SEAWEED EXTRACT HANDBOOK

chase
SM6
seaweed extract

chase
SM3
seaweed extract

PLANT GROWTH STIMULANTS

StanChem INTERNATIONAL

Viking Road,
Gapton Hall Industrial Estate,
Great Yarmouth, NR31 0NU
United Kingdom
0044 (0) 1493 419904
stanchem.co.uk

Opinions differ on the merits of seaweed extracts. To some they are the answer to all problems, to others merely 'muck and magic'. The truth lies somewhere between these extremes and this booklet attempts to identify the merits of seaweeds and their range of uses.

In summarizing scientific research findings and practical experience we have endeavoured to provide a reference book for farmers, consultants, technical representatives etc. when they discuss the uses of seaweed.

Stan Chem manufacture a range of seaweed extracts, the best known being **SM3** and **SM6** which are sold world wide for use on an extensive range of crops.

When reading this booklet, remember that SM6 only differs drom SM3 in its concentration, being double the strength and so used and half the application rate of SM3.

INTRODUCTION

The first records of seaweed being processed come from China in 2700 BC and the Chinese and Japanese have been using it for human and animal consumption ever since! Europeans came into the market rather belatedly in the 12th Century using seaweed as a manure.

Initially in the UK, agricultural use of seaweed was restricted to bulk fresh weed which was used as a manure and soil conditioner. As transport and labour costs rose and chemical fertilizers became more readily available so raw seaweed was replaced by two main types of processed seaweed.

1. SEAWEED MEAL: Dried seaweed used primarily as an animal feed supplement but also as a fertilizer and soil conditioner. It is relatively expensive but useful for vegetable growing and amenity turf, providing organic matter, trace elements and growth stimulants.

2. SEAWEED EXTRACTS: Liquid products manufactured from seaweed by various methods, i.e.:-

Product	***Production Method***	***Product pH (typical)***
SM3 & **SM6**	Water extraction	4.6
Maxicrop	Alkaline extraction	7.6
Kelpak	Ruptured cell susp.	4.5
Goemar	Cryo-microcrushing	3.5

Manufacturing technique is important in its effect on the final product. Alkaline extraction requires the use of higher temperatures and chemical inputs, which could affect the active ingredients and certainly results in a product with a higher pH value. The acidic nature of products such as **SM6** may well assist plant uptake both of the seaweed ingredients and any other material which may be included in a tank mix. Acidic buffering agents are marketed specifically to improve plant uptake of foliar sprays.

Seaweed extracts will vary in their strength, as measured by soluble seaweed solids content

EXAMPLE:

SM6	30 %	w/v seaweed solids
SM3	15 %	"
Maxicrop Original	8 %	"
Seamac	10 %	"
Kelpak	7 %	"

It can be argued that this is not a measure of biological activity, but until more accurate (and commercially practical) methods have been developed to identify and quantify active ingredients, then % solids remains the best guide. When making comparisons is should be remembered that alkaline products can contain significant potassium solids from the extraction process, not the seaweed. All products should, of course, be looked at in relation to the recommended application rate and cost per hectare.

WHAT IS THE EFFECT OF SEAWEED EXTRACTS ON PLANT GROWTH?

Seaweed extracts act as plant growth stimulants; their effectiveness may be influenced by the species included and the manufacturing technique used. Overall crop performance is improved due to their effect on :-

plant growth
protein and carbohydrate production
prolonged chlorophyll production and photosynthesis

THESE BENEFICIAL EFFECTS ARE MOST NOTICEABLE WHEN THE PLANT IS UNDER STRESS

WHAT ACTIVE INGREDIENTS ARE GIVING THESE EFFECTS?

This has been the subject of some contention ever since extracts first appeared on the market.

(a) MACRO NUTRIENTS AND TRACE ELEMENTS: More than sixty elements have been identified in seaweed and it was these that were first considered to provide the beneficial crop effects. However *Blunden (1)* has shown that even the most generous applications of extract would not meet crop requirements on their own.

TABLE 1 : **CROP TRACE ELEMENT REQUIREMENT (BLUNDEN 1)**

element	***grm/ha from extract***	***grm/ha per annum for hay crop***
Iron	22.0	280.0
Manganese	0.3	140.0
Zinc	0.7	140.0
Copper	0.3	140.0
Boron	0.006	56.0
Molybdenum	0.07	1.4
Cobalt	0.03	1.4

Nonetheless it is possible that seaweed extracts contain sufficient trace elements to remedy marginal deficiencies as has been demonstrated by *Aitken& Senn (2)*. It is also quite possible that the nutrients and trace elements may interact with other ingredients in the seaweed to produce a crop response.

Seaweed extracts on their own are unlikely to remedy a severe mineral deficiency and the appropriate element should be applied, preferably in combination with seaweed extract, to further stimulate growth.

(b) AUXINS: These plant hormones have been identified in seaweed *(3,4)* and more recently in extracts *(38)*, however it seems likely that they would be relatively short lived within an extract.

(c) GIBBERELLINS: Gibberellin activity has been identified in seaweed extracts but *Williams (5)* found the level of activity declined to virtually nil after three months.

In view of this , both auxins and gibberellins can be discounted as having any significant influence on seaweed extract activity.

See also Active ingredient information sheet

(d) CYTOKININS: Cytokinins are plant growth hormones closely involved in cell division, protein, carbohydrate and chlorophyll synthesis. Initially cytokinin like activity in seaweed extracts was confirmed by numerous workers including *Brain (6)* using **SM3**. Equipment necessary to identify individual cytokinins is extremely expensive and not readily available to all research workers. Nonetheless specific cytokinins have been identified in extracts by university workers in *Australia (7)* and *South Africa (8)*. *Blunden (9)* demonstrated similar yield increases from potatoes sprayed with either **SM3** or the cytokinin ***Kinetin.***

TABLE 2: YIELD INCREASES FROM SM3 + KINETIN

treatment	***application rate per hectare***	***tuber yield %control***
SM3	11.2 litres	112.9
Kinetin	1.4 grams	110.8

(e) BETAINES: Betaines are modified amino acids which have been isolated from seaweeds and which have several functions similar to those of cytokinins *(39).* Indeed earlier responses attributed to cytokinins could well have been due to betaines. Five betaines have been identified in **SM3** by *Blunden (10)* but they were not common to all seaweed species or extracts examined. Blunden *(40)* showed that in one bioassay procedure some betaines gave higher activity levels than those of the cytokinins used for reference purposes. Betaines can act as antistressors in both biotic and abiotic stress conditions. ***Glycine betaine*** has been shown to act as an osmoprotectant, to enhance water utilization *(11)* and to have a role in frost resistance in plants. As with cytokinins, the analytical procedure for betaines is not readily available for commercial operations.

TABLE 3: EXAMPLES OF BETAINE ANALYSES (mg/lt)

product	***glycine betaine***	***aminobutyric betaine***	***aminovaleric betaine***	***total***
SM6	195.7	109.8	35.1	340.6
Icelandic	14.1	25.2	10.1	49.4
Maxicrop Original	14.1	50.0	16.7	80.8
Seamac PCT	12.7	21.2	9.2	43.1

(f) ALGINATE: Alginate content varies with manufacturing process. There is no evidence of crop response to alginates within extracts, although alginate products are used specifically for root protection and soi conditioning.

(g) SUGARS: Foliar applied sugars can have an effect on crop growth and this has been applied in a number of countries, usually with molasses based products. More recently polysaccharides isolated from seaweed have been shown to stimulate the plant's natural defence mechanism (46).

Finnie and Van Staden (31) demonstrated that tomato root response to seaweed extract was due to organic compounds and one is drawn to conclude that the major crop responses result from the action of the betaines and cytokinins although there may be further interactions with other constituents.

See also Active ingredient information sheet

WHAT ARE THE CROP EFFECTS

Numerous crop responses have been attributed to the use of seaweed extracts, the most important are as follows :-

(a) HIGHER MARKETABLE YIELD: Obviously the most important response as far as the farmer is concerned. *Blunden (9)* achieved a 13% yield increase from potatoes treated with **SM3**, *Povolny (13)* 41% increase from glasshouse cucumbers and *Abdel Rahman (14)* reported increased yields from apples and strawberries. Increased leaf chlorophyll content should ultimately lead to increased yield. *Whapham (43)* demonstrated that seaweed extract, applied either to foliage or the soil, significantly increased the chlorophyll content in tomato leaves. Later *Blunden et al (40)* extended this observation to french beans, wheat, barley and maize. Trials conducted with **SM3** and **SM6** have shown yield responses in a wide range of crops and examples can be found in Appendix 1.

(b) BETTER QUALITY/IMPROVED SHELF LIFE: Usually associated with improved marketable yield; better quality is directly evident in bolder samples, improved skin colour and texture, higher sugar content etc. *Blunden (15)* found that the application of **SM3** to sugar beet increased the sugar content and improved the juice purity. He attributed this to *cytokinin like* responses, i.e. increased leaf area and chlorophyll life leading to increased carbohydrate production and delayed senescence. This in turn decreased the transfer of amino nitrogen from leaf to root thus improving juice quality.

TABLE 4: SUGAR BEET TRIAL (BLUNDEN 15)

	root wt kg	***sugar%***	***juice content in m.e.q.*** amino N	potassium	sodium
TRIAL 1					
control	53.4	15.53	3.93	9.14	0.57
treated	53.75	16.22	3.17	8.25	0.55
diff.	NS	*	*	*	NS
TRIAL 2					
control	59.3	15.87	4.03	7.19	0.73
treated	64.4	16.35	3.59	6.71	0.66
diff.	*	*	*	*	NS

ns = not significant *= statistically significant

Fruit responds well to seaweed extracts; *Senn (16)* showed that peach shelf life was increased, while *Povolny* found that fruit was firmer and storage losses reduced for both peaches *(17)* and Cox apples *(18)*.

Crops where **SM3** and **SM6** have shown specific quality improvements include ;-

crop	***country***	***quality***
Coffee	Brazil	Even ripening
Peaches	USA	Reduced stone split
Cabbage	UK	Better storage
Tomatoes	USA	Thicker skins for better transportation
Tomatoes	Australia	Higher sugar content
Wheat	UK	Higher protein
Oranges	Brazil	Better juice extraction
Potatoes	UK	More marketable tubers
Lettuce	UK	Better colour
Apples	Belgium	Better colour
Rice	Japan	Bolder grain
Kiwi Fruit	N Zealand	Better fruit size

(c) INCREASED RESISTANCE TO PEST AND DISEASE: It has long been held that seaweed extracts increase the plants natural resistance to pests such as aphids, red spider mites and nematodes, and diseases such as mildew. Why this should happen is still not entirely clear although it has been show that constituents of seaweed, including betaines (47), can induce systemic aquired resistance within the plant to various stress situations, including pest and disease attack. Workers at Cornell University have shown that plants under stress produce an amino acid compound to protect themselves; unfortunately this also appears to increase the feeding and reproduction rate of insects *(19)*, thus the relatively unhealthy stressed foliage becomes a more attractive target. Terriere *(20)* found that chelated metals reduced red spider mite reproduction rate; as seaweed extracts contain chelated elements it was thought this could be another contributory factor helping to control this particular pest.

Seaweed extracts also affect certain nematodes and degrees of control have been recorded for root knot nematodes by *Featonby Smith (21)*,*Whapham (44)* and *Wu (45)* on tomatoes, for Radopholus similis by *Tarjan (46)* on citrus and for Belonolaimus longicaudatus by *Morgan and Tarjan (22)* on centipede grass. Samples of roots from bananas treated with **SM3** in Australia showed a tenfold reduction in nematodes.

When the three major betaines found in seaweed extract were applied in quantities equivalent to those present in the extract there were significant reductions in nematode invasion. *(45,47)*

TABLE 5: NEMATODE RESULTS See also Nematode information sheet

	Australia bananas		***USA centipede grass***
	nematodes per 50g roots ***spirals***	***burrowing***	***total nematodes***
control	2679	250	912
treated SM3	297	0	220

Dropkin (23) found that the cytokinin, kinetin, inhibited nematode development in tomato roots. Kinetin applied to cucumbers inhibited powdery mildew *(24)* and has also been shown to decrease the occurrence of stem rust in wheat *(25)*. The role of betaines in increasing plant resistance to attack by fungi is of particular interest. *Manniger et al (42)* demonstrated that external application of betaines reduced the attack of rust on wheat. Powdery mildew control by the use of seaweed extract has also been recorded by *Senn (26)* on melons and *Stephenson (27)* on turnips. The latter also reported a reduction in botrytis on strawberries.

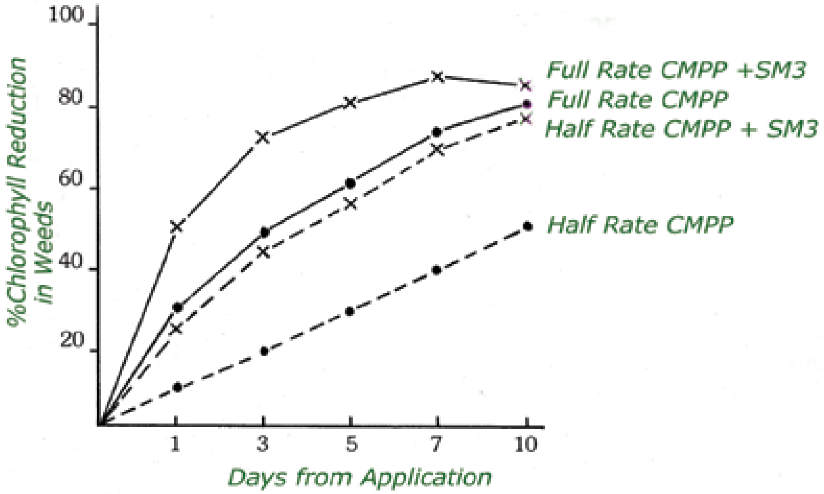
SM3 included in an American fungicide trial on tomatoes gave an increase in marketable yield similar to that achieved with *Maneb*. Although not acting as a fungicide it would appear that the growth stimulatory effect from **SM3**, either in direct terms or through systemic aquired resistance, was sufficient to counteract a potential substantial yield loss from disease.

TABLE 6: FUNGICIDE TRIAL ON TOMATOES - USA

treatment	***rate / acre***	***yield lbs***
chlorothalonil	1.5 lbs	70.75
maneb	3.0 lbs	56.72
SM3	1 gallon	55.92
dithane	3.0 lbs	46.60
control		25.10

(d) IMPROVED PESTICIDAL ACTIVITY: Many growers use seaweed extracts to increase the efficacy of their pesticides; typical examples are when it is added to Sulphur for disease control in wheat or apples and to hormone herbicides for weed control. *Brain (28)* demonstrated that the addition of **SM3** to CMPP almost halved the time taken to kill chickweed. In combination with half rates of CMPP the herbicidal activity was maintained and an 11% reduction in crop (barley) height caused by the full rate of CMPP was eliminated.

TABLE 7: SEAWEED EXTRACT AND HERBICIDE (BRAIN 28)



A three year study of oranges in the USA showed that not only did the use of Captan increase yields over previous years when there was no treatment but that the combination of **SM3** and half rate Captan gave a greater increase in yield than Captan alone.

TABLE 8: SM3 AND CAPTAN ON ORANGES -USA

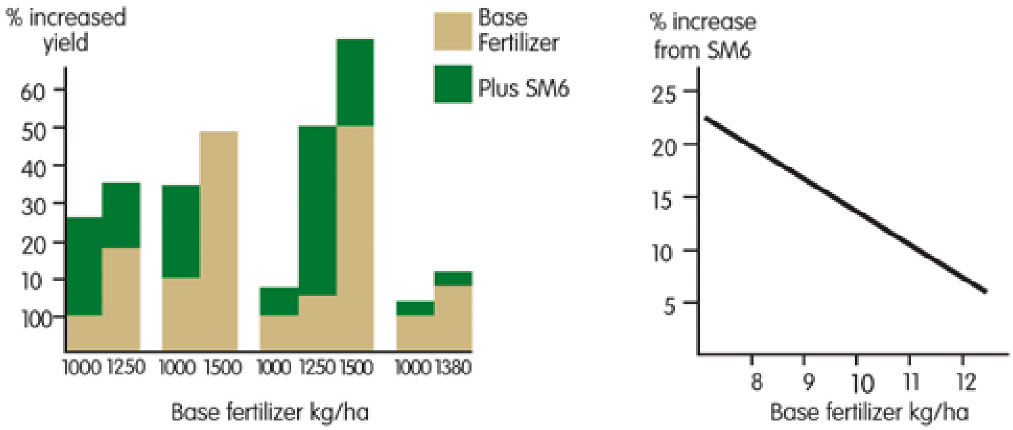
no treatment boxes/12 acres			***treatment***	***3 year treatment period boxes/12 acres***			
1974	***1975***	***ave***		***1976***	***1977***	***1978***	***ave***
797	573	685	Captan 16 lbs/acre	743	1817	2847	1802
471	703	587	Captan 7.5 lbs + **SM3** 0.5 gall	1740	2440	3633	2604

The addition of **SM3** to a routine fungicide programme on glasshouse tomatoes in the UK resulted in a clear reduction of Botrytis infection. ‘It was very obvious that the treated plants had made substantially more vegetative growth. This extra growth should lead to increased yields as the plants were stronger in appearance with a greater area of photosynthetically active tissue exposed to the available sunlight. It was thought that this might lead to problems with Botrytis particularly as the days shortened in the Autumn. However this was not the case and in fact LESS Botrytis infection was noted in the treated area.’

(e) INCREASED NUTRIENT UPTAKE; Although it has already been stated that extracts contain relatively small amounts of nutrients, nonetheless they do influence plant nutrient uptake. *Childers (30)* observed an increase in Magnesium uptake in peaches and *Maree (29)* found that foliar uptake of Calcium could be significantly increased. This has obvious implications for apple crops receiving regular Calcium sprays. Bananas have also shown a marked uptake of Manganese after treatment with **SM3**.

Trials with hydroponically grown barley showed that when seaweed extract was added to a trace element feed there was a greater increase in plant growth than from the trace elements alone *(41)*. Practical evidence in a series of UK potato trials indicated that treated plants made better use of available nutrients, to the extent that equivalent yields were achieved with less base fertilizer, when the crop was treated with **SM6**.

TABLE 9: POTATO FERTILIZER TRIALS WITH SM6



Although not necessarily an economic justification for reducing base fertilizer, the figures above emphasise the benefits from using **SM6**; even at the highest base fertilizer rate there was still a profitable response in most cases.

(f) STRONGER GROWTH: One of the benefits from using seaweed is that it stimulates strong healthy growth, not the rapid soft growth associated with high Nitrogen applications. Vigorous root systems are particularly noticeable giving the plant better access to nutrient and water supplies which must ultimately lead to increased yield. *Blunden (9)* recorded increased stem and lateral root growth with **SM3**. *Finnie & Van Staden (31)* and *Featonby Smith (21)* all found seaweed extract stimulated root growth in tomatoes. *Gregory (32)* applied **SM3** at a range of rates on Mung beans, demonstrating that it stimulated root initiation and elongation.

TABLE 11: ROOT GROWTH FROM SM3 (GREGORY 32)

treatments	***experiment 1 roots***		***experiment 2 roots***		***experiment 3 roots***	
	no.	***length mm***	***no.***	***length mm***	***no.***	***length mm.***
control	13.0	-	13.2	10.7	6.2	5.6
SM3 1 in 100	23.2	-	-	-	-	-
SM3 1 in 500	-	-	29.3	11.2	-	-
SM3 1 in 1000	37.2	-	26.5	11.1	19.2	8.2
SM3 1 in 2000	-	-	22.8	14.1	-	-
SM3 1 in 5000	-	-	-	-	6.7	7.2
Kinetin 10-8	-	-	14.2	9.7	5.6	4.7
IAA 10-5	-	-	-	-	20.2	3.4

Using a root drench on wheat *Nelson & Van Staden (33)* significantly enlarged stem diameter due to increased cell size, which would result in a sturdier plant. Commercial experience with **SM6** on wheat has shown that it can assist the plant to develop a good root system and reduce crop lodging. Similar results have been seen in Japan on rice treated with **SM3**.

Grass, both amenity and agricultural, is another area where regular use of seaweed extract will improve both root development and the quality of grass.

(g) SEED GERMINATION: Pre-soaking with Chase **SM3** or Chase **SM6** can improve the germination of some, but not all seeds, as demonstrated by *Wilczeg (34)*

Carrot seed production can be difficult due to poor germination rates but *Maguire (35)* made significant improvements by treating the seed crop at flowering stage. The effect could well have been due to delayed senescence allowing the seed to mature more evenly, thus giving better quality.

TABLE 12: CARROT SEED PRODUCTION

treatment	*%germination seed*	*grms/5 plants*
1984		
Control	50.9*	
SM3 3 pts/acre	65.1	
BA 50mg/lt	62.7	
1985		
Control	66.4*	70.6
SM3 3pts/acre	76.7	104.0
BA 50 mg/lt	73.7	79.6

(h) FROST RESISTANCE *Senn (23)* reported that tomatoes treated with seaweed extract withstood 3^{o}F of frost, while untreated controls were killed. Dwarf beans treated with **SM3** withstood three frosts of 3-6^{o}F whereas the untreated area was defoliated *(36)*. Just why seaweed extracts can have this effect is uncertain but it has been suggested that applied prior to frost it enables the plant to acclimatise itself to the onset of colder conditions. *Gagnon (37)* treated spruce seedlings with an amino acid, tyrosine, and found the needles were able to withstand 10^{o}F of frost while the controls died. Seaweed extracts contain both amino and modified amino acids (betaines) and it is possible that these assist the plant to withstand marginal frosts. In any event there are important implications for early maturing crops such as potatoes and blackcurrants.

SUMMARY

It is quite clear that seaweed extracts do have an effect on plant growth and quality. It is equally true that if a plant has access to its optimum requirements of nutrients, water, sunshine etc. then the effect of spraying with a seaweed extract, or any other foliar spray, would be minimal. However this optimal situation seldom arises and even in a glasshouse environment where requirements can be more accurately controlled, one is able to obtain beneficial responses by adding seaweed extract to the water supply. Responses will vary from year to year and between sites, but this is no different from the variation found in fertilizer trials. Good responses can be expected whenever the plants are subject to stress.

Economic forces, coupled with growing environmental pressures, will necessitate reduced Nitrogen usage and in this situation there is even greater reason to include Chase seaweed extract, **SM6**, in your input programme. You owe it to your crops - and yourself!

REFERENCES

1.	Blunden G	Cytokinin activity of seaweed extracts. Marine Natural Products Chemistry 1977, 377
2.	Aitken J +Senn T	Seaweed products as a fertilizer and soil conditioner. Botanica Marina 8. 1965, 144
3.	Mowat J	Auxins and gibberellins in marine algae. Proc.Intl.Seaweed Symp. 1961, 352
4.	Jacobs W	Nature and amount of Auxin in Algae. Plant Physiol.1985
5.	Williams D et al	Plant growth regulatory substances in commercial seaweed extracts. Proc.Intl. Seaweed Symp. 1981, 760
6.	Brain K et al	Cytokinin activity of commercial aqueous seaweed extract Plant Sci. Letters 1973,1,241
7.	Tay S et al	Detection of cytokinins in a seaweed extract. Phytochemistry 24.1985 ,2611
8.	Featonby Smith B +Van Staden J	Identification and seasonal variation of endogenous cytokinins in Ecklonia maxima Botanica Marina 27,1984,527
9.	Blunden G + Wildgoose P	Effects of aqueous seaweed extract and kinetin on potato yields. J Sci. Fd. Agric. 1977,28,121
10.	Blunden G et al	Characterisation and quantitative estimation of betaines incommercial seaweed extracts. Botanica Marina 29, 1986,155
11.	Bergmann H +	Effect of Glycine betaine on water use efficiency of wheat Biologia Plantae (Praha) Eckert H 1984,384
12.	Booth E	Manufacture and properties of liquid seaweed extracts.6th Intl. Seaweed Symposium 1969,655
13.	Povolny M	Effect of sea algae extract on glasshouse cucumbers Roslinna Vyroba 12,1966,335
14.	Abdel-Rahman	Responses of crops to treatments with biostimulants Cytex and Ergostim.Proc. 5th PGR Working Group 1978
15.	Blunden G et al	Effects of aqueous seaweed extract on sugar beet.Botanica Marina 22, 1979,539
16.	Senn T et al	South Carolina Exp Stn Results 1966
17.	Povolny M	Effect of seaweed extract on ripening and storage capacity of peaches and apricots. Roslinna Vyroba 18, 1972,703
18.	Povolny M	Influence of seaweed extracts on storability of apples Roslinna Vyroba 6, 1969,703
19.	The Grower	9th May 1985
20.	Terriere L	J Econ. Entomology 57 1964
21.	Featonby Smith + Van Staden	Effect of seaweed concentrate on growth of tomatoes in infested soil. Scientia Horticulturae 20 1983,137
22.	Morgan K + Tarjan A	Management of sting nematode on centipede grass with kelp extracts Proc.Fla.St Hortic. Soc. 93,1980,97
23. by	Dropkin V et al	Hypersensitivity reaction of tomatoes resistant to Meloido-gyne incognita reversal cytokinins.J Nematol 1 1969,55
24.	Dekker J	Effect of Kinetin on Powdery Mildew. Nature 197 1963
25.	Wang D	Effect of benzimidazole analogues on stem rust and chlorophyll metabolism. Can. J Bot.39 1961
26.	Senn T et al	Sth Carolina Stn Results 1961
27.	Stephenson W	Effect of seaweed on certain plants and diseases. Proc.5th Intl.Seaweed Symp.1966, 405
28.	Brain K et al	Enhancement of herbicidal effect by seaweed extracts Mar.Nat.Prod.Chemistry 1977, 345
29.	Maree P	Increase in Ca uptake when sprayed with calcium nitrate in presence of Kelpac & Seaborn.Univ. of Stellenbosch 1982
30.	Childers J	Effect of seaweed on peaches. Clemson University 1965
31.	Finnie J + Van Staden	Effect of seaweed concentrate and applied hormones on in vitro culture tomato roots. J Plant Phys.120 1985,215
32.	Gregory L	Root initiation experiments. USDA Beltsville Plant & Cell Phys. 14 1209
33.	Nelson W + Van Staden J	Effect of seaweed concentrate on wheat culms. J Plant Physiol. 115 1984,433
34.	Wilczeg C	Promotion of seed germination in table beet by an aqueous seaweed extract Hortiscience 1982
35.	Maguire J	Washington Stae University 1985
36.	Childers N	Rutgers University 1964 (Chase photographic records)
37.	Gagnon J	Nature 1964
38.	Sanderson K et al	Auxin in a seaweed extract. Identification and quantification of indole-3-acetic acid J Plant Physiol.129 1987 363
39.	Wheeler A	Endogenous growth substances Rothampstead Exp St.1973 101
40.	Blunden et al	Seaweed extracts used in agriculture EEC Cost 48 Report 1992

41. Steveni C Effect of seaweed concentrate on hydroponically grown spring barley. J Applied Phycol. 4,1992
42. Manniger et al Proceedings 3rd Int Conference on role of Formaldehyde in Biological Systems 1992,157
43. Whapham C et al Increased chlorophyll content of tomato leaves treated with seaweed extract.Brit. Phyco J. 27 1992,102
44. Whapham C et al Role of seaweed extracts in reduction of fecundity of Meloidogyne javanica.Fundam. Appl Nematol.1994 17,181-183
45. Wu Y et al Role of betaines in alkaline extracts in reduction of Meladogyne javanica and M. incognita infestations in tomatoes. Fund.Appl Nematol. 20 1997,99
46. Fournier Algal polysaccharides can act as elicitors for plant defence. New Phytologist.
47. Blunden G Seaweed extract as an elicitor of resistance in plants. Lecture

APPENDIX 1

Potato Trials UK

Numerous trials have been carried out on potatoes in the UK applying **SM3** and **SM6** at 11 lt/ha. Examples are illustrated below.

Variety	***Market Yield % diff from control***	***Variety***	***Market Yield % diff from control***	***Variety***	***Market Yield % diff from control***
Maris Bard	+ 19.3	***Desiree***	+ 12.0	***K Edward***	+ 25.0
"	+ 1.4	"	+ 4.0	"	+ 23.6
P Javelin	+ 15.3	"	+ 3.6	"	+ 21.9
"	+ 13.6	"	+ 1.2	"	+ 17.4
P Crown	+ 22.2	***P Squire***	+ 18.3	"	+ 16.5
"	+ 18.7	***K Edward***	+ 33.4	"	+ 13.3
P Dell	+ 14.0	"	+ 32.4	"	+ 7.9
Desiree	+ 13.9	"	+ 27.2	"	+ 5.9

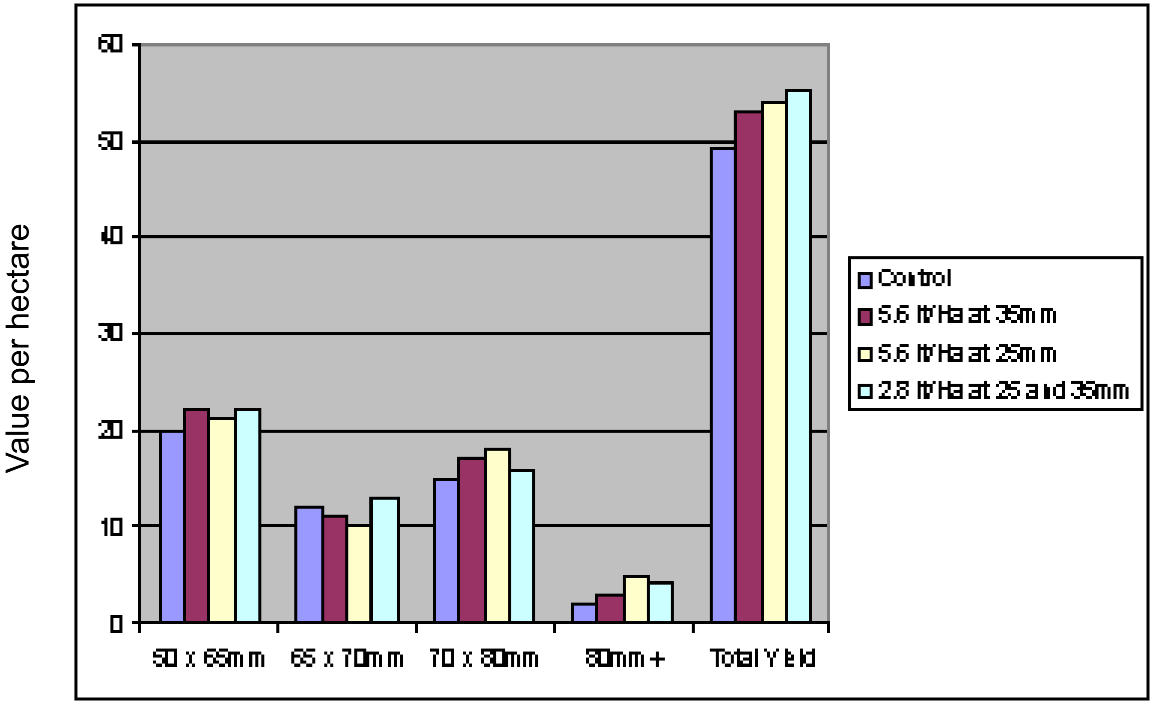
Potato Trials USA

Many trials have been carried out using **SM3** at 11 lt/ha.

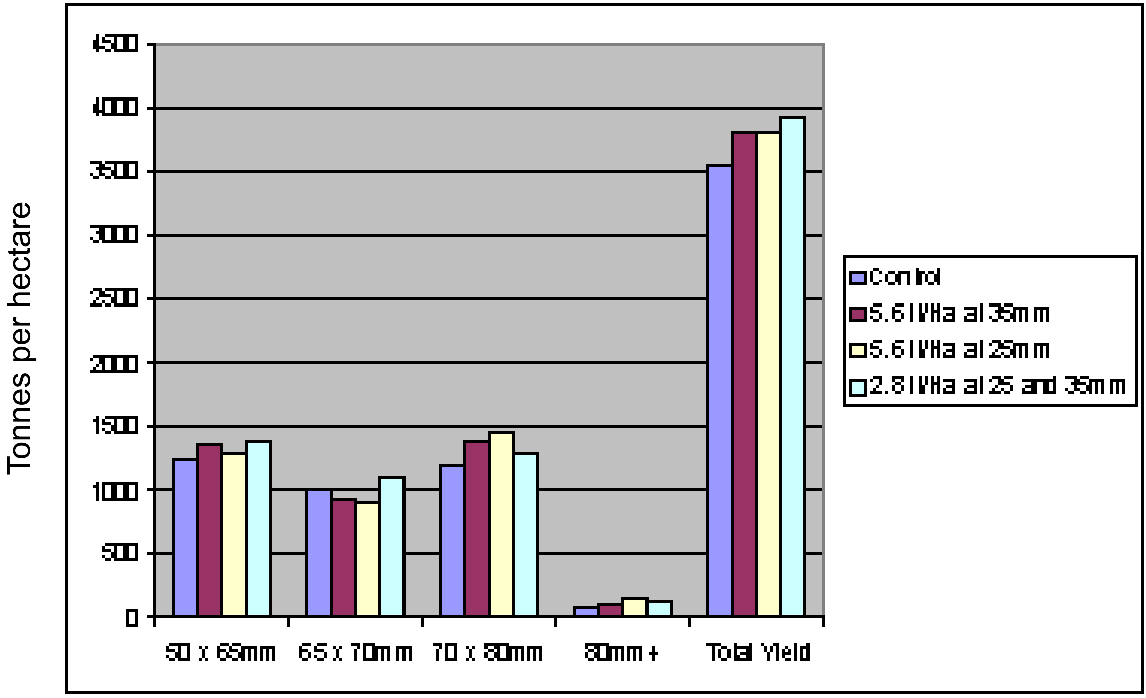
State	***Market Yield % diff from control***	***State***	***Market Yield % diff from control***	***State***	***Market Yield % diff from control***
Maine	+ 17.9	Nevada	+ 12.6	Idaho	+ 18.5
	+ 9.2	Washington	+ 7.2		+ 26.6
	+ 13.5	Idaho	+ 38.0		+ 36.2
	+ 11.7		+ 55.4		+ 15.9
	+ 28.8		+ 10.7		+ 28.1
	+ 4.8		+ 20.9		+ 9.4

SM6 Potato Trial UK 1997

Yield



Value



Sugar Beet Trial Holland

One hectare was treated with 11 lt **SM3**. Randomised samples were taken 14 days before harvest and at harvest. Samples were analysed by the Dutch Farmers Sugar Cooperative

Treatment	***% Sugar***	***%Extract***	***KMeq/kg***	***NaMeq/kg***	***Amino N Meq/kg***
14 days before					
Control	17.2	88.8	49.0	7.2	13.5
SM3	17.8	89.3	47.3	8.5	12.3
Harvest					
Control	16.4	87.4	47.3	12.8	17.0
SM3	16.9	89.3	46.4	6.4	15.4
Mean					
Control	16.8	88.1	48.1	10.0	15.2
SM3	17.3	89.3	46.8	7.4	13.8

Trends towards higher sugar percentage and purer juice, especially reducedAmino N confirms earlier trials work by Blunden.

Carrots USA

Carrots were treated with 11 lt/ha **SM3** when the roots had begun to broaden. Each treatment was replicated four times at four sites.

Treatment	***Yield tonnes/acre***	***% increase***
Site 1		
Control	15.6	
SM3	19.2	23.6
Site 2		
Control	12.9	
SM3	13.6	5.6
Site 3		
Control	21.2	
SM3	20.8	(1.9)
Site 4		
Control	13.2	
SM3	14.0	5.8

Tomatoes USA

Numerous trials have been carried out using **SM3** on outdoor tomatoes. Normal application rate is 11 lt/ha at first bloom.

	Yield/Acre Tonnes			***Wall Thickness***		
	Control	***SM3***	***% Diff.***	***Control***	***SM3***	***% Diff.***
Trial 1	28.43	32.33	+13.7			
2	30.59	40.23	+31.5	9.21	9.21	-
3	32.63	40.03	+22.7	5.45	6.19	+13.6
4	34.16	39.04	+14.3	6.81	7.95	+16.7
5	33.52	36.69	+ 9.5	7.70	7.89	+ 2.5
6	43.86	46.22	+ 5.4	6.64	7.12	+ 7.2
7	30.39	32.78	+ 7.9	7.87	7.81	(0.8)
8	31.87	36.04	+13.1	-	- -	

SM3 has consistently given an increase in marketable yield and there is a tendency for increased wall thickness making the fruit better able to withstand handling and transport.

Onions South Africa

SM3 was tested at four sites at various rates and timings

Treatment	*Yield Tonne/Ha.* Control	*SM3*	*% Diff.*
Site 1 10.25 lt/ha	27.44	41.41	+ 50.9
Site 2 6.7 lt/ha +7.2 lt after 1 month	16.13	26.06	+ 61.6
Site 3 12.9 lt/ha	55.93	66.39	+ 18.7
Site 4 16 lt/ha	49.91	58.50	+ 17.2

Cabbage Trial Essex

Plants were sprayed with 11 lt/ha **SM3** when 15cm tall. At maturity, samples from each treatment were cut, weighed and stored at ambient temperature for a week.

Treatment	*kg at cutting*	*kg after 7 days*	*% wt loss*
control	10.23	9.32	8.9
SM3	12.04	11.36	5.7
% increase	17.8	22.0	

Soya Beans USA

SM3 was applied at four rates when the crop was at 10% bloom. Each treatment was replicated four times

treatment	*yield tonnes/acre*	*% Increase*
control	1.33	
2.8 lt/ha	1.51	12.5
5.5	1.58	17.7
8.3	1.90	41.7**
11	2.05	53.1**

* Significant at 0.05 level

Vining Pea Trial UK

Vining peas for freezing were sprayed with 2.5 lt/ha **SM6** when 15 cms tall and again at first bloom

	yield tonnes/ha	*net increase £ per ha*
treated	5.31	39.51
control	4.10	_

Peppers USA

SM3 was tested at six sites in California. Treatment = 11 lt/ha at blossom

Yield tonnes/acre				***Shrink***		
Year/Site	***Control***	***SM3***	***% Diff.***	***Control***	***SM3***	***% Diff***
1979 1	6.82	7.21	5.5	6.4	6.2	3.1
2	6.97	7.48	7.4	5.6	4.9	12.5
3	4.30	4.54	5.6	4.8	4.6	4.2
1981 4	6.22	6.27	0.9	4.6	4.5	2.2
5	5.80	6.13	5.6	5.7	5.1	8.9
6	2.67	2.91	8.6	3.8	3.8	-
Mean	5.46	5.76	5.3	5.16	4.86	5.8

SM3 significantly increased yield and reduced the level of shrink

Apples USA

Golden Delicious, Red Delicious, Empire and Ida Red were treated with varying rates of **SM3** at bloom, late petal fall and fruit set. Each treatment was replicated four times.

Treatment/hectare	***Fruit per cluster***				***Fruit weight grams***			
	GD	RD	E	IR	GD	RD	E	IR
Trial 1								
Control	1.4	1.6	2.7	2.5	112	128	98	126
SM3 2.75 lt	1.9*	2.3*	3.8*	2.9*	132*	162*	115*	132*
Trial 2								
Control	1.5	1.6	2.6	2.5	115	134	110	120
SM3 5.5 lt	1.9*	1.8	2.9	2.7	130*	145*	122*	129
SM3 11lt	1.8	2.0*	3.2*	2.6	135*	142*	126*	136*

* significantly different

Apples Belgium

Cox apples were treated with **SM3** at varying stages and rates

Treatment/Growth Stage	***Yield kg/tree***	***55mm+***	***% apples well coloured***
Control	20.0	77.2	87.0
SM3			
2l/ha Green bud			
3l/ha Pink bud	23.5	74.9	95.0
3l/ha Early flower			
2l/ha Petal Fall			
% Increase	17.5	(3.0)	9.2

Pears Belgium

Conference pears were treated at varying rates and stages for two years

Treatment/Growth Stage	*Yield kg/tree*	*% Difference*
Year 1		
Control	16.0	
SM3		
2l/ha Green Bud		
3l/ha White bud	23.3	+45.6
3l/ha Early Flower		
2l/ha Full Flower		
Year 2		
Control	29.2	
SM3 (as above)	34.5	+18.4

Grape Trial Iraq

Table grapes were treated over two years with various rates of **SM3** by Mosul University

	yield kg/vine		***berry wt/grams***	
	year 1	***year 2***	***year 1***	***year 2***
control	16.3d	15.2d	7.3c	7.1d
SM3 9 lt/ha	20.5c	18.9bc	12.2a	11.5a
SM3 10 lt/ha	22.6a	21.0a	12.4a	12.1a
SM3 11 lt/ha	21.8b	20.4b	11.7a	10.7b

Means with different letters are significantly different at 5% level

Peaches USA

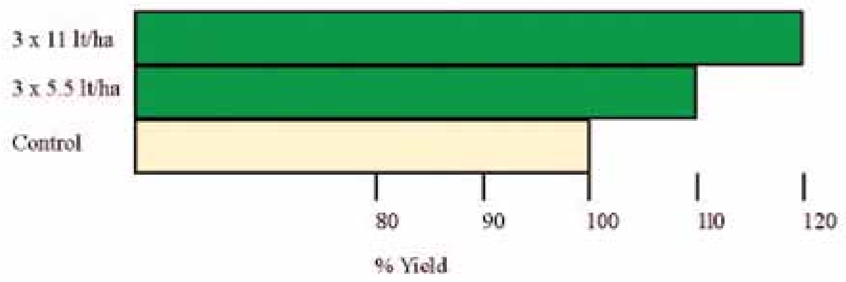
SM3 was tested for 5 years by state extension workers in Alabama. 5.5 lt/ha was applied at pit hardening and 5.5 lt one week later.

Treatment		***1979***	***1980***	***1981***	***1982***	***1983***
Gross Yield	***Control***	25.3	38.8	56.3	26.4	47.3
Kg/tree	***SM3***	28.8	41.8	56.7	27.7	52.7
	% diff	+14.0	+7.7	+0.8	+5.2	+11.3
% Split	***Control***	28.5	16.6	11.2	7.9	9.3
Pip	***SM3***	24.4	15.0	6.7	7.8	7.8
	% diff.	(14.4)	(9.6)	(40.2)	(1.3)	(16.1)
Marketable	***Control***	22.3	32.2	50.0	22.7	42.9
Yield	***SM3***	26.8	35.4	52.9	25.5	48.5
Kg/tree	***% diff***	+20.4	+10.0	+5.9	+12.2	+13.1

Grass - UK

A grass crop grown for silage was treated with two applications rates of SM3 at three successional application times.

Results:



Both applications rates gave a significant increase in culmulative yield providing an economic benefit well in excess of the material cost.

Wheat Trials - UK

Various rates of SM6 have been tested by an independent trials organisation on winter wheat using a plot sprayer and replicating treatments four times.

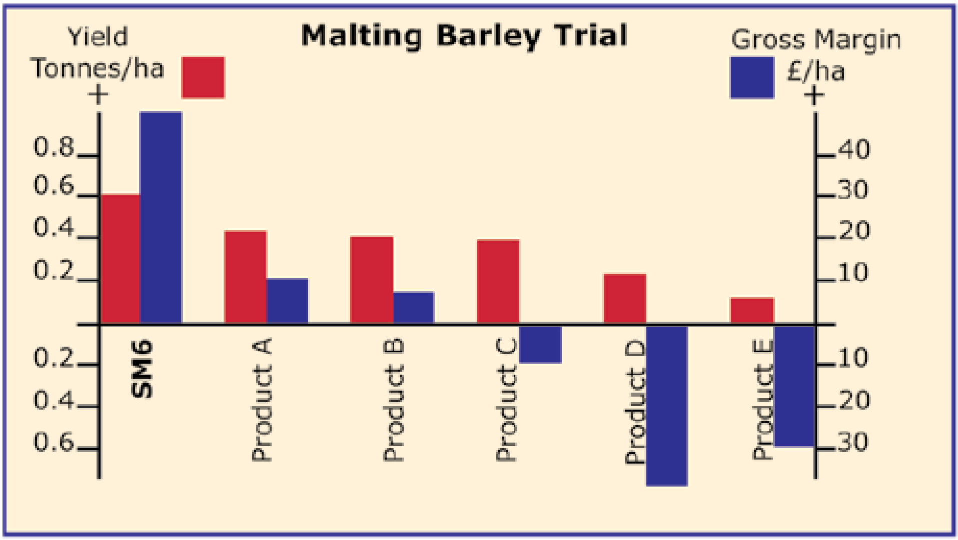
Results:
The major effect on wheat yields is obtained by spraying at GS31 when the product encourages tillering. Subsequent spraying at GS59 delays senescence and in so doing enhances the final product quality.

	Treatment LT/HA				***Yield/HA***	
Year		***GS31***	***GS39***	***GS59***	***Tonnes***	***%***
1	Control	--	--	--	7.89	100
	SM6	1.25	--	1.25	8.76	111
	SM6	--	--	1.25	8.19	104
	SM6	2.5	--	2.5	7.18	91
2	Control	--	--	--	8.88	100
	SM6	1.5	--	1.5	9.25	104
	SM6	1.5	1.5	--	9.12	103
	SM6	--	1.5	1.5	8.88	100
3	Control	--	--	--	8.63	100
	SM6	1.5	--	1.5	9.08	111
4	Control	--	--	--	9.49	100
	SM6	1.4	--	1.4	9.49	100
	SM6	2.8	--	2.8	9.74	102.6

Malting Barley

SM6 was independently compared with a number of other foliar feeds for its efficacy on malting barley. All products were applied at manufacturers recommended rates. The table shows SM6 came out a clear winner, both for yield and financial return.

Results:



APPLICATION RATES Chase SM6 Seaweed Extract (half those of SM3)

NB. These are guides and may be adjusted to suit local circumstances.

Crop	Application Rate and Timing
Apples, Pears	1.4 lt/ha applied four times between green cluster and fruit set. Where calcium sprays are applied it can be beneficial to add 0.8 lt/ha SM6 in the tank mix
Barley	1.4 lt/ha at GS 11-14 to encourage root development in autumn
Malting	1.4 lt/ha at GS 29-31, a further 1.4 lt no later than flag leaf, GS39
Feed	1.4 lt/ha at GS29-31, a further 1.4 lt at flag leaf to ear emergence, GS 39-59
Brassica	5.6 lt/ha split into 4 equal doses, beginning when the plant has four true leaves
Carrots	2.8 lt/ha when there is adequate foliage followed by 2.8 lt as the roots begin to expand
Celery	2.0 lt/ha soon after transplanting, a further 2.8 lt one month later
Citrus	2.0 lt/ha when new growth begins. Repeat during main growth periods
Cotton	2.0 lt/ha injected with seed, 2.5 lt at first square, 1 lt at first flower
Currants/Rasps	2.8 lt/ha when there is adequate new leaf and again at flowering. 2.8 lt immediately post harvest will help improve next years fruit bud
Grass	
Permanent	2.8 lt/ha in spring and again in autumn, if appropriate
Intensive	2.8 lt/ha in the spring followed by 2.8 lt after each cut or grazing period when there is sufficient leaf cover
New Leys	2.8 lt/ha when there is adequate leaf cover
Amenity Grass	2.8 - 5.6 lt/ha in the spring and again in the autumn. Further applications may be justified every 4-6 weeks through the summer
Hops	1.4 lt/ha applied 4 times during the active growing season. Applications at burr stage and again 7-14 days later can be especially beneficial
Kumara (Sweet Potato)	1.4 lt/ha at planting and again 6-8 weeks later
Kiwi Fruit	5.0 lt/ha at 80% flowering and again 10 days later
Lettuce	2.8 lt/ha once plants are established and again before hearting commences.
Lucerne	2.8 lt/ha when the crop is 10-15 cms tall. Repeat after each cut once there is sufficient new leaf.
Oats	1.4 lt/ha in autumn at 3-5 leaf stage to encourage root development 1.4 lt/ha at GS 29-31 followed by 1.4 lt at GS 39-59
Onions/Leeks	2.8 lt/ha once crop has at least 6-8 leaves. Repeat 3-4 weeks later
Peas	2.8 lt/ha at 15cm height, 2.8 lt at bloom cluster
French Beans	2.8 lt/ha at 15cm height, 2.8 lt at first flower.

Potatoes

Improve tuber numbers for earlies/seed/salad crops
2.8 lt/ha at tuber initiation and 2.8 lt 10-14 days later

Improve % large tubers rapid bulking varieties
5.6 lt/ha when tubers approximately 25mm

Slow bulking varieties and general ware crops
2.8 lt/ha when tubers approximately 25mm plus 2.8 lit 10-24 days later

Protected crops
2.8 lt/ha after cover removal plus 2.8 lt 10-14 days later

Rape 2.8 lt/ha in autumn, 2.8 lt in spring when flower buds are still hidden

Strawberries 2.8 lt/ha to newly planted runners. Thereafter 5.6lt split into 4 doses at regular intervals from start of spring growth until fruit set.

Squash/Pumpkins 1.4 lt/ha four times starting when plant is established

Sugar Beet 2.8 lt/ha as soon as there is sufficient foliage (6-8 true leaves) and 14 days later

Sugar Cane 2.2 lt/ha at planting, when 1 metre high and 8 weeks before harvest

Sweet Corn/Maize 5.6 lt/ha when the crop is 15-45 cms tall (7- 8 leaves)

Tomatoes, outdoor 2.8 lt/ha shortly after planting, a further 2.8 lt at flowering

Vines 1.4 lt/ha applied 4 times between bud burst and start of flowering

Wheat 1.4 lt/ha in autumn at 3-5 leaf stage of overwintered crops
Feed 1.4 lt/ha at GS 29-31, 1.4 lt at GS39
Milling 1.4 lt/ha at GS 29-31, 1.4 lt at GS59

Transplants Apply 1 in 200 parts water, sprayed or dipped prior to planting to encourage good root development

Glasshouse crops Dilute at 1 in 800-2000 when including in pesticide
Dilute at 1 in 2000 when watering or feeding

Polycovered crops 2.8 lt/ha immediately after polythene removal, 2.8 lt two weeks later

Fertigation Normally apply a total of 5.6 lt/ha split regularly through the crop's life

COMPATABILITY

SM6 is compatible with most other spray materials but always read the labels and if in doubt consult your distributor or Stan Chem.

APPLY IN 220-240 LT/HA WATER. AVOID SPRAYING IN THE MIDDLE OF THE DAY DURING HOT, SUNNY PERIODS.