



**HORTICULTURE RESEARCH INTERNATIONAL**  
KIRTON

**CONTRACT REPORT FV149**

**AN INVESTIGATION OF THE EFFICACY  
OF A PROTOTYPE MECHANICAL METHOD  
FOR APPLYING A STARTER SOLUTION TO  
CAULIFLOWER CROPS IN COMPARISON  
WITH A HAND APPLICATION**

**UNDERTAKEN FOR THE HDC**

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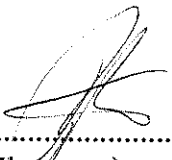
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**AUTHENTICATION**

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

  
.....  
(Signature)

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Date 22/12/93.....

Report authorised by ..... M B Wood  
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Date 28/12/93.....

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Report: December 1993

Project Number: FV 149

Project Title: An investigation of the efficacy of a prototype mechanical method for applying a starter solution to cauliflower crops in comparison with a hand application.

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Location of project: HRI-Kirton

Date commenced: October 1992

Date completed: October 1993

Key words: Cauliflower, starter solutions, phosphate, mechanical injector

## **RELEVANCE TO GROWERS AND PRACTICAL APPLICATION**

### **Application**

It is apparent from this series of trials that machine applied starter solution could be as effective as a hand application of two percent solution of 10:52:17 N:P:K fertiliser, but for this to be the case then either the volume of solution applied, or concentration used, must be increased.

### **Summary**

Over the past few years in trials concerning starter solutions where it was applied by hand, a two percent solution of 10:52:17 N:P:K soluble fertiliser has been shown to have optimal beneficial effects on cauliflower crops. The object of the three similar trials reported here was to investigate whether machine applying this solution would be as effective and if not what changes should be made.

Fifty, 30 or 0 ml of a two or five percent solution of the fertiliser was applied, either by hand directly into the planting hole, or by the machine developed by Ramsey Soil Injection Ltd of Lincoln which can be attached to most modern transplanters. The trial was done three times to cover a range of establishment conditions and these were April, May and June planted.

The trials confirmed that 50 ml of a two percent solution directly in the planting hole was beneficial in terms of early growth rates, time to harvest and duration of harvest, but some of the observed efficacy was lost when this solution was applied by machine. It is suggested that to increase the efficiency of the machine applied starter solution, either more of, or a more concentrated solution of, 10:52:17 should be used. However this concentration should be less than five percent which was very phytotoxic when applied by hand and still had a slight detrimental effect when applied by machine.

## **EXPERIMENTAL SECTION**

### **Introduction**

The potential of a high phosphate starter solution on the cauliflower crop has been demonstrated at HRI Kirton by MAFF (ROAME F04E), HDC (Projects FV123 & FV94) and privately (Kemira Horticulture Ltd) funded trials.

The MAFF funded work has looked at the role of starter solutions to improve the efficacy of nitrogen fertilisation and ultimately to reduce the nitrogen fertiliser requirement of vegetable crops. With the HDC funded work FV123: Early summer and autumn cauliflower; evaluation of the effect of booster feeds in comparison with starter solutions on performance and continuity of production, showed that 50 ml of a two percent solution of 10:52:17 NPK fertiliser appeared to be optimal when applied by hand and FV94: Autumn and early summer cauliflower, improving early field growth of cellular trays raised crops especially following or during periods of stress showed that a starter solution did reduce the time to 50 percent cut and shorten the length of cut. Work undertaken for Kemira Horticulture Ltd has constantly shown benefit of starter solution in shortening time to 50 percent cut, shorter lengths of cut and improved quality. In one extreme example the starter solution increased the number of plants establishing.

All of these trials had the starter solution applied into the planting hole immediately prior to the transplant but of course if this technique is to be accepted commercially then it has to be done mechanically on the transplanter.

Therefore, Ramsey Soil Injection Ltd of Lincoln developed a machine, which can be attached to most modern transplanters, to inject the starter solutions around the root-ball at planting. Observations during the equipment development, and commercial interest in it, have been encouraging, but the efficacy of the machine against the hand application that was used in trials needs to be investigated and the optimum quantities and concentration of solution applied be determined. This was the object of this trial, which was done on three occasions.

## Materials and Methods

### 1. Treatments and trial design

#### i Volume of starter solution

1. 50 ml
2. 30 ml
3. 0 ml (control)

#### ii Concentration of starter solution

1. 2% solution 10:52:17 N:P:K
2. 5% solution 10:52:17 N:P:K

NB The trial was conventionally fertilised using Kaynitro as the source applied at a rate giving 250 kg/ha N, across all treatments irrespective of any starter solution treatment.

#### iii Application method

1. By hand
2. By machine developed by Ramsey Soil Injection Ltd

#### iv Crop timing

1. April planted
2. May planted
3. June planted

At each planting the ten treatments were fully randomised and blocked per replicate. There were three replicates.

### 2. Trial diaries

#### i Trial 1: February sown, April planted.

Field/soil type: Lane 2/ Coarse silty marine alluvial

Soil analysis: pH 7.7 Indices: P-4, K-2, Mg-3

Previous cropping: 1991 Alliums  
1992 Grass

Cultivations: 13.11.92 4 tonnes/ha ground limestone applied  
14.12.92 Ploughed  
22.04.93 Lely rotterra immediately pre-planting

Fertiliser: Base: 22.04.93 150 kg/ha N as Kaynitro applied  
Top: 26.05.93 100 kg/ha N Kaynitro applied

Propagation: 08.02.93 Variety Fremont sown in 308 plastic cellular trays. Seeds were chitted at 21°C for 24 hrs before being placed in an unheated Venlo glasshouse. Plants were given liquid feeds of 100:200 mg/l N:K<sub>2</sub>O as necessary. Fosetyl-aluminium (as 5 g/m<sup>2</sup> Aliette) against downy mildew and damping-off were applied. Plants were treated with a pre-planting drench of chlorpyrifos (as Dursban 4)

Planting: 22.04.93 Trial planted

Herbicides: 20.05.93 Propachlor as 9 l/ha Ramrod and chlorthal-dimethyl as 6 kg/ha Dacthal applied

Insecticides: 03.07.93 Pirimicarb as 420 kg/ha Aphox and cypermethrim as 250 ml/ha Ambush applied

Fungicides: None

Irrigation: None

Notes: Fresh wt. samples of 5 plants/plot done on 21/5, 8/6 & 23/6



Final pre-harvest inspection date 6/7, first harvest date 8/7, final harvest date 28/7

ii Trial 2: April sown, May planted

Field/soil type: As for Trial 1

Soil analysis: As for Trial 1

Previous cropping: As for Trial 1

Cultivations: As for Trial 1

Fertiliser: Base: As for Trial 1

Top: As for Trial 1

Propagation: 14.04.93 Variety Fremont sown in 308 plastic cellular trays.  
See trial 1 for details

Planting: 26.05.93 Trial planted

Herbicides: 01.06.93 Propachlor as 9 l/ha Ramrod and chlorthal-dimethyl as 6 kg/ha Dacthal applied

Insecticides: 22.06.93 Cypermethrin as 250 ml/ha Ambush applied  
03.07.93 Pirimicarb as 420 kg/ha Aphox and cypermethrin as 250 ml/ha Ambush applied

Fungicides: None

Irrigation: None

Notes: Fresh wt. samples of 5 plants/plot done on 24/6, 7/7 & 21/7  
Final pre-harvest inspection date 28/7, first harvest date 29/7,  
final harvest date 23/8

iii Trial 3: May sown, June planted

Field/soil type: As for Trial 1

Soil analysis: As for Trial 1

Previous cropping: As for Trial 1

Cultivations: As for Trial 1

Fertiliser: Base: As for Trial 1

Top: As for Trial 1

Propagation: 04.05.93 Variety Fremont sown in 308 plastic cellular trays.  
See trial 1 for details

Planting: 22.06.93 Trial planted

Herbicides: 26.06.93 Propachlor as 9 l/ha Ramrod and chlorthal-dimethyl as  
6 kg/ha Dacthal applied

Insecticides: 29.06.93 Demeton-s-methryl as 560 ml/ha Campbell's DSM and  
cypermethrin as 250 ml/ha Ambush applied  
03.07.93 Pirimicarb as 420 kg/ha Aphox and cypermethrin as  
250 ml/ha Ambush applied  
04.08.93 Demeton-s-methyl as 560 ml/ha Campbell's DSM  
applied

Fungicides:           None

Irrigation:           None

Notes:                Fresh wt. samples of 5 plants/plot done on 15/7, 28/7 & 11/8  
Final pre-harvest inspection date 20/8, first harvest date 23/8,  
final harvest date 10/9

### 3. Assessments

1. Fresh weight of plant samples on three occasions
2. Phytotoxicity records on two occasions
3. Harvest and yield data

## Results and Discussion

1. Fresh weights of five-plant samples on three occasions per trial.

The data for these observations are given in Tables 1, 2 and 3 for the three trials respectively. In the first trial, Table 1, the 50 ml of a two percent solution given by hand had a beneficial effect upon growth whereas the equivalent five percent solution was phytotoxic. When these solutions were applied by machine the benefits of the two percent solution was still apparent at least at the second two samplings whereas the phytotoxic effects of the five percent solution were much diminished. This later observation was assumed to be because the machine did not place the solution in such close proximity to the root ball as the hand application. The use of 30 ml of solution was not as effective as using 50 ml.

In the second trial, Table 2, there was very little effect at all of starter solution on the crop establishment and growth but the third trial, Table 3, supported the findings for Trial 1, in that 50 ml of a two percent by hand was beneficial but the equivalent with a five percent solution was very phytotoxic, however, in Trial 3 the benefits of the two percent solution is lost when machine applied, as is the phytotoxic effects of the five percent solution. The overall results

suggest that the machine is less effective than hand application when using 50 ml of a two percent solution but the indications are that if a higher concentration or a greater quantity of a two percent solution was given then the machine may equate with hand applications.

Table 1 Fresh wt(g) of five-plant samples taken from Trial 1.

Treatment			Fresh wt(g) of samples		
Volume of starter sol %	Strength of starter sol %	Application method	21 May	8 June	23 June
50	2	Hand	164	1176	6203
50	5	Hand	38	465	2148
50	2	Machine	121	1246	6202
50	5	Machine	110	834	4015
30	2	Hand	124	977	4990
30	5	Hand	102	909	4835
30	2	Machine	85	1051	4363
30	5	Machine	107	1297	5248
0	-	Hand	101	729	4628
0	-	Machine	90	1125	4285
SED (18 df) = ±			14.8	243.4	741.4
50	-	-	108	930	3739
30	-	-	82	1059	4859
0	-	-	96	927	4457
SED (18 df) = ±			9.1	149.0	454.0
-	2	-	124	1113	5440
-	5	-	89	876	4062
SED (18 df) = ±			7.4	121.7	370.7
-	-	Hand	86	851	4561
-	-	Machine	103	1111	4823
SED (18 df) = ±			6.6	108.8	531.6

Table 2 Fresh wt(g) of five-plant samples taken from Trial 2.

Treatment			Fresh wt(g) of samples		
Volume of starter sol %	Strength of starter sol %	Application method	24 June	7 July	21 July
50	2	Hand	293	1707	6287
50	5	Hand	199	1703	6310
50	2	Machine	351	2377	7275
50	5	Machine	242	1198	6285
30	2	Hand	362	1637	6120
30	5	Hand	329	1780	6555
30	2	Machine	366	2080	6783
30	5	Machine	318	1828	6760
0	-	Hand	311	1825	5823
0	-	Machine	393	2025	5902
SED (18 df) = ±			90.0	490.7	1035.5
50	-	-	271	1761	6539
30	-	-	344	1831	6555
0	-	-	352	1925	5863
SED (18 df) = ±			55.1	250.9	634.1
-	2	-	343	1950	6616
-	5	-	272	1642	6478
SED (18 df) = ±			45.0	204.8	517.7
-	-	Hand	299	1742	6219
-	-	Machine	334	1902	6601
SED (18 df) = ±			40.2	183.2	463.1

Table 3 Fresh wt(g) of five-plant samples taken from Trial 3.

Treatment			Fresh wt(g) of samples		
Volume of starter sol %	Strength of starter sol %	Application method	24 June	7 July	21 July
50	2	Hand	434	2170	6262
50	5	Hand	124	965	3567
50	2	Machine	259	1588	5795
50	5	Machine	229	1357	4808
30	2	Hand	322	1598	6183
30	5	Hand	265	1440	5382
30	2	Machine	305	1943	6450
30	5	Machine	275	1468	5310
0	-	Hand	289	1550	5218
0	-	Machine	288	1543	5182
SED (18 df) = ±			39.8	257.9	684.3
50	-	-	262	1520	5108
30	-	-	292	1612	5831
0	-	-	289	1547	5200
SED (18 df) = ±			24.4	157.9	419.0
-	2	-	330	1825	6173
-	5	-	223	1308	4767
SED (18 df) = ±			19.9	128.9	342.1
-	-	Hand	286	1535	5322
-	-	Machine	271	1580	5509
SED (18 df) = ±			17.8	115.3	306.0

2. Plant vigour scores on two occasions

The data for this observation is given in Tables 4, 5 and 6 for the three trials respectively and basically support the findings given by the fresh weights of plant samples given in Tables 1, 2 and 3. In fact it proved more difficult to pick up differences by visual scoring and the major impact was the phytotoxicity of the five percent solution when applied by hand which was not observed when applied by machine. The growth enhancing effect of the two percent solution by hand was not visually so obvious in Trials 1 and 3 as when recorded by fresh weight.

Table 4 Vigour scores on two occasions for Trial 1.

Volume of starter sol %	Strength of starter sol %	Application method	Vigour scores	
			21 May	23 June
50	2	Hand	11.3	10.7
50	5	Hand	7.7	6.3
50	2	Machine	10	10.7
50	5	Machine	10	9.0
30	2	Hand	10.3	10
30	5	Hand	10	10
30	2	Machine	10	10
30	5	Machine	10	10
0	-	Hand	10	10
0	-	Machine	10	10

Table 5 Vigour scores on two occasions for Trial 2.

Volume of starter sol %	Strength of starter sol %	Application method	Vigour scores	
			24 June	21 July
50	2	Hand	10	10
50	5	Hand	9.0	10
50	2	Machine	10	10
50	5	Machine	10	10
30	2	Hand	10	10
30	5	Hand	10	10
30	2	Machine	10	10
30	5	Machine	10	10
0	-	Hand	10	10
0	-	Machine	10	10

Table 6 Vigour scores on two occasions for Trial 3

Volume of starter sol %	Strength of starter sol %	Application method	Vigour scores	
			15 July	11 August
50	2	Hand	11.7	10.7
50	5	Hand	6.3	7.0
50	2	Machine	10	10
50	5	Machine	10	9.3
30	2	Hand	10	10
30	5	Hand	10	10
30	2	Machine	10	10
30	5	Machine	10	10
0	-	Hand	10	10
0	-	Machine	10	10

Scale 10 = 0 ml hand planted on each occasion 0 = dead or missing



### 3. Harvest and yield data

The harvest date and length of cut data are given in Tables 7, 8 and 9 respectively for the three trials and very closely reflect the findings from the fresh weights of plant samples given in Tables 1, 2 and 3. In the first trial there was a 2-4 day earlier harvest by 50 ml of a two percent solution applied either by hand or machine and both had a shorter cutting period. The equivalent hand applied solution with a five percent solution was 2-10 days later to cut and had a protracted harvest period. The five percent solution when applied by machine did not show any differences from the control.

The only effect seen in the second trial was the phytotoxic effect of the five percent solution applied by hand. Trial 3 supported Trial 1 again very similar to the fresh weight data where advantages were seen in earlier cut with hand applied 50 ml of the two percent solution and phytotoxicity of five percent but in this case the machine applied two percent solution did not show the advantages of its hand applied equivalent.

Table 7 Harvest data for Trial 1.

Treatment		Application method	Date of			Length of cut (days)
Volume of starter solution	Strength of starter sol %		10% cut	50% cut	90% cut	
50	2	Hand	7 July	9 July	12 July	5.9
50	5	Hand	10 July	19 July	26 July	16.3
50	2	Machine	7 July	8 July	13 July	6.8
50	5	Machine	8 July	11 July	18 July	10.0
30	2	Hand	9 July	14 July	19 July	9.2
30	5	Hand	7 July	10 July	18 July	10.2
30	2	Machine	7 July	10 July	15 July	8.6
30	5	Machine	7 July	9 July	15 July	8.3
0	-	Hand	8 July	11 July	16 July	8.3
0	-	Machine	10 July	14 July	19 July	8.8
SED (18 df) = ±			1.4 days	2.2 days	2.8 days	1.87 days
50	-	-	8 July	12 July	17 July	9.8
30	-	-	7 July	11 July	16 July	9.1
0	-	-	9 July	13 July	18 July	8.6
SED (18 df) = ±			1.0 days	1.5 days	2.0 days	1.33 days
-	2	-	7 July	10 July	15 July	7.6
-	5	-	8 July	12 July	19 July	11.2
SED (18 df) = ±			0.8 days	1.3 days	1.6 days	1.08 days
-	-	Hand	8 July	13 July	18 July	10.0
-	-	Machine	8 July	11 July	16 July	8.5
SED (18 df) = ±			0.7 days	1.2 days	1.5 days	0.97 days

Table 8 Harvest data for Trial 2.

Treatment		Application method	Date of			Length of cut (days)
Volume of starter solution	Strength of starter sol %		10% cut	50% cut	90% cut	
50	2	Hand	26 July	30 July	6 August	9.8
50	5	Hand	30 July	4 August	11 August	12.1
50	2	Machine	26 July	28 July	1 August	4.5
50	5	Machine	26 July	29 July	3 August	6.3
30	2	Hand	26 July	29 July	2 August	5.6
30	5	Hand	27 July	1 August	8 August	11.3
30	2	Machine	26 July	29 August	1 August	5.0
30	5	Machine	26 July	29 August	1 August	4.8
0	-	Hand	28 July	1 August	5 August	7.1
0	-	Machine	26 July	29 July	2 August	5.3
SED (18 df) = ±			0.8 days	1.5 days	3.0 days	2.50
50	-	-	27 July	31 July	5 August	8.1
30	-	-	27 July	30 July	3 August	6.7
0	-	-	27 July	30 July	3 August	6.2
SED (18 df) = ±			0.5 days	0.9 days	1.8 days	1.53
-	2	-	26 July	29 July	3 August	6.2
-	5	-	27 July	31 July	6 August	8.6
SED (18 df) = ±			0.4 days	0.8 days	1.5 days	1.53
-	-	Hand	27 July	1 August	6 August	9.2
-	-	Machine	26 July	29 July	2 August	5.2
SED (18 df) = ±			0.4 days	0.7 days	1.3 days	1.12

Table 9 Harvest data for Trial 3

Treatment		Application method	Date of			Length of cut (days)
Volume of starter solution	Strength of starter sol %		10% cut	50% cut	90% cut	
50	2	Hand	21 August	25 August	27 August	5.4
50	5	Hand	26 August	30 August	6 September	11.0
50	2	Machine	23 August	26 August	31 August	7.4
50	5	Machine	25 August	28 August	2 September	8.8
30	2	Hand	24 August	27 August	31 August	7.3
30	5	Hand	24 August	26 August	1 September	7.8
30	2	Machine	23 August	25 August	24 August	6.3
30	5	Machine	23 August	25 August	28 August	5.2
0	-	Hand	24 August	27 August	31 August	6.8
0	-	Machine	23 August	26 August	29 August	6.1
SED (18 df) = ±			0.8 days	0.9 days	1.6 days	1.49
50	-	-	24 August	27 August	1 September	8.1
30	-	-	23 August	26 August	30 August	6.7
0	-	-	24 August	27 August	30 August	6.5
SED (18 df) = ±			0.5 days	0.6 days	1.0 days	0.91
-	2	-	23 August	26 August	29 August	6.6
-	5	-	24 August	27 August	2 September	8.2
SED (18 df) = ±			0.4 days	0.5 days	0.8 days	0.75
-	-	Hand	24 August	27 August	1 September	7.7
-	-	Machine	23 August	26 August	30 August	6.8
SED (18 df) = ±			0.4 days	0.4 days	0.7 days	0.67

Yield data are given in Tables 10, 11 and 12 respectively. There were no consistent significant effect of treatment upon yields in Trial 1. For Trial 2 where for all previous observations starter had had no effect there is a significant loss of yield when using 50 ml of five percent solution applied by hand, this is because of missing and not sized heads. This observations is repeated in Trial 3 and in this particular case the machine planted gave higher Class I than the hand planted.

Table 10 Yield data for Trial 1.

Treatment			Class I heads	Class II heads	Total mkbl yield	Percentage No. of missing plants
Volume of starter solution	Strength of starter sol %	Application method	10% cut	50% cut	90%	(Ang trans)
50	2	Hand	627	2178	2805	0
50	5	Hand	693	2013	2706	5.0
50	2	Machine	330	2508	2838	0
50	5	Machine	792	1980	2772	0
30	2	Hand	924	1848	2772	3.5
30	5	Hand	726	2079	2805	0
30	2	Machine	924	1815	2739	0
30	5	Machine	528	2244	2722	0
0	-	Hand	627	2244	2871	0
0	-	Machine	726	2145	2871	0
SED (18 df) = ±			251.6	244.1	93.4	2.42
50	-	-	610	2170	2780	1.3
30	-	-	775	1996	2772	0.9
0	-	-	676	2194	2871	0
SED (18 df) = ±			1779	172.6	66.1	1.71
-	2	-	701	2087	2788	0.9
-	5	-	682	2079	2764	1.3
SED (18 df) = ±			145.2	140.9	53.9	1.40
-	-	Hand	719	2072	2792	1.0
-	-	Machine	660	2138	2798	0.7
SED (18 df) = ±			129.9	126.0	48.2	1.25

Table 11 Yield data for Trial 2.

Treatment			Class I heads	Class II heads	Total mktl yield	Percentage No. of missing plants
Volume of starter solution	Strength of starter sol %	Application method	10% cut	50% cut	90%	(Ang trans)
50	2	Hand	990	1848	2858	7.0
50	5	Hand	1221	1353	2574	12.4
50	2	Machine	759	2046	2808	0
50	5	Machine	957	1881	2838	0
30	2	Hand	1221	1584	2805	8.5
30	5	Hand	1353	1254	2607	10.5
30	2	Machine	726	2077	2805	7.0
30	5	Machine	726	1947	2673	10.5
0	-	Hand	1221	1584	2805	12.1
0	-	Machine	990	1848	2838	7.0
SED (18 df) = ±			288.6	298.9	114.0	5.06
50	-	-	982	1782	2769	4.8
30	-	-	1006	1716	2722	9.1
0	-	-	1105	1600	2706	9.6
SED (18 df) = ±			176.7	183.1	69.8	3.10
-	2	-	924	1889	2813	5.6
-	5	-	1064	1609	2673	8.4
SED (18 df) = ±			144.3	149.5	57.0	2.53
-	-	Hand	1201	1978	2679	10.1
-	-	Machine	832	1960	2792	4.9
SED (18 df) = ±			129.1	133.7	51.0	2.26

Table 12 Yield data for Trial 3.

Treatment			Class I heads	Class II heads	Total mkbl yield	Percentage No. of missing plants
Volume of starter solution	Strength of starter sol %	Application method	10% cut	50% cut	90%	(Ang trans)
50	2	Hand	1584	1287	2871	3.5
50	5	Hand	1056	1221	2277	8.9
50	2	Machine	1485	1353	2838	3.5
50	5	Machine	1056	1617	2673	5.0
30	2	Hand	1320	1419	2739	0
30	5	Hand	1254	1419	2673	3.5
30	2	Machine	1584	1287	2871	3.5
30	5	Machine	1683	1122	2805	0
0	-	Hand	1089	1619	2706	0
0	-	Machine	1881	957	2831	0
SED (18 df) = ±			146.8	205.2	160.4	5.6
50	-	-	1295	1369	2665	5.2
30	-	-	1460	1312	2772	1.8
0	-	-	1485	1287	2772	0
SED (18 df) = ±			89.9	125.7	98.2	3.4
-	2	-	1493	1336	2830	2.6
-	5	-	1262	1345	2607	4.3
SED (18 df) = ±			73.4	102.6	50.2	2.8
-	-	Hand	1261	1393	2653	3.2
-	-	Machine	1538	1267	2805	2.4
SED (18 df) = ±			65.7	91.8	71.7	2.5

Generally there were no significant effects of treatment upon quality factors.

## **Conclusions**

1. Generally 50 ml of the two percent solution applied by hand increase early growth which resulted in an advanced shorter harvest but no effect upon yield or quality. In only one out of the three occasions did the machine applied two percent solution have a similar beneficial effect on the crop.
2. The five percent solution applied by hand was phytotoxic delaying harvest, lengthening harvest period and reducing yield. This effect was largely negated when the five percent solution was applied by machine, this was considered to be due to putting less of this solution in close proximity to the root zone.
3. 50 ml of a two percent solution is recommended but it must be close to the root zone, to effect this by machine will probably mean increasing the concentration of the starter solution or quantity given.

## **Recommendations for further work**

1. It is apparent that to consistently get the beneficial effects seen from hand applied starter solution by machine then either a greater quantity of starter per plant must be given to ensure the amount around the root zone is adequate or else the concentration must be increased to somewhere between two and five percent. This could be quantified to assess which is the most economic and logistical answer.

## **Acknowledgements**

The author is indebted to the excellent technical assistance of Miss J Bowtell and Miss S A Minns of the Station staff.