several results different to both the other two and the control treatments. These isolates are a Strain I and a Strain II indicting virulence differences between the strains and the fact that one strain cannot be "written off" as being less of a problem than the other but rather that there is a variation between the effect of different strains on germination and growth.

Fusarium isolates 11 and 16 gave poorer germination than the other three treatments.

There was no difference between the two fertiliser applications on germination, but in combination with Sporekill the higher rate gave a better germination after 28 days, although Sporekill by itself again suppressed germination..

The addition of mycorrhiza improved germination except for the treatment where no fusarium was added. This indicates the usefulness of mycorrhiza in situations where the seed is not of good quality, or where there may be a problem with the soil in which the seed is planted. In addition, the mycorrhiza dramatically improved the germination of the poorer fusarium treatments.

Once again, the control treatments gave a better germination than when Sporekill was added.

Both fungicidal treatments gave a greatly improved germination on the control, when taken in conjunction with the fusarium treatments.

6.1.2 Pasteurised Caledon soil

Fusarium isolates 21 and 25 gave a poorer germination, as was the case with the Elsenburg soil.

The germination of the cultivar Eytan was, as was the case with the petri dish germination, better than that of Ben Shemen. Although this was not the result of

soil, but of the seed, it is important to know this when comparing the results of the further trials.

6.1.3 Untreated Caledon soil.

The cultivar Eytan germinated better than Ben Shemen.
There was no difference between the germination for the various fungicidal treatments.

6.1.4 Comparison between Elsenburg and Caledon treated and untreated soil

With normal fertilisation, fungicidal treatments and no fusarium the Elsenburg soil gave the best germination, followed by the pasteurised Caledon soil, with the untreated Caledon soil giving the poorest germination.
The addition of Biostart increased germination on both the treated and untreated Caledon soils.
Once again, the addition of mycorrhiza suppressed germination.

6.2 Lifting of bulblets.

The bulblets were lifted after 6 months growth in the cups, and after the growth had died back. Here the percentage bulblets lifted over number of seed planted was taken as the criteria from all the available information.

6.2.1 Elsenburg soil

Control vs Fusarium inoculations – Fusarium isolates 11 and 16 (Tretrments 2 and 3) were poorer than the control or other treatments.
The double fertiliser rate gave poorer percentage of usable bulblets than the normal fertilisation, although there was no difference in germination. This indicates that too much fertiliser may be deleterious to the quality of the growth

of the plant, as shown by Comrie (undated publication). In interaction with the fungicidal applications this held true.

The application of mycorrhiza increased the percentage of bulblets whereas the addition of Sporekill again suppressed the number . This is in agreement with the results discussed in 2.1 above.

In the interaction of fusarium and mycorrhiza it was found that the poorer combinations gave even poorer results.

In the interaction of fusarium and fungicides the fungicidal treatments both proved to be better than the control, while no fusarium gave the best results, with isolates 11 and 16 being the poorest.

For the percentage of bulbs from seed lifted -

(i) Isolate 25 and control were better than the other treatments.

(ii) Normal fertilisation level was better than the double level.

(iii) Mycorrhiza was better that control.

The number and percentage germination from the re-sown bulblets showed that the normal level of fertilisation was better than the double level, and that Isolate 21 and control gave the best results.

6.2.2 Pasteurised Caledon soil

The results on soil with no fusarium treatment was superior to any of the fusarium treated soils.

The percentage bulbs from seed planted for cultivar Eytan was better than for Ben Shemen indicating also a difference between cultivars as far as the fusarium treatments are concerned. The addition of Biostart increased the percentage of bulblets.

6.2.3 Untreated Caledon soil

Biostart suppressed the percentage bulblets over the control.

There was no difference as far as cultivar or fungicidal treatment were concerned.

6.2.4 Comparison between Elsenburg soil and Caledon treated and untreated soil.

Again the Elsenburg soil proved the best, followed by the Caledon treated soil and last the Caledon untreated soil.
Sporekill once again suppressed the number of bulblets.
Biostart suppressed the number of bulblets, and this was more marked on the untreated than on the treated soil.

6.3 Re-sowing the cups with Eytan seed

6.3.1 Elsenburg soil

Recordings were taken at one, two and 5 months after sowing to evaluate any differences that might have arisen as a result of the residual effect of the fusarium treatments.

All three recording dates showed that the normal rate of fertilisation resulted in a better stand of seedlings than the double rate. After the five months it was apparent that fusarium treatments 1 & 4 were superior to the others. Various interactions showed that the stand of seedlings was more constant when either mycorrhiza or sporekill was added to the fusarium treated cups. Sporekill also suppressed seedling stand for the double fertiliser treatment and when used in conjunction with mycorrhiza.

6.3.2 Pasteurised Caledon soil

No significant differences at 15% level were forthcoming.

6.3.3 Caledon untreated soil

The Sporekill treatments were better than the control, and in conjunction with mycorrhiza gave the best result.

6.3.4 Elsenburg soil compared with both the Caledon treated and Caledon untreated soil.

The addition of mycorrhiza resulted in poorer results than when no mycorrhiza were added to the soil mixes.

When Sporekill was added the results were as follows:

Sporekill resulted in increased number of seedlings for the Elsenburg soil, whereas the number of seedlings was reduced for both the Caledon soils when Sporekillwas added.

Apron C gave the best results, followed by Thiram with no fungicide giving the poorest results. For the Caledon treated soil Apron C also gave the best results, with the other treatments having no significant difference. The Caledon untreated soil, however, gave a different result in that the Apron C gave the poorest result with the other two treatments being equal. On average over all the soils, Thiram proved to give a poorer stand of seedlings than either Apron C or Control.

When comparing mycorrhioza with fungicidal treatments the results showed that for the Elsenburg soil Apron C gave better results than Thiram which was better than Control. In the case of the Caledon treated soil Apron C was the best with the others the same, whilst for the Caledon untreated soil Thiram and Control together were better than Apron C. No significant difference was apparent when all the soils were compared together.

When comparing mycorrhiza with Sporekill there was no significant difference when the Elsenburg soil was used, whilst Sporekill gave better stand of seedlings for both the Caledon treated and untreated soils. Overall, Sporekill gave better results than did the mycorrhiza treatments.

In conclusion, as was to be expected, better results were forthcoming from the treated Caledon soil, but the lack of differences resulting from the re-sowing on the fusarium infected soil was surprising.

SUMMARY / RECOMMENDATIONS

This study was undertaken basically to study the effects of various treatments on onion seed. As materials such as mycorrhiza or herbifume are not normally used on seed, but rather on the soil into which the seeds or seedlings are planted, certain seedlings were also planted out to determine any effect which these adjuvants to seed may have on the plant after planting or on the storage ability of the crop after harvesting. Soil from which poor seedling results had been obtained commercially was also included when this became available.

Although the results shown do not perhaps look remarkable on the surface, there are several very interesting points raised under the discussion, some of which could be the subjects for further work, not least being the suppressing effect that mycorrhiza have on the germination percentage. This should be borne in mind by all producers who intend using adjuvants in their seedbeds, as any reduction in germination of seed results in increased cost of seed. Seed cost is an aspect which is becoming of greater importance especially in view of the increase in the usage of hybrid cultivars. It must be borne in mind that any increase in crop represents virtually a direct increase in income as the fixed costs remains by and large the same whatever the yield obtained. Similarly any increase in input costs results in a direct drop in income.

The results obtained show that there are many factors which affect the germination rate of seed and it would appear that care must be taken before any additives or seed treatments are used. For example if seed is to be treated with a fungicide it should be treated without the use of a wetting agent (table 35), and the amount of fungicide used should be carefully monitored (tables 20, 32) – this is also of course of cardinal importance from a safety point of view. However where pre-treated seed is used, or where the seed is healthy, the use of pre-sowing additives did not give any improvement. It is unfortunate that a disinfectant material such as Sporekill suppressed germination on a regular basis, as this type of material fits so well into the current thought on the use of fungicides. Where mycorrhiza was used the effect was only seen later on when the plants were growing, and in the results (eg tables 27, 28, 29). It was

interesting that Biostart also improved both the size of the bulbs and also the keeping quality (eg. tables 50, 52). This indicates that further work on these types of additives is necessary, especially as the emphasis these days is placed more and more on the use of the organic type of product. The use of mycorrhiza, Biostart and possibly other similar additives to the soil in which the crop is to be planted seems to warrant further investigation.

If the disease status of the soil is unknown it would appear to be wise to treat it (eg tables 37, 53), and if Herbifume is used to note that the influence will only be apparent at a later stage in the development of the plant (eg tables 12, 28, 31). It would also be interesting to establish the results of using combinations of products such as Biostart and Herbifume.

In conclusion it must be stressed that further work on the effect of these and other adjuvants on the germination of seed, growth of plants, yield and resultant storage ability of the crop shou;ld be undertaken. The effect of various adjuvants to the soil in which the seed is sown and the seedlings are planted should also be investigated, again with the intention of obtaining increased yields with better onion keeping quality. Any possible decrease in costs, or increase in profit obtained from the production of onions should be investigated so that the improvements may be implemented by producers.

LITERATURE.

1. Anon. 1995. The New Encyclopaedia Britannica. Volume 8 p 995.
2. Anon. 1998. Seed analysis manual for auditing officers. Seed Quality Control Directorate of Plant and Quality Control.
3. Anon. 1999. Statistics on Fresh Produce Markets Report 36 1/1/98 - 31/12/98. National Dept. of Agric.
4. Anon.Undated. Herbifume - give your crops a clean start. Plaaskem (Pty) Ltd.
5. Hygrotech Seed. Undated. Sporekill Manual. Hygrotech Seed.
6. Hygrotech Seed. Undated. Sporekill - a healthy alternative to a healthier production.
7. Hygrotech Seed. Undated. Sporekill - 'n revolusie in plantsiekte bestuur. Hygrotech Seed.
8. Hygrotech Seed. Undated. Sporekill - report back on tests - are there any pathogens that Sporekill does not control in water? HygrotechSeed.
9. Hygrotech Seed. Undated. Sporekill - report back on tests - random testing of irrigation waters in the Cape. Hygrotech Seed.
10. Coetzee, P. 1994. Goue reëls by die verplanting van uiesaailinge. Roodeplaat Bulletin No. 40, June 1994.
11. Comrie, A., undated. Die Ui. NIGS. Elsenburg.
12. Comrie, A., 1987. Uiesaailingproduksie Deel 1. Groentekortkursus, Elsenburg.
13. Fugler, E., 1989. Saailing gehalte bepaal uie-oes. Landbou Weekblad 23 June 1989.
14. Hartman, J. P. 1997. Unifruco newsletter on Quartinary Ammonium Compounds (including Sporekill). Unifruco, Cape Town.
15. LNR-Roodeplaat (Wes-Kaap), 1998. Handleiding vir uie verbouing in Ceres en Overberg. LNR Elsenburg.
16. LNR-Roodeplaat (Wes-Kaap), 1999. Afsterwing van uieplantjies in die Koue Bokkeveld tydens die 1997 ui-seisoen. LNR Elsenburg.
17. Microbial Solutions (Pty Ltd), 1996. The Biostart Range of Products. Microbial Solutions, Roodepoort.

18. Nelson, C.E. and Safir, G.R. 1982. Increased drought tolerance of mycorrhizal onion plants caused by improved phosphorus nutrition. Planta 154, 407-413.

19. Schreuder, W., 1996. Sporekill: a revolution in plant disease management. Hygrotech Forum, Autumn 1996.

20. Swart L. et al., 1998. Handleiding vir uie verbouing in Ceres en Overberg. ARC Elsenburg.

21. van Rooyen, CL. and Comrie A., 1997. Uieproduksie in die Wes-Kaap. National Dept. of Agriculture, Pretoria.

Personal communication

Aveling Terry, 1997. Personal communication.

Comrie A., 1995. Personal communication.

Venter, Marianne W., 1996. Personal communication. Myco Greengro, Somerset West.

ANNEXURE 1

Trial 1

Figure 2 Plots sections of petri dish germination after 29 days, according to source of seed – refer Table 9.

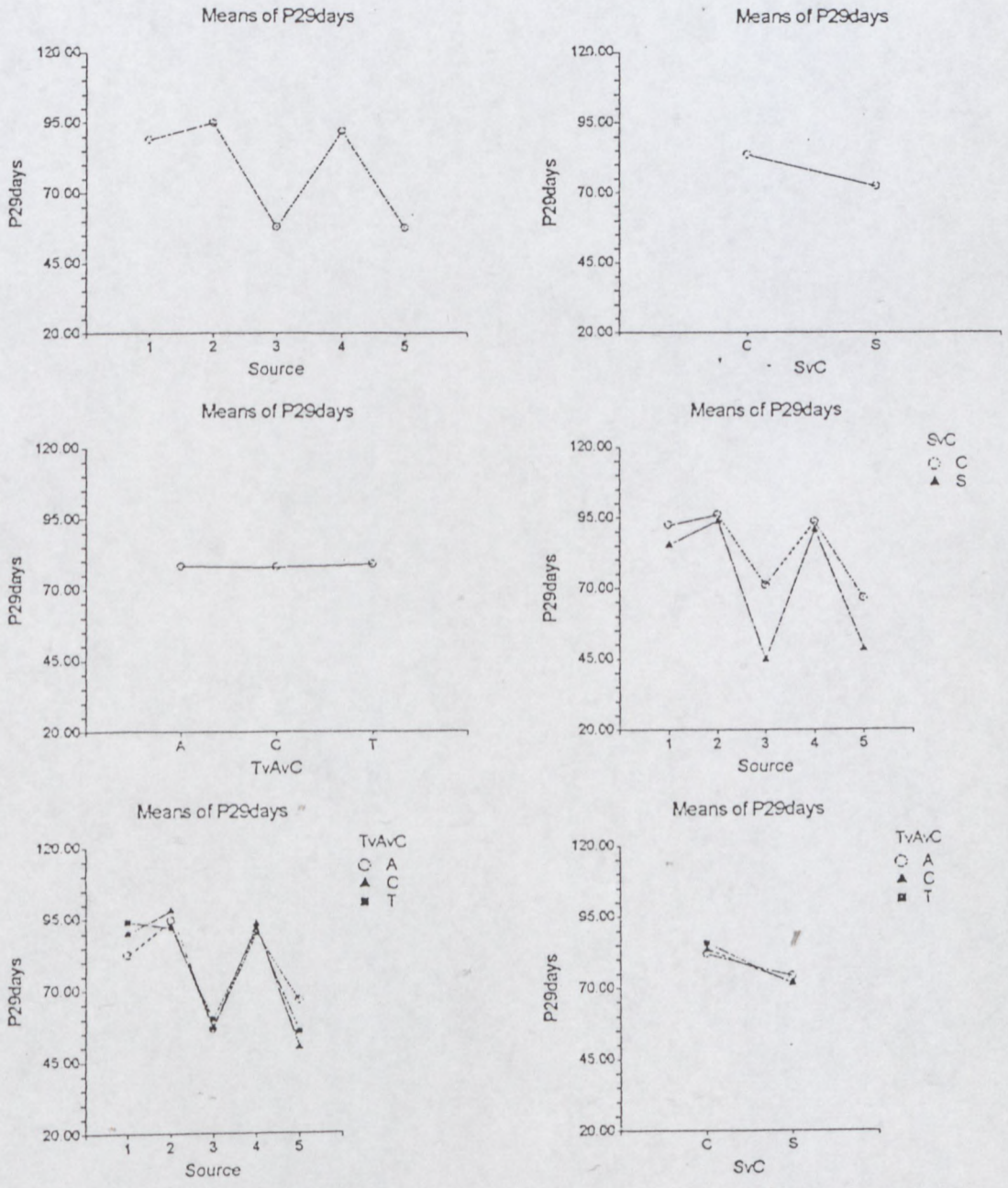
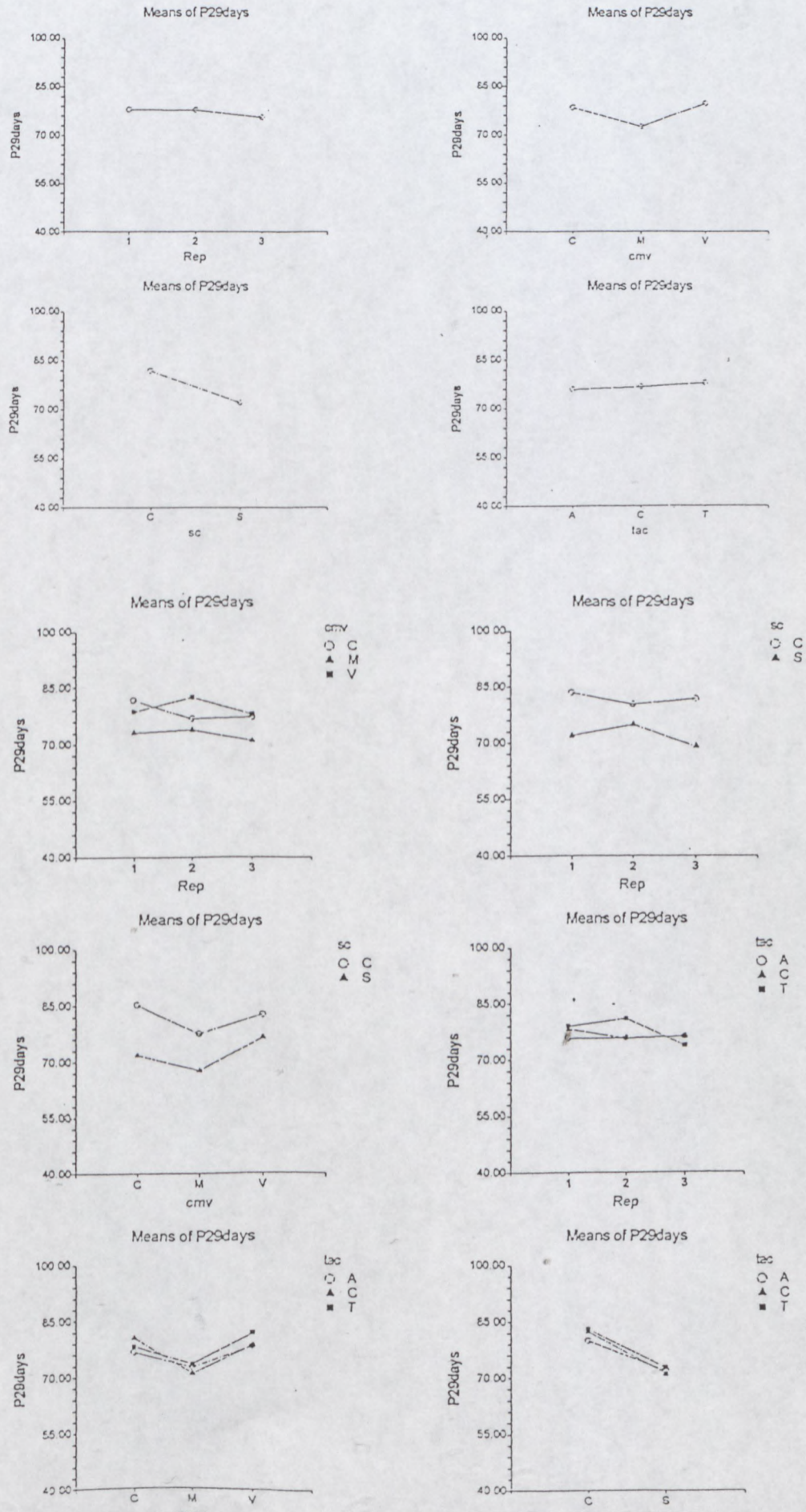


Figure 3 Plots sections of petri dish germination after 29 days, according to source of seed – refer Table 10.



Trial 4

Figure 4 Plots sections of percentage marketable bulbs – refer Table 26.

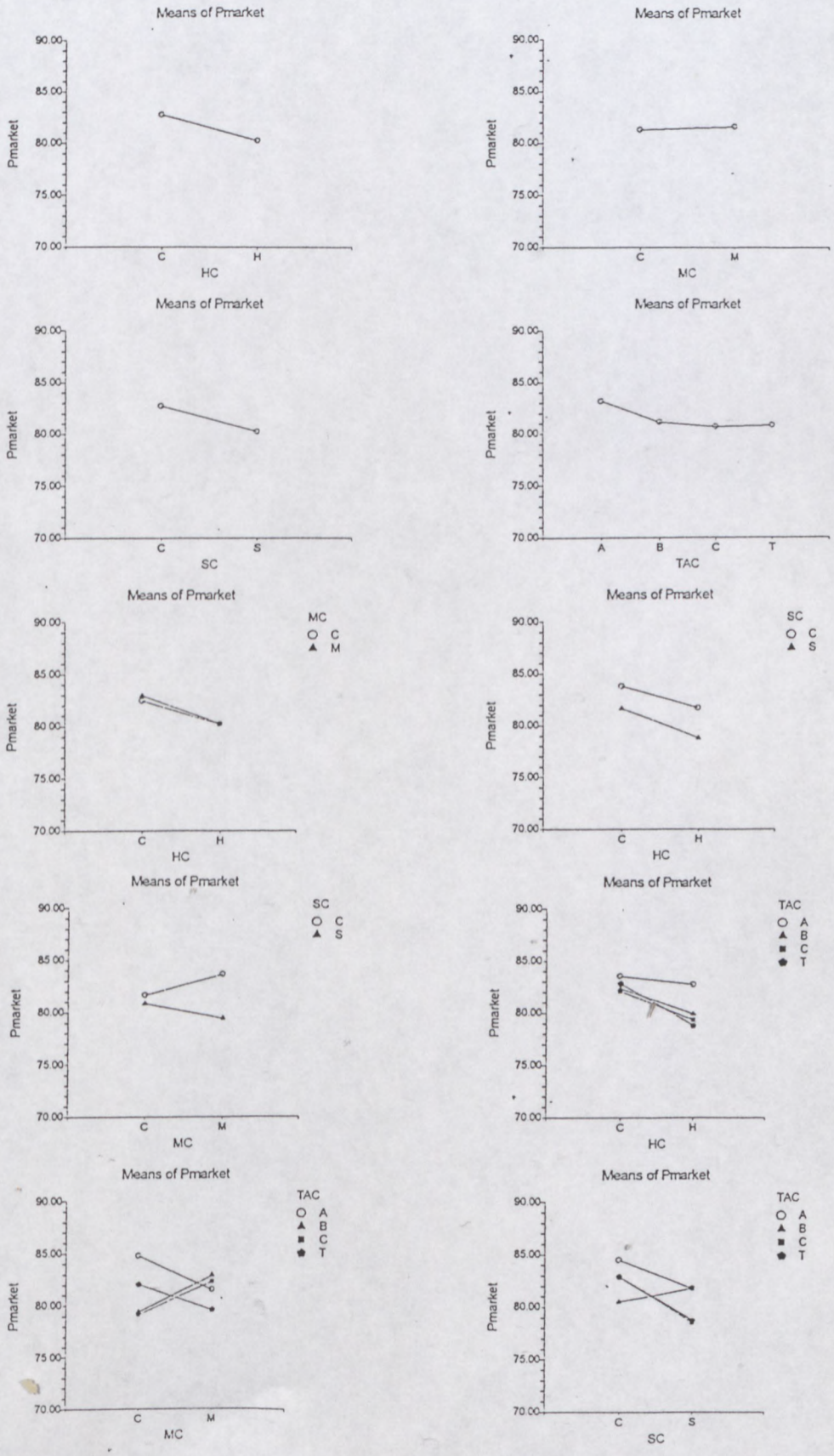


Figure 5 Plots sections of total mass of bulbs harvested – refer Table 27.

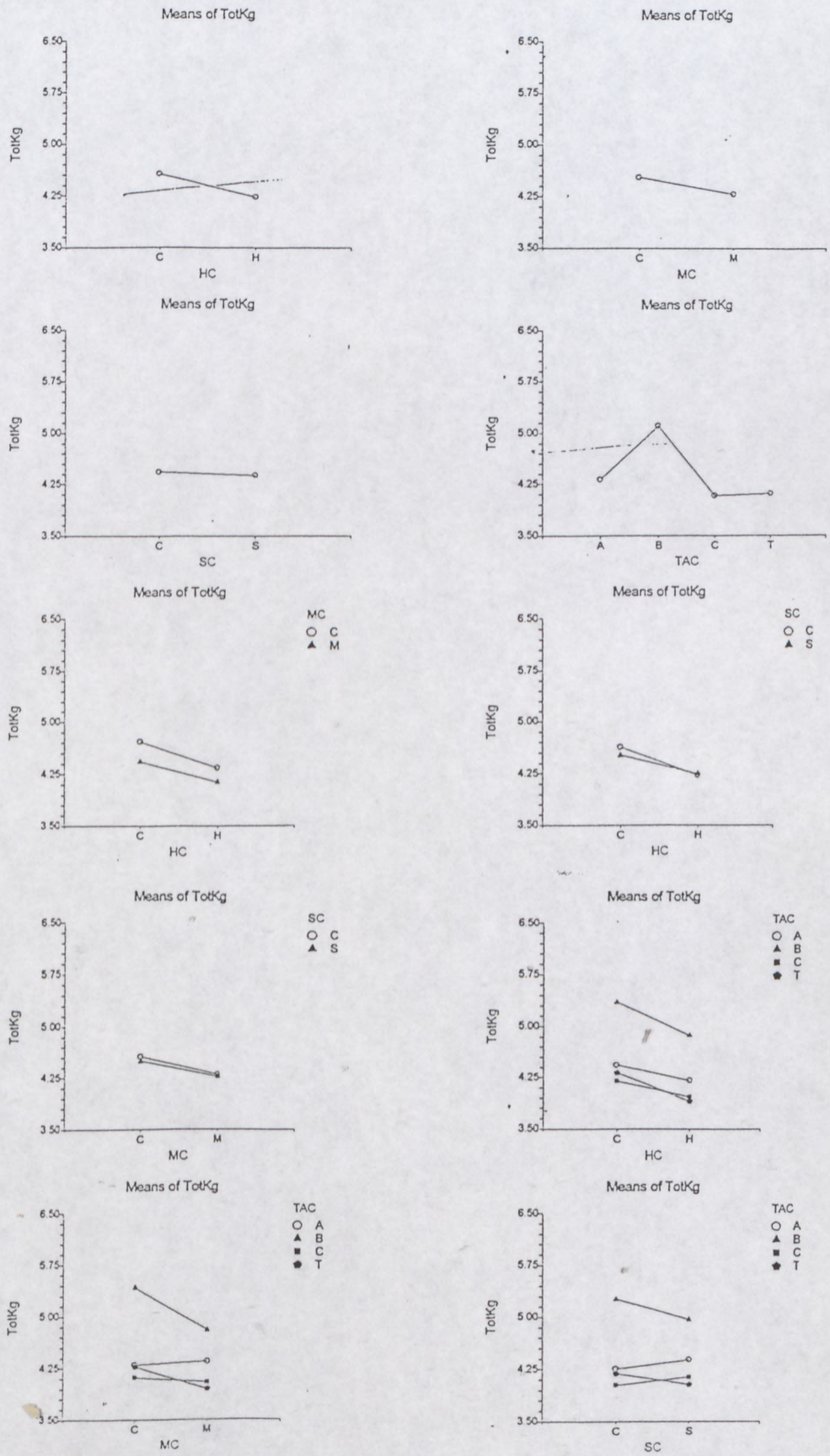


Figure 6 **Plots sections of total number of bulbs harvested – refer Table 28.**

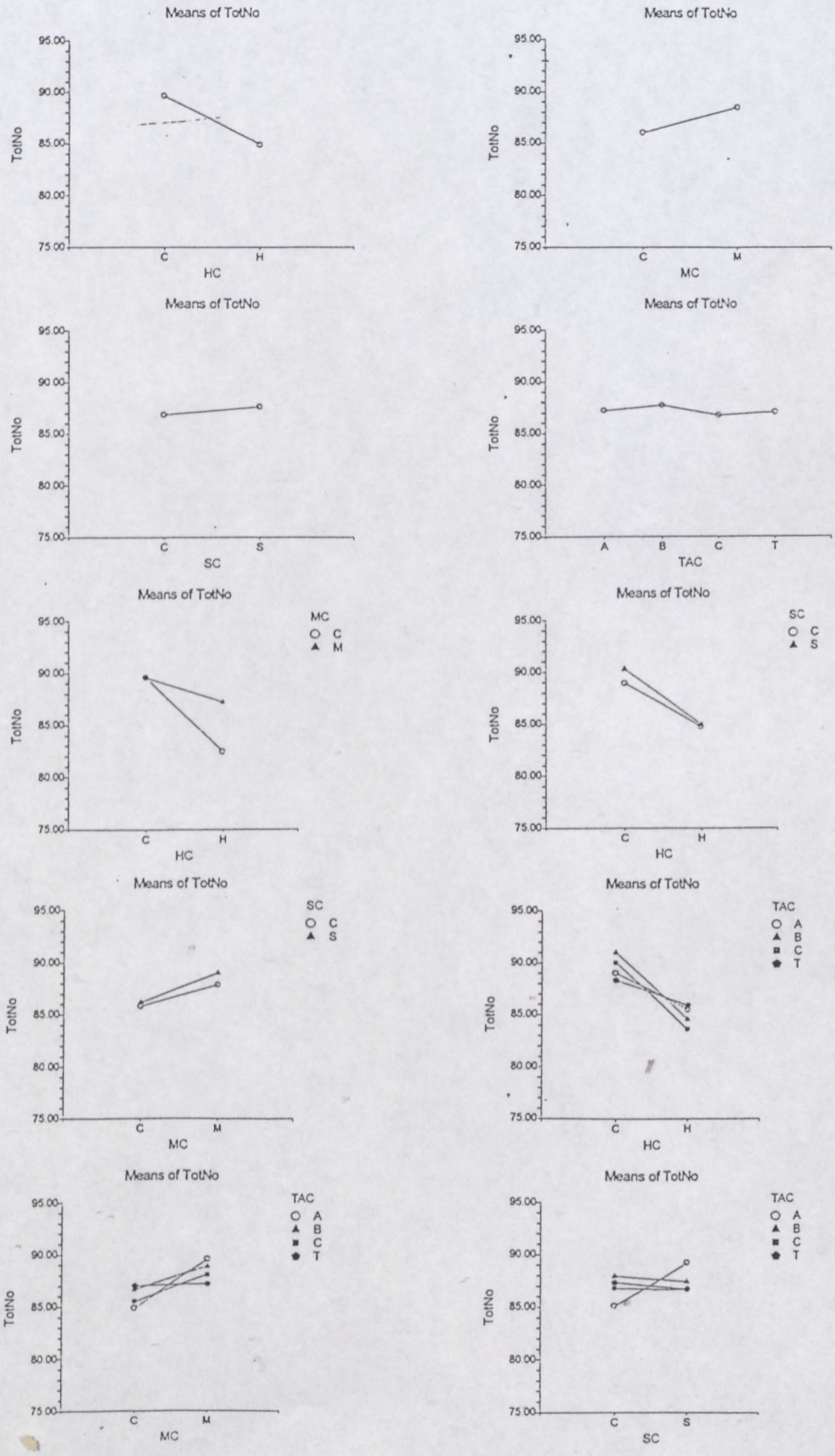


Figure 7 **Plots sections of number of medium bulbs harvested – refer Table 29.**

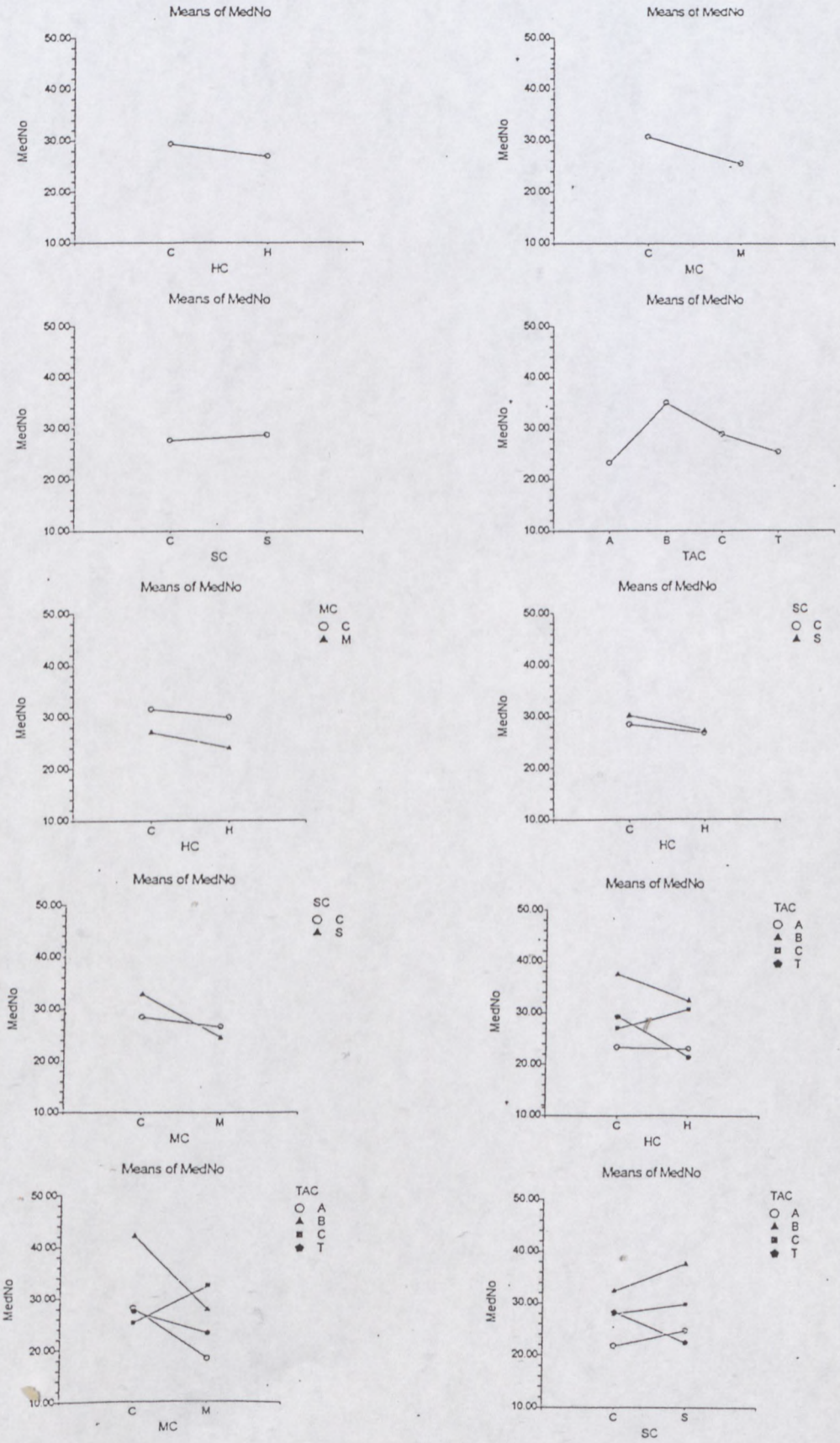


Figure 8 **Plots sections of mass of medium bulbs harvested – refer Table 30.**

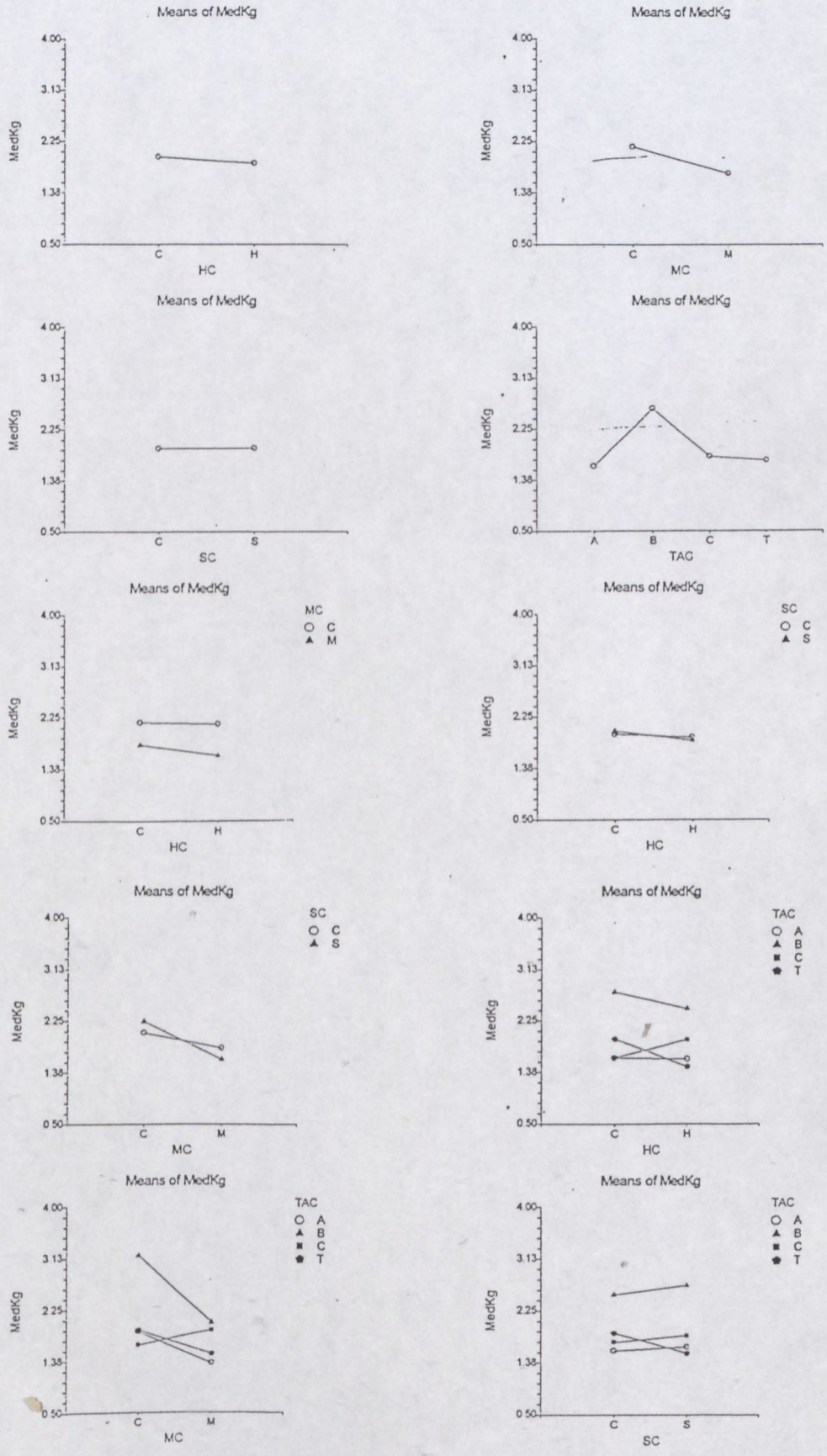
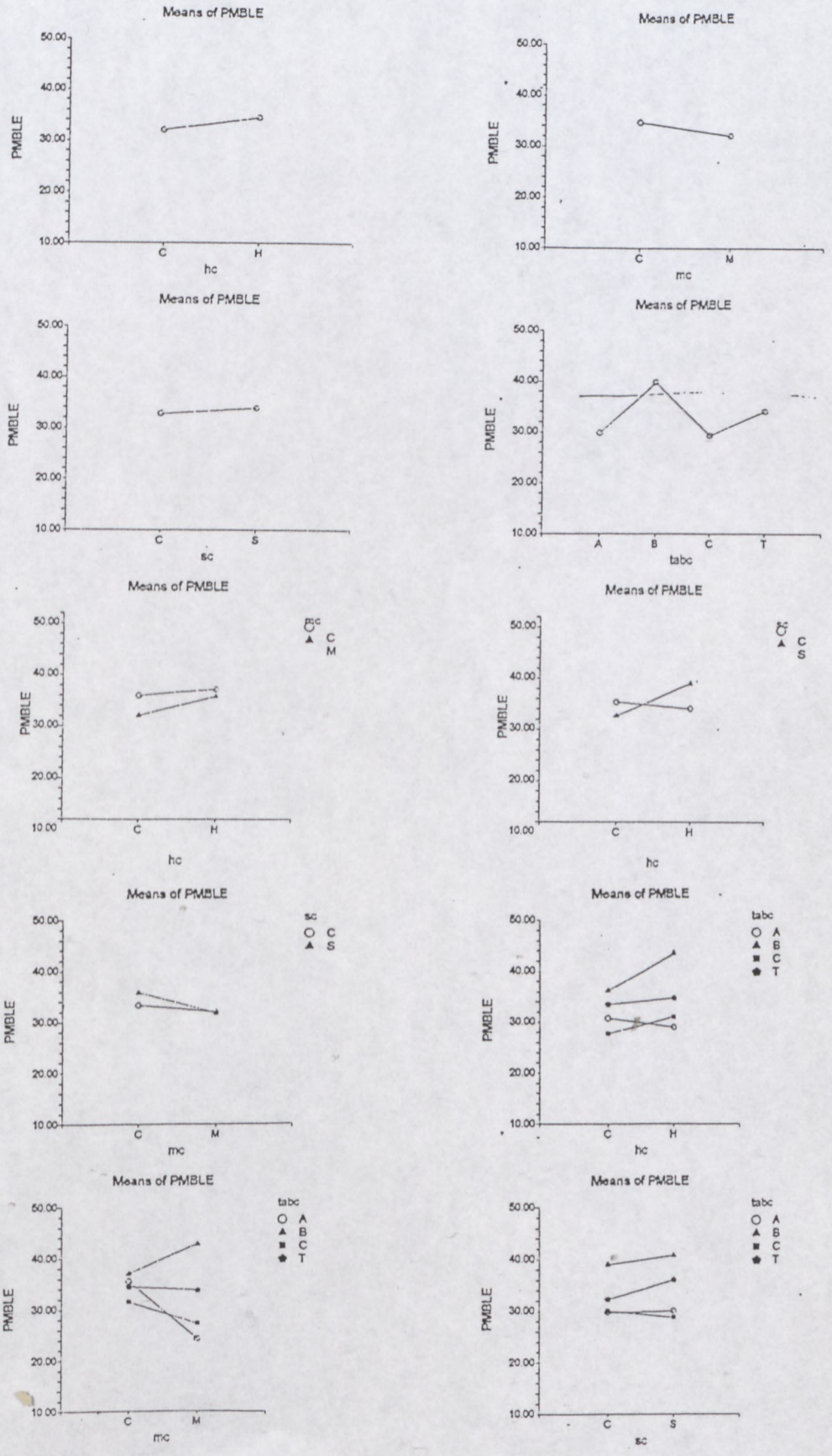


Figure 9 **Plots sections of the percentage of bulbs marketable after 6 months – refer Table 31.**



Trial 5

Figure 10 **Plots sections of percentage germination after 28 days of sowing in petri dishes - refer Table 34.**

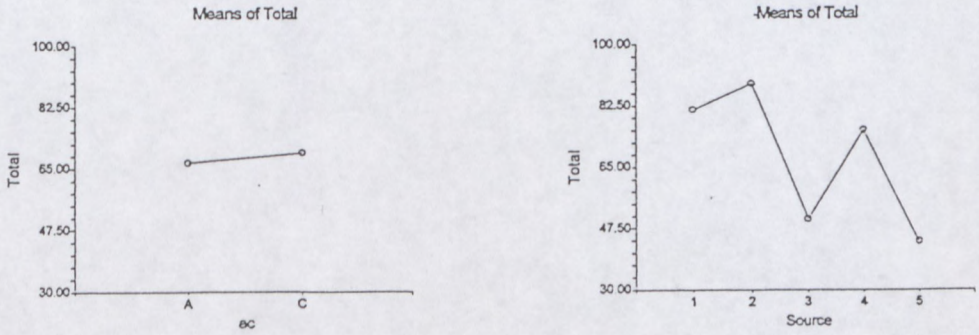
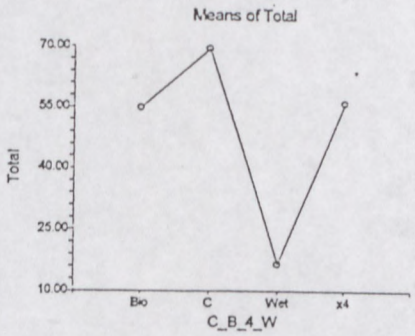


Figure 11 **Plots sections of percentage germination after 28 days of sowing in petri dishes - refer Table 35.**



Trial 6

Figure 12 **Plots sections of germination percentages in cups after 2 months – refer Table 37**

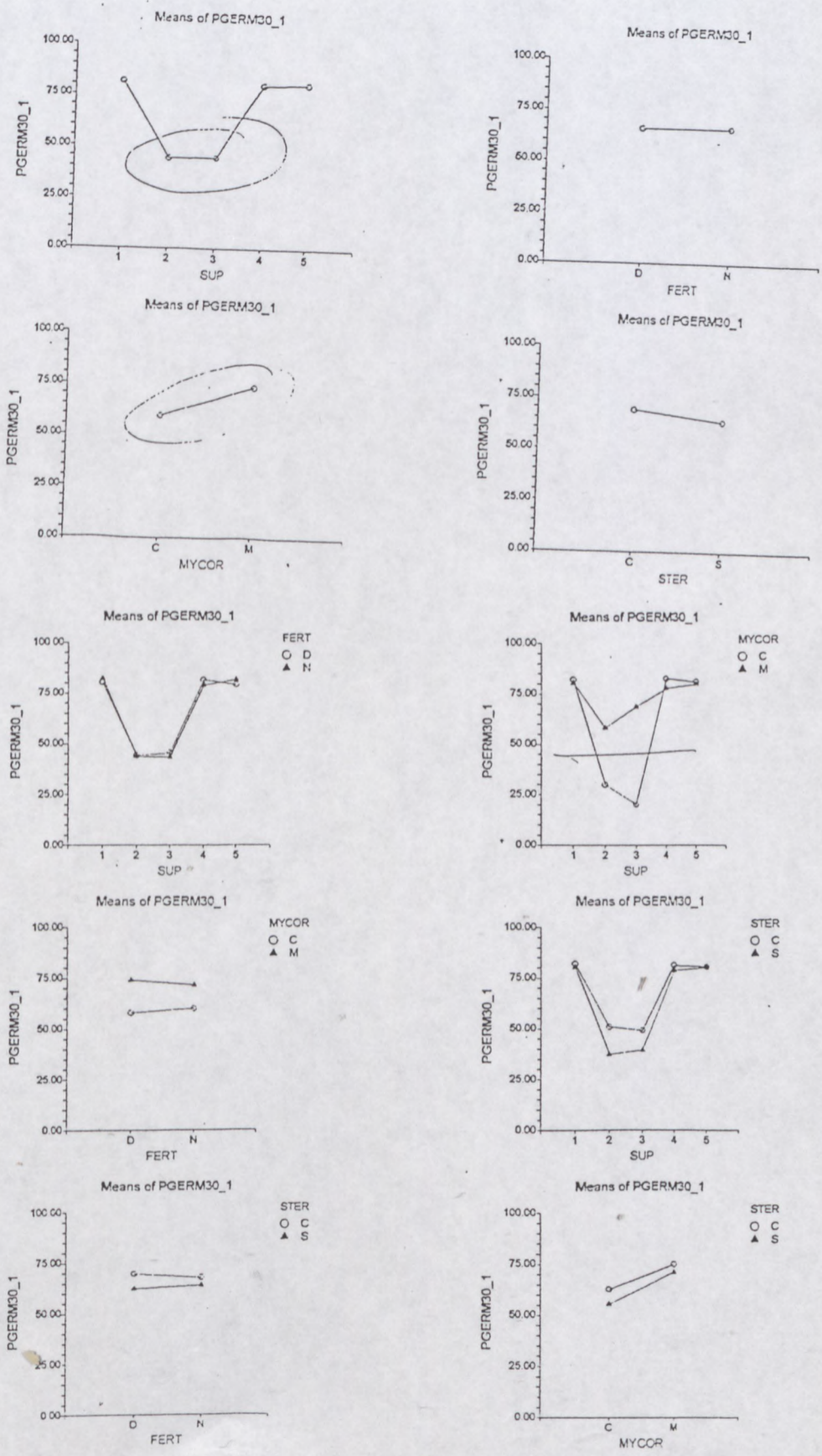


Figure 13 **Plots sections of germination percentages in cups after 2 months – refer Table 38**

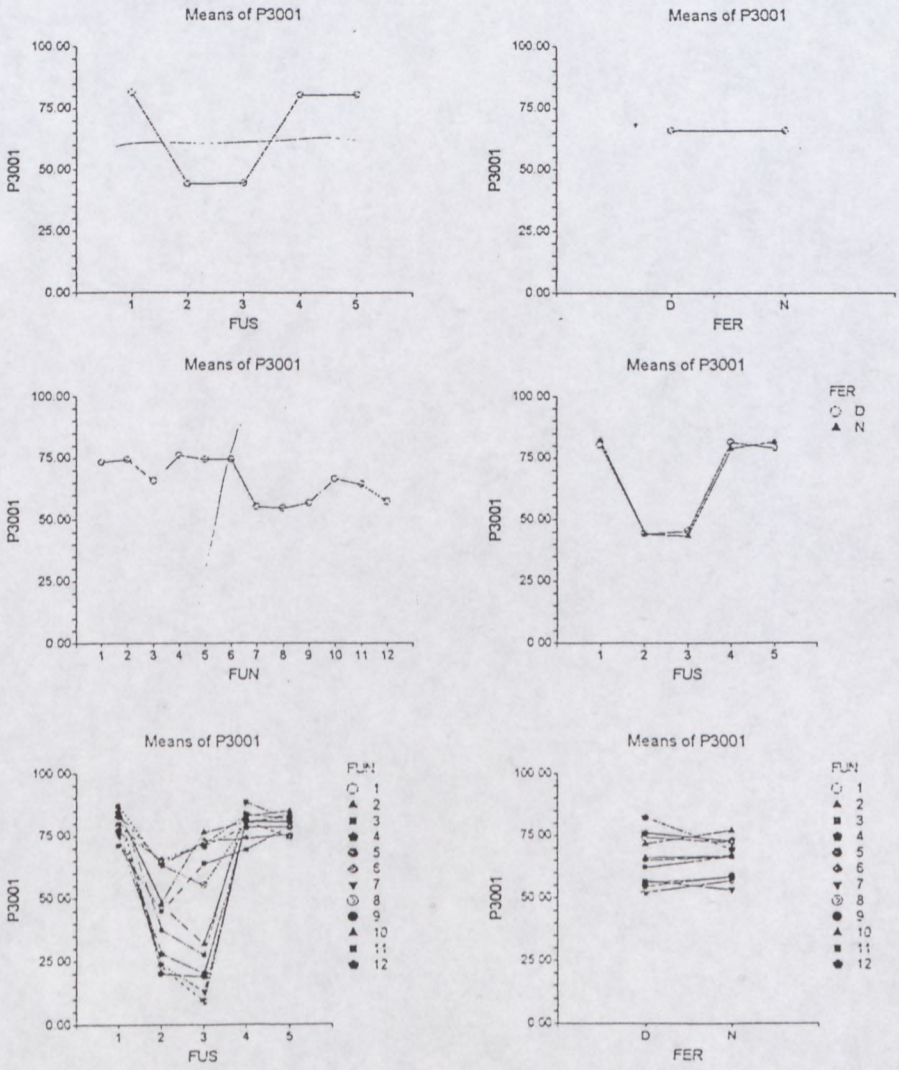


Figure 14 **Plots sections of germination percentages in cups after 2 months – refer Table 40**

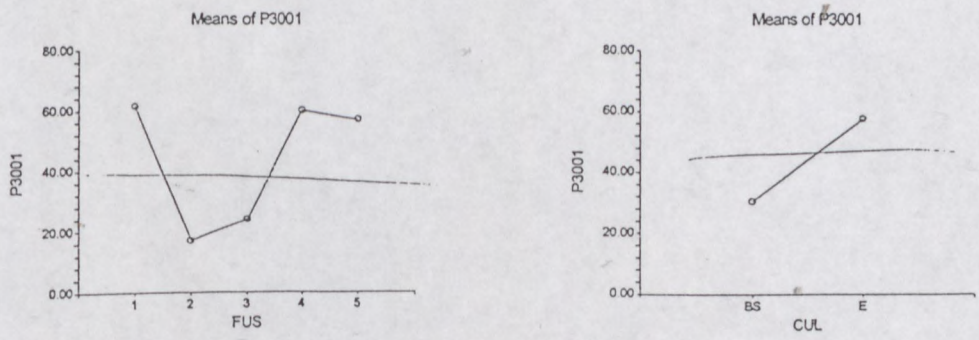


Figure 15 **Plots sections of percentages of bulblets lifted six months after sowing in cups – refer Table 45.**

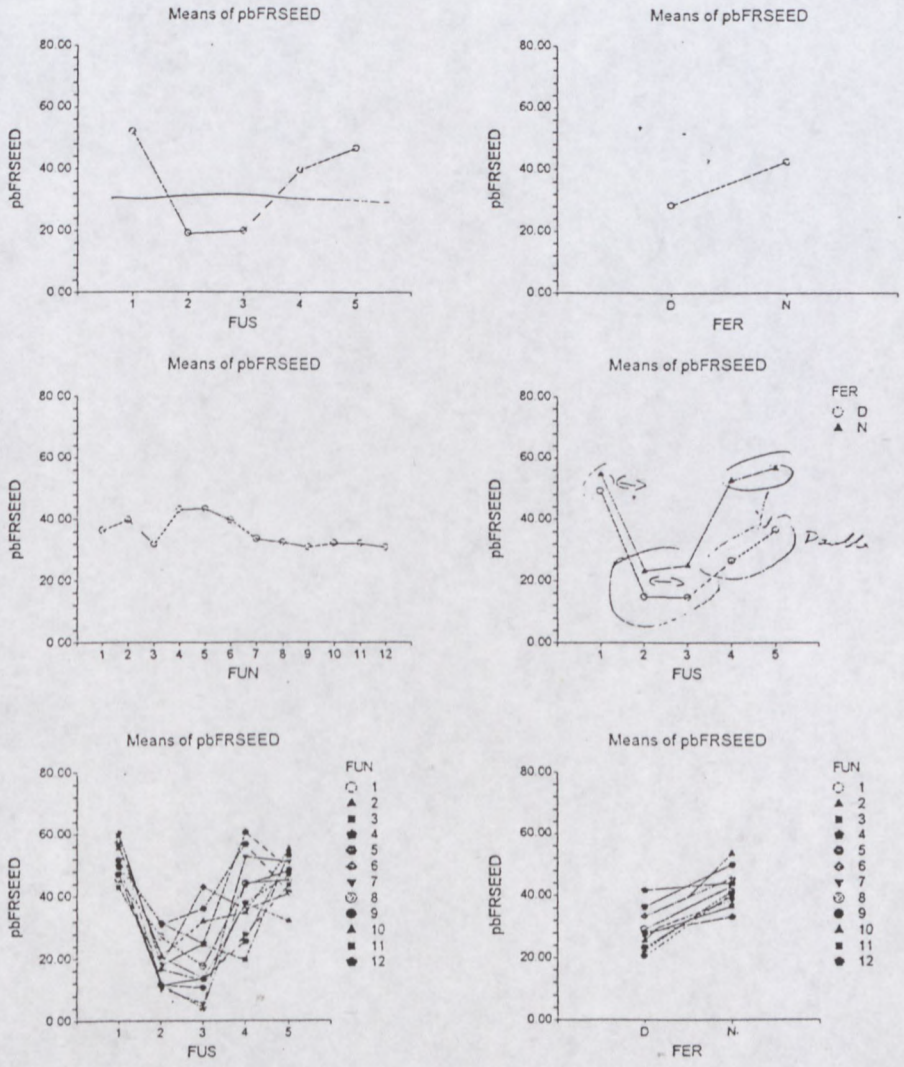


Figure 16 **Plots sections of percentages of bulblets lifted six months after sowing in cups – refer Table 46.**

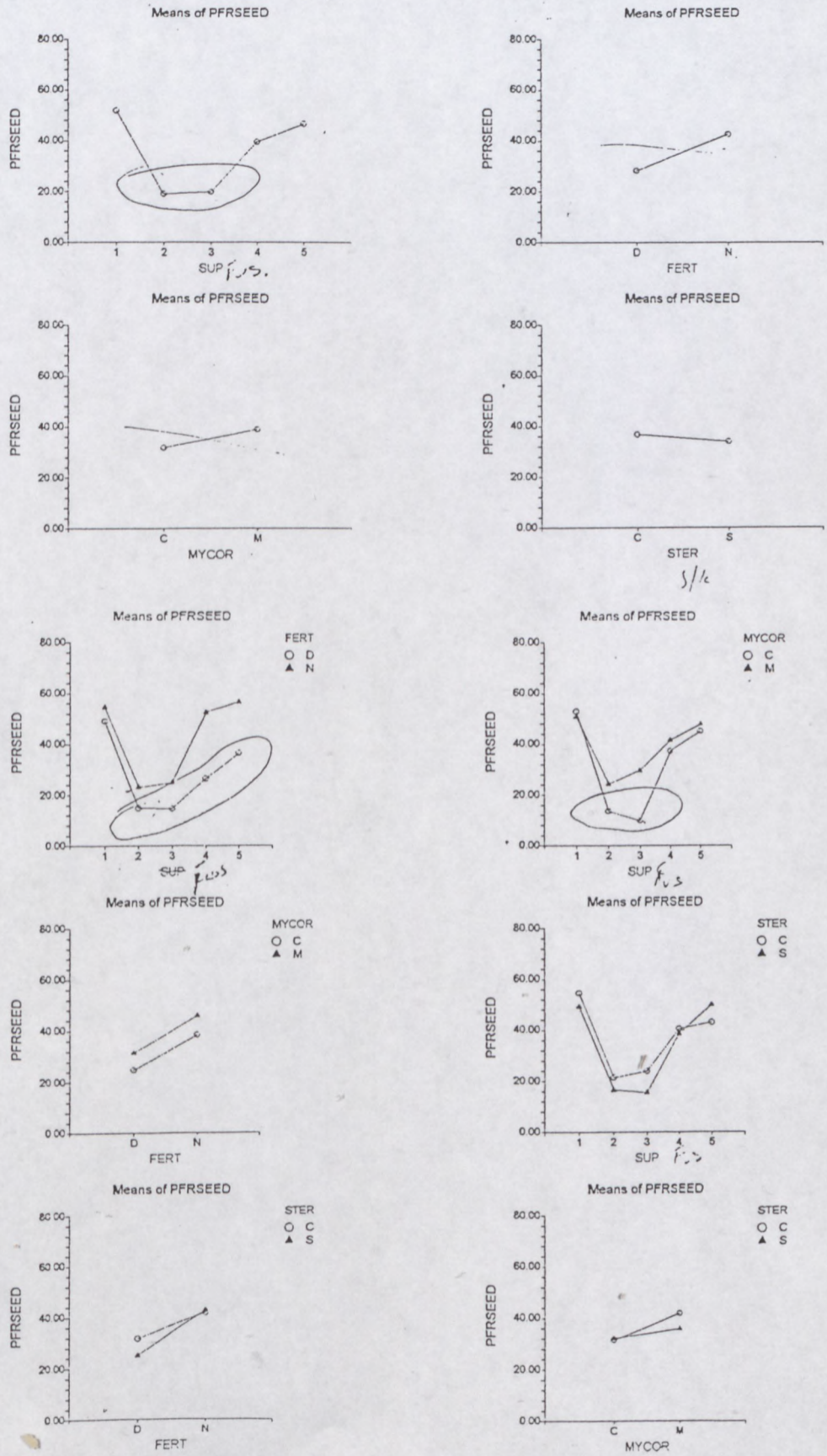


Figure 17 **Plots sections of percentages of bulblets lifted six months after sowing in cups – refer Table 48.**

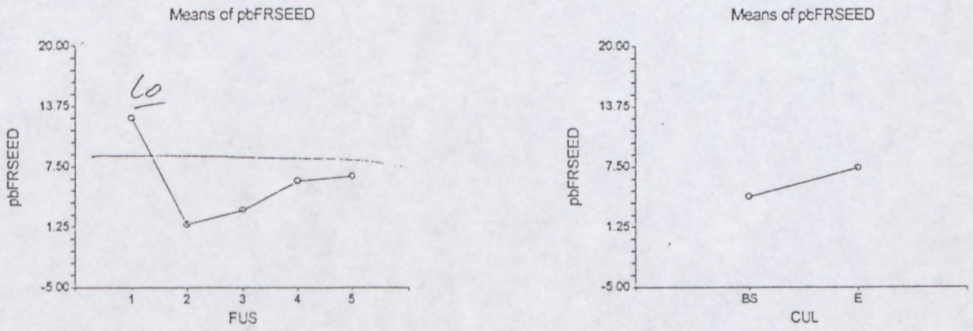


Figure 18 **Plots sections of percentages of bulblets lifted six months after sowing in cups – refer Table 52.**

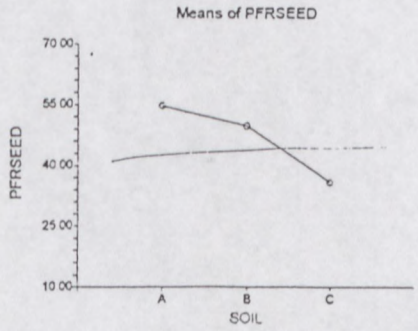


Figure 19 **Plots sections of percentages of bulblets lifted six months after sowing in cups – refer Table 53.**

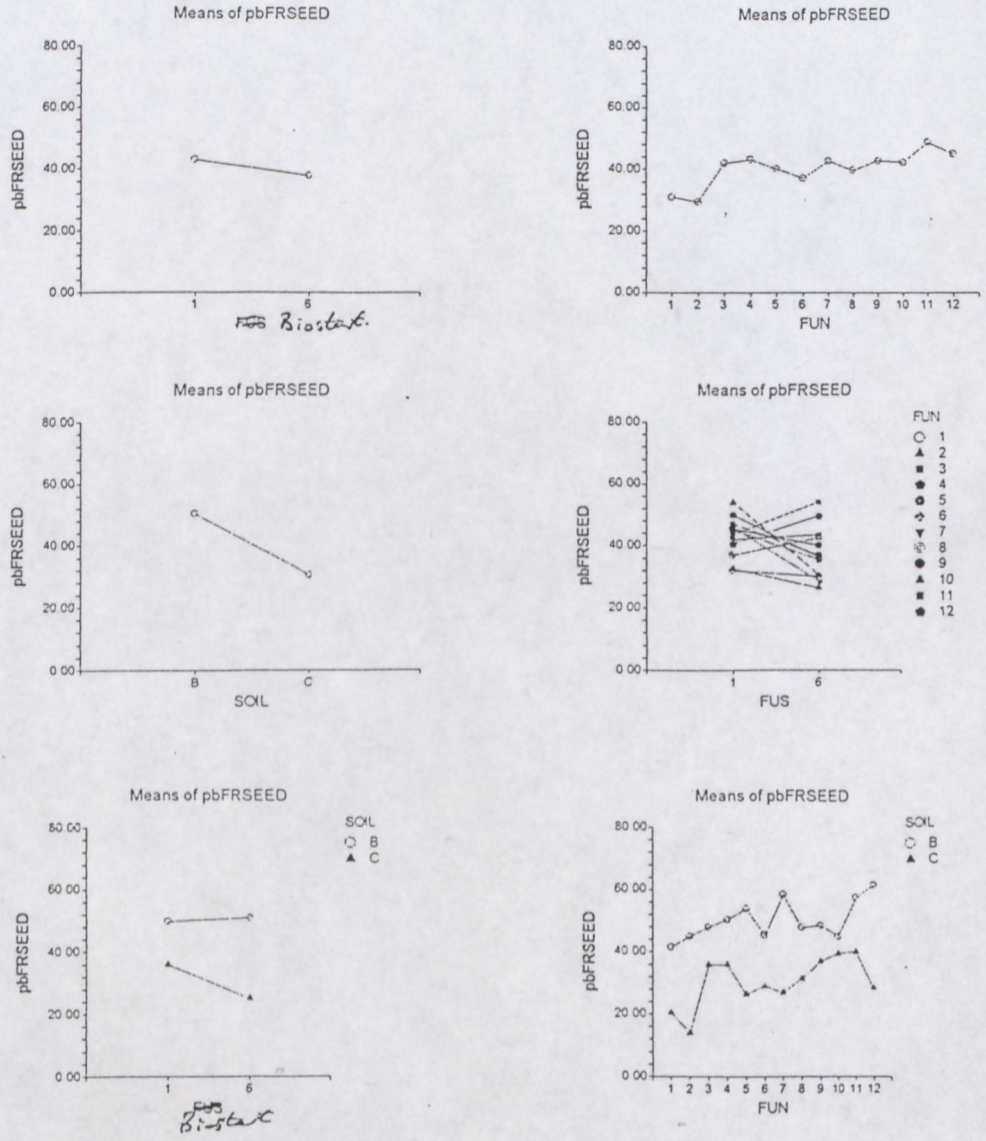


Figure 20 **Plots sections of percentage germination 28 days after re-sowing in cups – refer Table 55.**

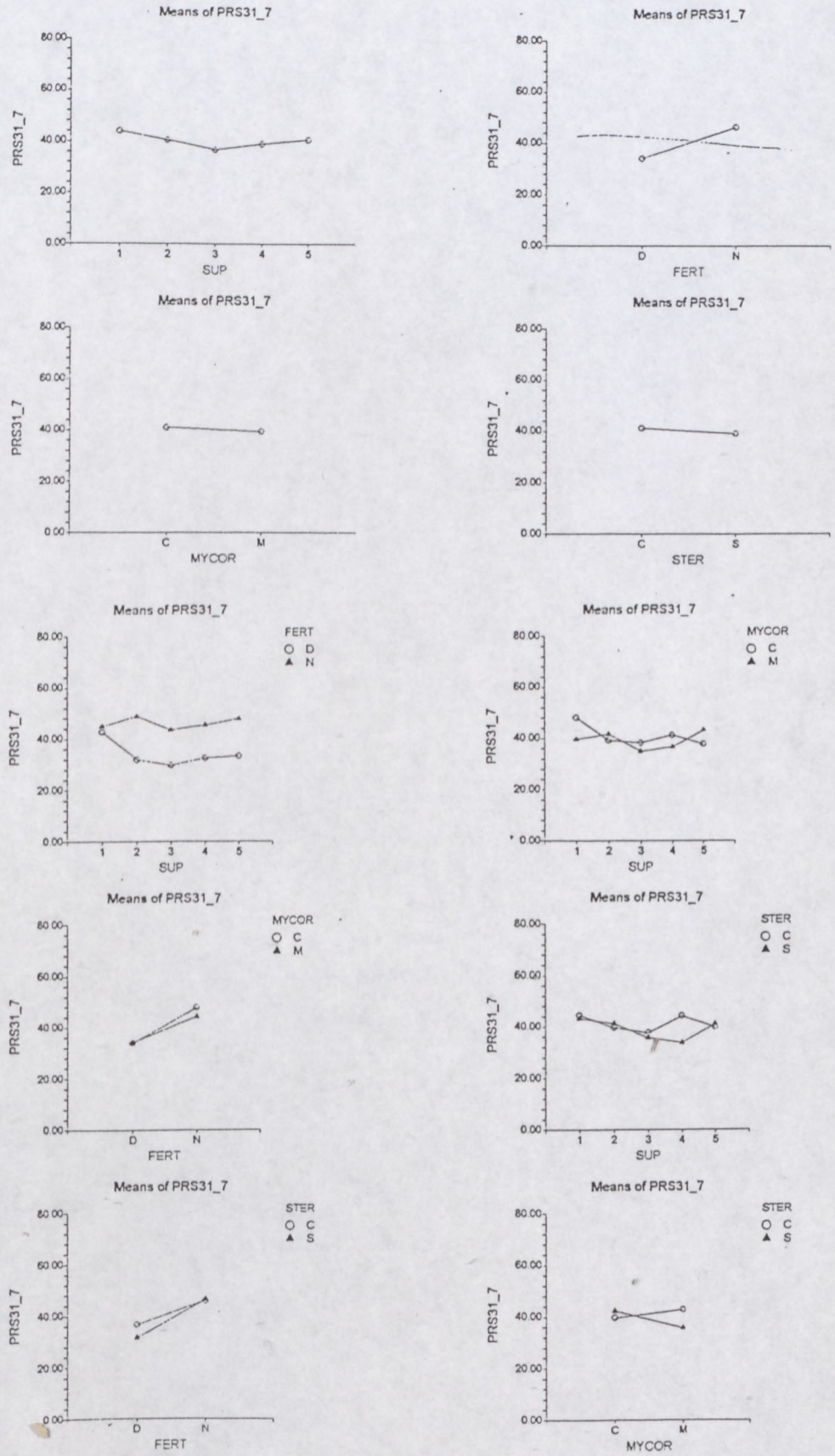


Figure 21 **Plots sections of percentage germination 2 months after re-sowing in cups – refer Table 56.**

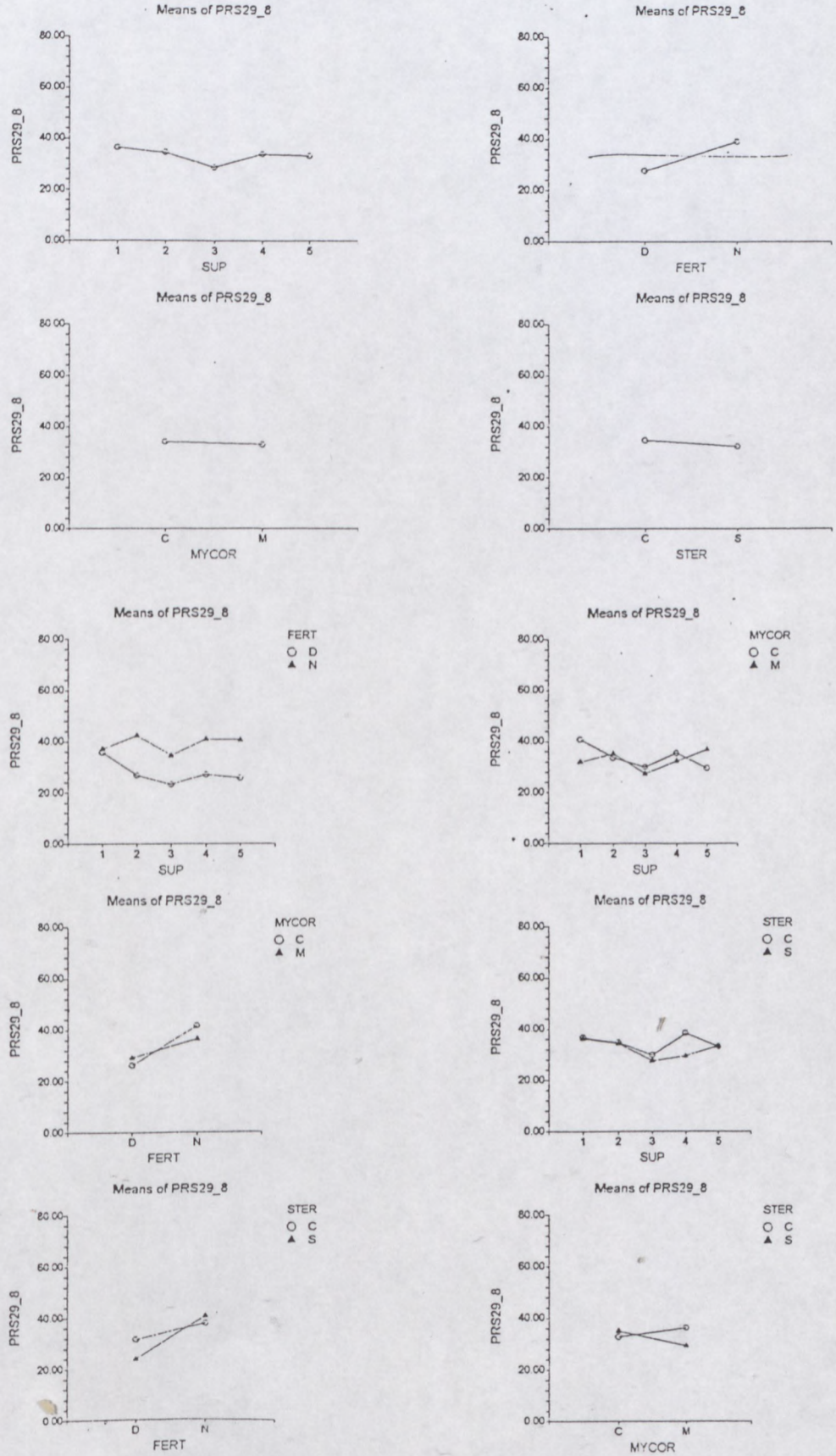


Figure 22 **Plots sections of percentage germination 5 months after re-sowing in cups – refer Table 57.**

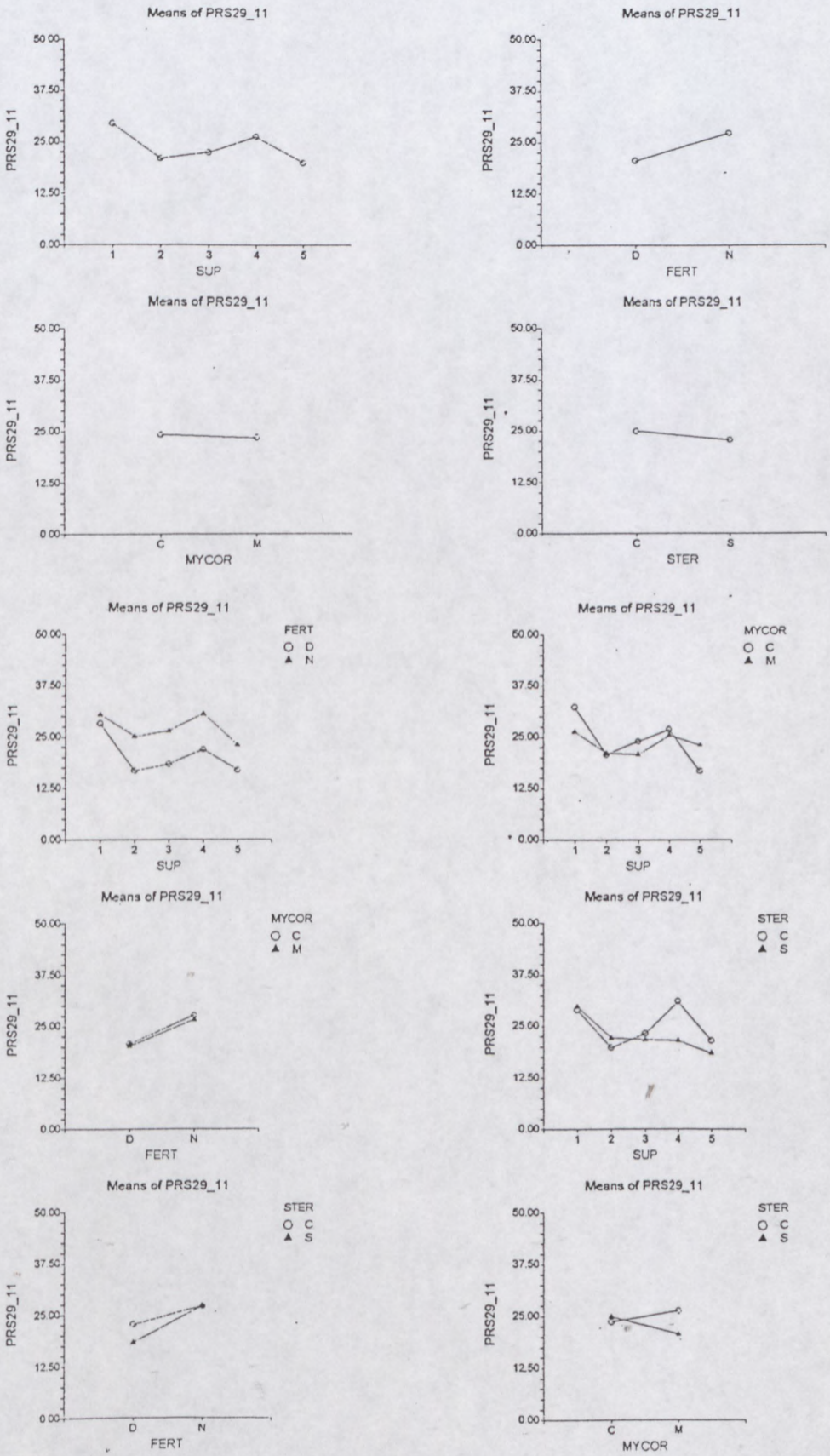


Figure 23 **Plots sections of percentage germination 5 months after re-sowing in cups – refer Table 62.**