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Excessive vegetative growth in Tasmanian broccoli

Dr. Philip Brown
Tasmanian Institute of Agricultural Research

Project Number: VG02113

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This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the vegetable industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of Hills Transplants Pty Ltd and McCain Foods Pty Ltd.

ISBN 0 7341 1156 8

Published and distributed by:
Horticultural Australia Ltd
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Sydney NSW 2000
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Final Report

Excessive Vegetative Growth in Tasmanian Broccoli Crops

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(June 2005)

Dr Philip Brown
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Acknowledgements

This project was supported by McCain Foods, Hills Transplants, and McCains broccoli growers. The financial and in kind support from these groups is gratefully acknowledged.

Dr Suzanne Morris was project leader for the first two years of the project. Dr Phil Brown took over as project leader in 2004 when Dr Morris left TIAR to take up a new appointment. Commercial crop monitoring trials undertaken in 2004 and 2005 were conducted by Serve-ag Pty Ltd and were coordinated by Dr Rachel Walker. The assistance of Serve-ag agronomists and McCain contracted broccoli growers is gratefully acknowledged.

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Media Summary

The development of side shoots on branches in broccoli has been considered detrimental to crop yield and quality. The main broccoli cultivar grown for processing in Tasmania is Marathon, and this cultivar is particularly susceptible to side shoot development. Anecdotal evidence suggested that the incidence of side shoots in Tasmanian crops had increased recently, prompting investigation of strategies to reduce branching. Physical removal of branches resulted in yield increases of up to 20%. Extensive trialling of management practices aimed at reducing branching failed to identify an effective strategy. It was subsequently demonstrated that, within a crop, plants with high numbers of branches did not necessarily have low yields. Increasing yield in broccoli crops can therefore be achieved through improved agronomic practice aimed at increasing overall plant size. A longer term solution to the problems of increased variability in maturity time and increased incidence of disease associated with branching must come from selection of improved cultivars. A promising new cultivar has been identified in the project and will be further evaluated by industry.

Technical Report

Introduction

Broccoli (*Brassica oleracea* L. var. *italica*) crops are grown commercially in Tasmania both for the fresh market and for processing. Declining margins and a trend towards static or declining yield have raised concerns in the processing industry that reduced profitability will make broccoli unattractive to growers in the near future. McCain Foods Pty Ltd, one of the two companies who contract growers to produce broccoli for processing in Tasmania, identified branching of broccoli plants as a potential contributor to the trend in yields.

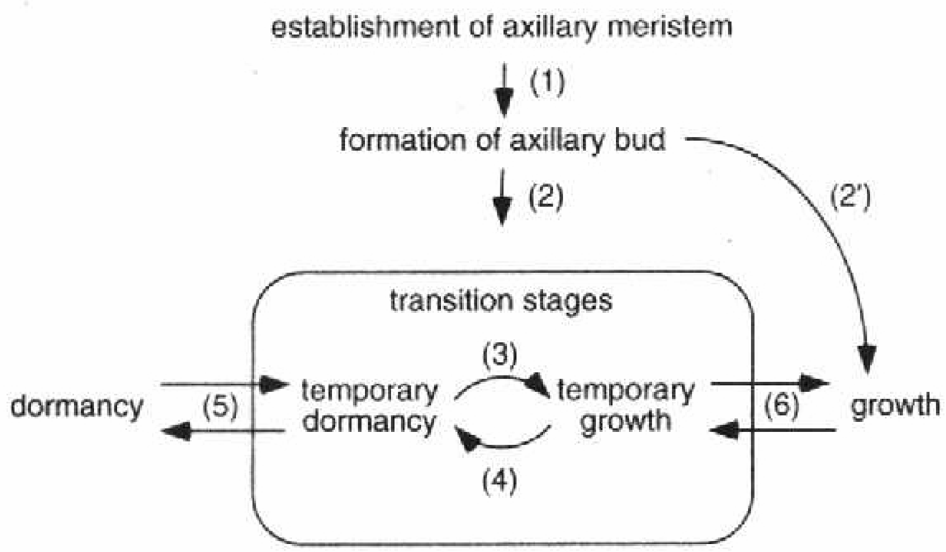
Branching in broccoli occurs when side shoots grow out from the main stem of the plant. These side shoots vary in size and number. Side shoots are often large enough to produce inflorescences, but these heads are rarely large enough for harvesting and processing. Excessive branching may, however, decrease yield as the developing inflorescences on the side shoots compete with the main head for resources. In addition, branching restricts air flow around the main head, increasing the risk of head rot and other diseases, and makes the harvesting operation more difficult by restricting cutter access to the main stem. Lateral branching in broccoli has the potential therefore to result in a reduction in terminal spear size, increased harvesting costs, reduced processing efficiency and increased disease incidence.

Observations from McCain field officers suggest that the incidence of branching in broccoli crops has increased over the past 10 years. One cultivar, Marathon, has been the dominant cultivar for processing during that time, so changes in management practices were considered likely to have contributed to the observed increase in frequency of branching. Fertilizer application rates have increased and management of irrigation has improved. Nursery raised seedlings have replaced field raised bare root transplants to establish the crops. Modifications in nursery management have also occurred over the past 10 years as the industry has gained experience in handling the transplants. In addition, changes in climate may have occurred, with a greater frequency of warmer than average seasons possibly contributing to reduced yields. As little is known about the cause of branching it is impossible to identify which if any of these factors, or combination of factors, has influenced the incidence of branching in Tasmanian broccoli crops.

Side shoots have been observed to grow out within three weeks of transplanting. As side shoots commence outgrowth soon after transplanting, nursery practices may precondition the plants to produce side shoots soon after transplanting.

Regulation of branching has been extensively studied in a range of plant species. Most studies have concentrated on apical dominance. Cline (1994) defines apical dominance as the control exerted by the shoot apex over the outgrowth of the lateral buds. This type of control, where one plant organ affects another organ, is referred to as ‘developmental correlation’ (Sachs, 1991). In the case of apical dominance, it is a ‘correlative inhibition’ process whereby the shoot apex inhibits the growth of lateral buds from the axillary meristematic regions of the plant. The development of lateral buds in intact plants is regulated primarily by the balance between the plant hormones auxin coming from the shoot apex and cytokinin acting locally. There is substantial evidence to suggest that auxin and cytokinin are involved in the mechanism(s) behind apical dominance (Cline 1994; Napoli et al, 1999). Cytokinins are thought to enhance lateral bud sink strength by increasing cell division and expansion. Therefore, cytokinin has been implicated in source/sink relations as a substance that increases sink activity through increased metabolic activity (Kupier, 1993: Roitsch and Ehneb, 2000). Thimann and Sachs (1964) also attributed nutritional and other factors to the rate of subsequent growth after buds had been released from inhibition.

In some plants, axillary meristems may undergo immediate development to form a lateral shoot. Other plants may initiate lateral growth but then become dormant after the growth of several leaves. These dormant axillary buds resume growth and development at a later time depending on their developmental program or in response to environmental cues. The stages of axillary bud outgrowth and dormancy can be described diagrammatically as follows (Shimizu-Sato and Mori, 2001):



The transition stages represent an intermediate between dormancy and growth, where buds are either in temporary dormancy or temporary growth. In some cases such as broccoli, the axillary buds might progress immediately to growth. Another possible pathway for broccoli axillary buds could be through the transition stages. It is in these transition stages that the axillary buds respond to environmental cues or developmental programs (genetics) and either continue to growth or enter dormancy.

Rubinstein and Nago (1976) demonstrated that plants grown under high nitrogen conditions show greater lateral bud growth than similar plants in conditions where nitrogen is limiting. A similar conclusion was drawn from sunflower, where a reduction in nitrogen supply from 420ppm to 52.5ppm prevented the release of lateral buds from inhibition (McIntyre, 1977). An experiment conducted on sprouting broccoli by Kumar and Sharma (2001) found that the number of secondary heads produced from lateral branches (one head per branch) increased with an increase in nitrogen application. Potassium and phosphorus were also applied at increased levels in this trial and may also have been involved in promoting branching. Prasad (1985) claimed the addition of phosphorus through the root systems of deprived plants often has remarkable promotive effects on lateral bud outgrowth. Potassium has also been found to induce bud growth in intact *Solanum* and *Nicotiana* plants at high levels (Wakhloo, 1970). Numerous other studies have documented differences in branching associated with different levels of nutrition, light and water in growth of crops. Given the range of factors known to influence branching, it is unlikely that a single critical change in management practice in commercial broccoli production will have triggered the problem now being investigated in Tasmania.

Broccoli plants have always produced a small number of side shoots, but the number produced was never considered as a major concern to industry. Over about the past 10 years however, growers and field officers have observed an increase in the number of side shoots produced in crops, and any effect of these side shoots on yield needs to be established.

Both fresh market and processing broccoli varieties produce excessive side shoots, with at least 85% of Greenbelt and Marathon varieties surveyed this season producing significant side shoots. Many of these side shoots produced a small head that can compete with the main head for available resources. This problem appears to be variety specific, as some varieties, such as Maverick, did not produce any significant side shoots.

Although both fresh market and processing crops are affected by this problem, the production of side shoots appears to be of major concern to processors, as processing crops are grown for a longer period to maximize head size. As the majority of broccoli processing occurs in Tasmania, there is little interest from interstate in pursuing this problem. Therefore, development of a strategy to control side shoot production in broccoli should be developed specifically for the Tasmanian industry.

1. Branching and Yield

Introduction

Development of lateral branches on plants results in partitioning of available photosynthate to both the main growing point and the growing points of the side shoots. The growth rate and final size of a broccoli head developing on a branched plant is therefore likely to be lower than on an unbranched plant if total photosynthate supply is the same for both. Measurement of the potential yield loss associated with branching in broccoli has not been attempted previously, and is an obvious first step in this project. As treatments to prevent branching are not currently known, the removal of developing branches was chosen as the treatment to manipulate branch number. While this treatment cannot be used to assess changes that may occur at the time of branch initiation and early development, it does allow assessment of the effects of developing branches on partitioning of photosynthate to the main broccoli head.

Materials and Methods

A field trial was conducted in the 2001/02 season in a crop situated 40°S 145°E. The trial was established to quantify the reduction in yield associated with lateral branching in broccoli. The trial was located in a commercial crop established using six-week-old ‘Marathon’ broccoli speedlings. For the duration of the trial, plants received standard treatment for pest/disease control, fertilisation, and irrigation.

The trial was located adjacent to an irrigation run on 12 twin rows in a position that avoided any possible edge effects. A randomised complete block design was situated on a gentle south east-facing slope on krasnozem soil. The trial design consisted of 4 blocks, each containing three 10m long plots. Within each row, plants were spaced at 25cm while inter-row spacing was 85cm. This resulted in approximately 50 plants located in each plot.

Three treatments were used in the experiment: removal of all lateral shoots 3 weeks after transplanting (early removal), removal of all lateral shoots 6 weeks after transplanting (late removal), and an untreated control. Removal involved cutting off lateral branches as close as possible to the leaf axis using a surgical scalpel. At the time of removal, all visible lateral branches at each node were removed.

Three separate harvests, commencing 12 weeks after planting, were conducted to determine yield of mature heads from the trial plots. The first harvest involved removing all primary broccoli heads that were approximately 15cm or greater in diameter. The heads were cut with approximately 3-5cm of stem attached and placed into a small plastic bin for weighing on a 20kg capacity balance. The number of primary heads and total primary head weight were recorded for each plot. A random sample of 10 heads was taken from each plot with head diameter and weight recorded for each spear. Head diameter was estimated using a template with 5cm increments i.e. 10-15cm, 15-20cm etc. In addition, two heads from each plot were used for architectural analysis. The second harvest was conducted 3 days after the first. All heads that had reached a harvestable size were harvested, counted and weighed. The number and weight of secondary heads (heads on side shoots) of harvestable size were also determined. The third harvest was carried out four days after the second and involved a similar procedure to that used during harvest one. In addition to recording both primary and secondary head number and weight from each plot, the number and weight of non-harvestable heads was also measured. Non-harvestable heads included those that had formed from lateral branches that were too small for factory processing. A sample of one head per plot was taken for individual weighing and architectural analysis.

Total mean primary head weight was calculated for each treatment. This was carried out for the plot area and then converted to a commercial scale i.e. per hectare basis. Assuming approximately 32,000 plants are transplanted per hectare, yield per hectare could be calculated by dividing 32,000 plants by the number of plants harvested per plot. This figure was then multiplied by the mean total yield per plot for each treatment to give yield per hectare.

Head architecture was also analysed on samples collected from each treatment at each sample date. In addition to head diameter, the criteria proposed by Tan et al (1999) for head quality assessments were made: head shape, convex (5) to concave (1); branching angle, tight (5) to spreading (1), and cluster separation (head tightness), no obvious cluster (5) to clusters over the surface of head (1). In this assessment, a cluster was regarded as the inflorescence produced from a secondary branch, growing from the base of the broccoli head. Head quality rankings of 1 were least desirable (unmarketable) and rankings of 5 were most desirable (highly marketable).

Results

Removal of branches significantly increased yield and decreased maturation time. Head quality attributes were not significantly influenced by lateral branching.

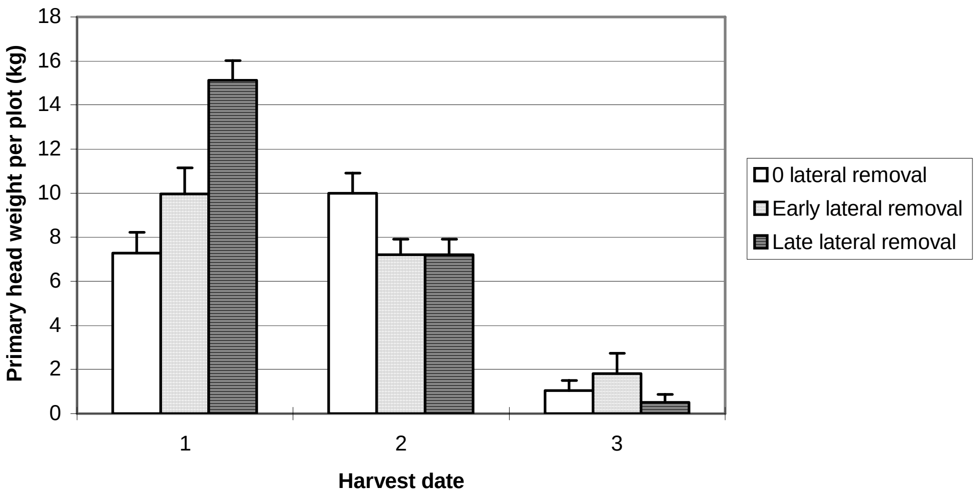


Figure 1: Total primary head weight (kg) per plot for each harvest date. Standard errors of means for each harvest date are illustrated.

Late lateral removal resulted in a significantly greater mean total primary head weight ($P<0.05$) than early lateral removal and zero lateral removal treatments at the first harvest. Yield from control plots was significantly higher yield both early and late lateral removal during harvest two, most likely as a result of the low yield obtained from the treatment during harvest one. As control plots provided the lowest yield at the first harvest, the number of primary heads available for subsequent harvest was higher than the remaining two treatments. There was no significant difference between treatments at the final harvest. By this time, most primary heads from each treatment had been harvested.

The total yield of primary heads over the three harvests was significantly higher in the late lateral shoot removal treatment compared to the early removal and control treatments. The yield from the early lateral removal treatment was 9% lower than the late lateral removal treatment, while the yild from the control was 16% lower than the late lateral removal treatment.

Treatment	Mean total primary head yield per plot (kg)	Mean total primary head yield per hectare (kg)	Percentage yield reduction
Control	18.33 ± 0.76	13453 ± 557	16.32 ± 3.47
Early lateral removal	18.99 ± 0.93	14607 ± 715	9.14 ± 4.45
Late lateral removal	22.81 ± 0.66	16077 ± 465	0.00 ± 0.00

Table 1: Mean total primary head yield on trial and crop basis, and percentage yield reduction for each treatment. Data shown as mean ± standard error.

At harvest one, late lateral removal provided a significantly higher ($P<0.05$) number of primary heads per plot than the remaining two treatments. Plants with zero lateral removal produced a significantly higher primary head number at harvest two ($P<0.05$). The higher numbers of heads harvested at the first harvest date in the late lateral removal treatment indicated the greatest uniformity in maturity for this treatment.

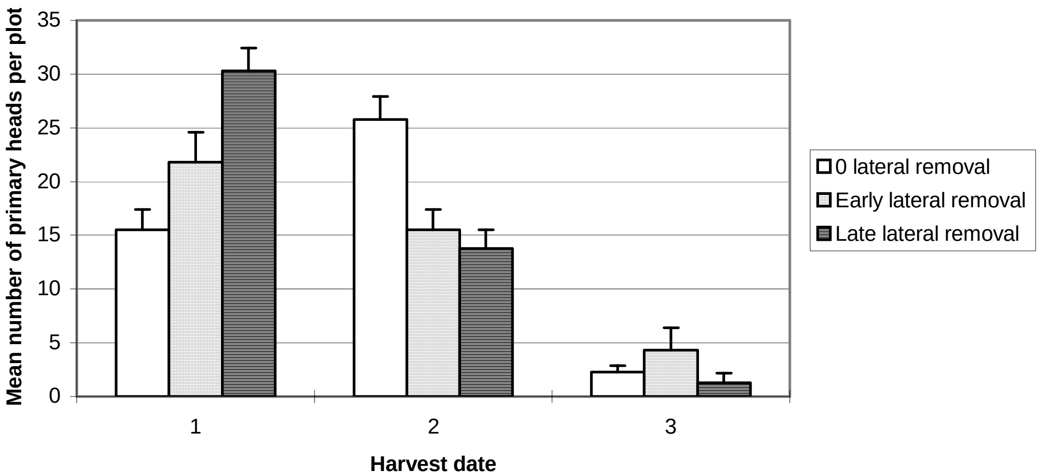


Figure 2: Mean number of primary heads per plot at each harvest date. Standard errors of the means for each harvest date are illustrated.

Late lateral removal plots yielded significantly heavier primary heads ($P<0.05$) than both early and zero lateral removal treatments at harvest one. No significant difference was found between treatments at harvest three ($P>0.05$). Although individual heads were not sampled and weighed during harvest two, mean head weight was extrapolated based on the number of heads harvested and the total head weight for each treatment.

Harvest	Treatment	Mean Individual Head Weight (g)	Standard Error
1 (6/4/02)	Zero lateral removal	478.5_a	18.2
	Early lateral removal	513.1_a	13.4
	Late lateral removal	610.0_b	21.1
2 (9/4/02)	Zero lateral removal	(388)	-
	Early lateral removal	(465)	-
	Late lateral removal	(522)	-
3 (13/4/02)	Zero lateral removal	406.3	32.0
	Early lateral removal	461.7	46.5
	Late lateral removal	480.0	21.2

Table 2: Mean individual primary head weight at each harvest. Significantly different means are denoted by the letter subscripts ($P<0.05$). Results in brackets indicate mean individual primary head weight calculated using mean number of primary heads and mean total primary head weight.

Plants with zero lateral removal produced significantly more non-harvestable secondary heads ($P<0.05$) than both early and late lateral removal plants. Removal of side shoots obviously reduces the number of potential sites for secondary head formation. Early lateral removal-treated plants grew significantly more secondary heads ($P<0.05$) than late removal-treated plants. This highlights the influence of timing of lateral removal as plants that had laterals removed early were provided with enough time to regrow lateral branches.

Treatment	Mean number of non-harvestable secondary heads	Standard Error
Zero lateral removal	105.5_a	9.9
Early lateral removal	67.8_b	3.7
Late lateral removal	19.5_c	3.5

Table 3: Mean number of non-harvestable secondary heads for each treatment at harvest three. Significantly different means are denoted by the letter subscripts ($P<0.05$).

Head diameter was significantly higher ($P<0.05$) for early and late lateral removal compared to zero lateral removal-treated plants. This reflected the significantly heavier heads in early and late lateral removal-treated plants. The other significant difference obtained in architectural analysis was branching angle rankings for heads sampled during the first harvest. Early removal-treated plants produced heads with a significantly lower branching angle ranking ($P<0.05$) than zero and late removal-treated plants.

Heads from the late removal-treated plants were ranked with a significantly tighter branching angle (P<0.05). This may be linked to events occurring in the head at the time of branch removal. That is, branching may induce a change in inflorescence morphology whereby plants with low levels of branching produce a tight (well-defined) head compared to extensively branched plants.

Harvest	Treatment	Head diameter (cm)	Head shape (1-5)	Branching angle (1-5)	Cluster separation (1-5)
1	Zero removal	$16.31 \pm 0.60_a$	4.00 ± 0.38	$3.75 \pm 0.16_a$	2.50 ± 0.33
	Early removal	$17.75 \pm 0.41_b$	3.25 ± 0.25	$2.88 \pm 0.40_b$	2.38 ± 0.46
	Late removal	$17.31 \pm 0.44_b$	4.50 ± 0.27	$4.63 \pm 0.18_c$	2.50 ± 0.27
3	Zero removal	16.88 ± 0.66	3.75 ± 0.25	3.00 ± 0.41	3.00 ± 0.58
	Early removal	16.13 ± 1.80	4.25 ± 0.25	4.00 ± 0.41	3.00 ± 0.41
	Late removal	15.63 ± 1.21	4.00 ± 0.71	3.00 ± 0.85	1.75 ± 0.48

Table 4: Mean head quality rankings of samples taken at harvest one and three. Significantly different means are denoted by the letter subscripts (P<0.05).

Conclusions

Removal of lateral branches from field grown broccoli plants results in yield increases of up to 16% compared with untreated plants. The yield increase was greatest when developing lateral branches were removed later (6 weeks after transplanting) compared with the early removal treatment (3 weeks after transplanting). Development of new lateral branches occurred after the early removal treatment, resulting in competition between those branches and the main head. In comparison, the main head was able to develop with minimal competition from side shoots after the late removal treatment was applied.

Side shoot removal increased the speed at which the main head matured, resulting in significantly higher yields at the first harvest date. However, yield from untreated control plants was greater at the second harvest date, reflecting delayed maturity. Variability in speed of maturation within a crop is detrimental as it spreads harvesting over a longer time period requiring more passes through the crop to collect all mature heads.

Differences in head architecture between heads from control and lateral removal treatments may also have been associated with the rate of head development. Removal of side shoots resulted in tighter heads. The longer duration of head development in the untreated plants may have allowed greater elongation of branches within the head and therefore a more open head structure.

While removal of side shoots increased main head yield and rate of maturation, and improved head shape, the effects of preventing side shoot initiation have not been demonstrated. Processes involved in initiation of side shoot growth may affect yield potential, and rate of photosynthate production may also be influenced by the development pattern, meaning that conditions that prevent branching may not increase yield. However, the presence of branches does affect speed of maturation and head shape, so controlling branching will be important in improving uniformity in broccoli crops.

2. 2001/02 Trial: Effect of Transplant Age

Introduction

Anecdotal evidence indicates that difference in incidence and severity of branching exist between crops in Tasmania in any season, and that incidence of branching has increased over the past 10 years. Environmental and crop management factors must therefore affect the development of side shoots. Analysis of yield following removal of side shoots confirmed that branching in broccoli was likely to contribute to reduced yields. Identification of crop management practices or environmental conditions that promote branching is therefore important if branching is to be reduced in order to increase yield. Experimental work was therefore focused on identifying factors affecting the incidence of branching.

One of the changes that has occurred in broccoli production in Tasmania over the past 10 years is the use of transplants of a younger age. Use of young transplants is recommended as it allows maximum leaf area development prior to initiation of the inflorescence. A field trial was therefore undertaken to examine whether transplant age at time of transplanting affected side shoot production.

Materials and Methods

This trial was conducted in three commercial cv Marathon paddocks in the Cuprona region. The trial consisted of three treatments: transplants of 5, 6 and 7 weeks old. Transplants were produced at Hills Transplants nursery in Don, following standard transplant management within the nursery. There were around 80 plants per treatment, and each treatment had 4 replicates. Due to bad weather conditions during the commercial harvests, only data from 2-4 replicates were collected per site.

Plants were analysed once, at either the first or second commercial harvest. Plants with marketable heads were removed from the field, the primary heads and any secondary heads cut and weighed, and the length of any side shoots measured. Only secondary heads greater than 5 g (~4 cm in diameter) were weighed.

Results

Transplant age had no effect on the incidence of side shoots within the crop. Transplants of all ages produced only 3% of plants without side shoots (Table 1).

There appeared to be a small effect of transplant age on severity of branching, with 7 week old transplants producing more side shoots than either the 5 or 6 week old transplants. Heads from plants without side shoots were 5-21% heavier than heads from plants with side shoots. No consistent differences in head weight and total length of side shoots were found between transplants of different ages. The average weight of secondary heads was 28 g regardless of treatment (Table 2).

Site #	Transplant age (weeks old)	# plants with SS	# plants without SS
1	5	76.8 ± 0.5[a]	3.3 ± 0.5[a]
	6	72.0 ± 4.4[a]	2.0 ± 2.0[a]
	7	76.3 ± 1.1[a]	2.5 ± 0.3[a]
2	5	71.8 ± 3.5[a]	1.8 ± 1.2[a]
	6	70.3 ± 3.9[a]	3.0 ± 1.3[a]
	7	70.3 ± 2.8[a]	3.5 ± 1.0[a]
3	5	76.8 ± 0.3[b]	3.3 ± 0.3[b]
	6	79.0 ± 0.7[a]	1.0 ± 0.7[a]
	7	77.8 ± 0.9[ab]	1.5 ± 0.9[ab]

Table 1 Effect of transplant age on production of side shoots (SS) in cv Marathon broccoli. Data shown are means ± SE. Values within a column and site that have the same letter are not significantly different at the P = 0.05 level.

Site #	Transplant age (weeks old)	Main head weight (-SS) (g)	# plants	Main head weight (+ SS) (g)	Total length side shoots (cm)	Total weight side shoots (g)	# plants	# side shoots	# side shoots with heads
1	5	690.7 ± 58[a]	7	591.1 ± 23[a]	29.8 ± 1.1[a]	23.6 ± 2.4[a]	41	49	18
	6	700.4 ± 42[a]	12	525.8 ± 15[b]	29.8 ± 1.0[a]	39.3 ± 6.1[b]	48	47	16
	7	688.1 ± 62[a]	8	545.8 ± 17[ab]	31.1 ± 1.0[a]	31.7 ± 4.0[ab]	39	70	20
2	5	550.0	1	605.7 ± 16[ab]	34.1 ± 1.0[a]	26.0 ± 3.7[a]	23	54	14
	6	655.0 ± 98[a]	3	568.5 ± 14[b]	29.8 ± 1.1[ab]	25.4 ± 3.5[a]	23	61	12
	7	693.0 ± 87[a]	5	628.1 ± 19[a]	29.1 ± 1.0[b]	26.7 ± 3.4[a]	27	66	13
3	5	575.0	1	499.0 ± 8.[b]	24.6 ± 1.0[a]	25.1 ± 3.1[a]	47	191	31
	6	583.0 ± 4.5	3	519.2 ± 10[ab]	25.9 ± 0.9[a]	26.5 ± 3.1[a]	52	182	35
	7		0	537.2 ± 17[a]	22.0 ± 0.9	25.5 ± 2.7[a]	41	206	29

Table 2. Effect of transplant age on yield and production of side shoots (SS) in cv Marathon broccoli. Data shown are means ± SE. Values within a column and site that have the same letter are not significantly different at the P = 0.05 level.

Conclusions

The results of this trial were consistent with those of the initial field trial in that the presence of side shoots reduced yield, in this experiment by 21%. However, due to the large proportion of plants producing side shoots in this experiment, it was difficult to adequately compare yields from plants with and without side shoots, so caution needed when interpreting the yield finding.

Transplant age did not affect the (i) main head yield, (ii) length of side shoots or the (iii) weight of secondary heads. It can therefore be concluded that changes in crop management associated with age of transplants used in commercial production over the past 10 years were not responsible for the observed increase in incidence of side shoots in crops.

3. 2002/03 Trial 1: Boron and Zinc applications

Introduction

Changes in nutrition management both in the nursery during seedling production and in the field following transplanting have occurred over the past 10 years. Mineral nutrition has been linked to apical dominance in several published studies, so it was considered possible that deficiency of one or more elements may have contributed to increased incidence of branching. The trace elements boron and zinc were selected for study based on evidence from the literature and advice from Hills transplants that these elements may be applied at lower rates than in other production regions.

Materials and Methods

The experiment investigated the effects of applications of boron and zinc to seedlings on lateral branching after transplanting. Seedlings were grown at Hills with either standard nutrient regime or standard nutrient regime plus two applications of boric acid. Seedlings were transplanted into standard potting mixture in 6″ pots at the University and grown for five weeks. Additional boron and zinc applications were applied after transplanting. The experiment consisted of six treatments in total, with 10 plants per treatment;

1. Control (no additional B or Zn before or after transplanting)
2. B + none (B applied before transplanting, none after transplanting)
3. None + B (B applied after transplanting, none before transplanting)
4. B + B (B applied before and after transplanting)
5. None + Zn (Zn applied after transplanting, none before)
6. B + Zn (B applied before transplanting, Zn applied after transplanting)

Plants were harvested 5 weeks after transplanting for assessment of branching.

Results

None of the treatments had a major impact on the incidence of branching. In all cases, between 80 and 100% of plants had one or more side shoot at the time of harvesting.

Table 2. Effect of boron and zinc applications on branching of cv Marathon transplants. Data shown are means ± SE. Values within a column, having the same letter are not significantly different at the P = 0.05 level.

Treatment	% plants with branches	Branches per plant	Plant fresh weight (g)
Control	100	3.9 ± 0.5a	21.6 ± 1.3a
B + none	80	2.4 ± 0.5c	20.3 ± 1.3ab
None + B	90	2.7 ± 0.5bc	17.7 ± 1.7b
B + B	90	2.3 ± 0.3c	17.0 ± 1.1b
None + Zn	100	3.2 ± 0.4ac	20.1 ± 1.6ab
B + Zn	100	3.8 ± 0.4ab	18.9 ± 1.1ab

While the incidence of branching was not affected, there appear to be two important treatment effects. Boron application to seedlings appeared to decrease branching (branch number and branch weight), and boron applications after transplanting decreased plant weight.

Control

Boron + none

Boron + Boron

None + Boron

None + Zinc

Boron + Zinc

B + B None + B B + none Control None + Zn B + Zn

The upward cupping of leaves in the boron treatments is consistent with toxicity of the nutrient. Thus, while the boron treatments may have reduced development of side shoots it is likely that the rate of boron applied would reduce overall plant yield due to nutrient toxicity.

Conclusions

Branching in broccoli is not a response to deficiencies in either boron or zinc. Reduced number and size of branches were recorded following boron applications, but this response was attributed to phytotoxicity rather than deficiency.

4. 2002/03 Trial 2: Phosphorous nutrition

Introduction

Phosphate nutrition has been implicated in the literature in regulation of some processes linked to apical dominance. Changes in the amount of phosphate available to broccoli plants can be made in the nursery and in the field, and have occurred over the past 10 years in Tasmania. Effects of reduced and increased phosphate application in the nursery on branching following transplanting were examined in a field trial in Spring 2002.

Materials and Methods

Plants with altered P in the nursery compost and foliar fertilizer were grown at Forthside Research Station from late August and harvested in November. Transplants were grown in reduced P compost with or without additional foliar fertilizer application and assessed for side shoots production. Plants were harvested 11 weeks after transplanting and prior to significant head formation.

Treatment code	Compost P	Foliar P
A	Super P 0 kg/m^3	+P
B	Super P 0.5 kg/m^3	+P
C	Super P 1.0 kg/m^3	+P
D	Super P 1.5 kg/m^3	+P
E*	Super P 2.4 kg/m^3	+P
F	Super P 4.8 kg/m^3	+P
G	Super P 0 kg/m^3	–P
H	Super P 0.5 kg/m^3	–P
J	Super P 1.0 kg/m^3	–P
K	Super P 1.5 kg/m^3	–P
L	Super P 2.4 kg/m^3	–P
M	Super P 4.8 kg/m^3	–P
N**		

* E – most similar to current commercial program
** N – seedlings were raised in a greenhouse until transplanting with a typical compost and foliar nutritional program.

Results

Seedlings from each treatment were collected and differences assessed at transplanting. Seedlings that had no P in the compost and received no foliar P were the shortest and had the smallest leaf area compared with plants from other treatments (G; Table 1). At transplanting, those treatments that received the largest quantity of P (treatments E, F and M) had the greatest leaf area (Table 1).

Table 1. Assessment of cv Marathon seedlings with altered P compost and foliar fertilizer at transplanting. Data shown are means ± SE. *n* = 10.

Treatment code	Main stem length (cm)	Leaf area (mm^2)
A	2.1 ± 0.1	1455.4 ± 79.2
B	2.6 ± 0.1	1759.5 ± 69.0
C	3.3 ± 0.1	1615.6 ± 48.0
D	3.0 ± 0.1	1771.0 ± 53.9
E	3.2 ± 0.1	1963.5 ± 49.1
F	2.4 ± 0.1	1904.5 ± 64.2
G	1.4 ± 0.1	1118.1 ± 79.0
H	2.3 ± 0.1	1437.8 ± 38.6
J	2.0 ± 0.1	1577.1 ± 54.3
K	2.5 ± 0.1	1731.4 ± 69.5
L	2.2 ± 0.0	1371.7 ± 53.1
M	2.2 ± 0.1	2154.0 ± 123.3
N	3.0 ± 0.1	1580.2 ± 103.9

Plants were also assessed at the onset of flowering. There was no significant difference in main stem length or the number of side shoots produced among treatments; however the reduction in the total length of side shoots from treatment J was highly significant (Table 2). Treatment J seedlings had low P in the compost and received no foliar P.

Table 2. Effect of changes in P compost and foliar fertilizer on production of side shoots in cv Marathon broccoli. Data shown are means ± SE. *n* = 60.

Treatment code	Main stem length (cm)	Number of side shoots	Total length of side shoots (cm)
A	13.3 ± 0.2	7.5 ± 0.3	42.0 ± 2.5
B	13.0 ± 0.2	8.2 ± 0.2	46.1 ± 2.1
C	12.6 ± 0.3	7.9 ± 0.2	43.7 ± 2.9
D	14.0 ± 0.2	8.0 ± 0.2	51.2 ± 2.1
E	12.9 ± 0.3	7.2 ± 0.3	41.4 ± 3.1
F	13.7 ± 0.2	7.8 ± 0.2	43.6 ± 1.9
G	11.7 ± 0.2	5.9 ± 0.2	32.8 ± 2.2
H	12.2 ± 0.2	6.3 ± 0.2	36.5 ± 1.5
J	11.1 ± 0.2	6.1 ± 0.2	19.8 ± 1.2**
K	12.1 ± 0.2	6.5 ± 0.2	31.0 ± 2.0
L	11.9 ± 0.1	6.9 ± 0.2	34.1 ± 2.0
M	12.6 ± 0.2	6.9 ± 0.2	32.4 ± 2.0
N	12.6 ± 0.2	7.6 ± 0.2	42.3 ± 2.9

** $P < 0.001$

No difference in development and vigour of treatment J plants was observed at transplanting (Table 1) or in plants at the onset of flowering (Table 2). Although the number of side shoots in treatment J plants was similar to other treatments, a reduction in total side shoot length may be sufficient to encourage growth of the main head and thus increase yield.

Conclusions

Changes in phosphate nutrition during nursery production of seedlings cannot be used to reduce branching in field grown broccoli. The only treatment that changed branch development was the low P treatment which reduced side shoot length. While no symptoms were evident at the time of transplanting, this treatment was likely to have induced P deficiency in the seedlings and reduced growth rate after transplanting. The effect of the treatment on final yield was not determined in the trial. Increased yield due to suppression of lateral shoot growth is possible, but reduced yield associated with reduced growth rate through P deficiency is also possible. Further investigation of the reduce P treatment was therefore warranted.

5. 2003/04 Trial 1: Source/Sink Manipulation

Introduction

The trials undertaken in 2002/03 concentrated on treatments to overcome branching in broccoli crops, but none of the treatments tested was successful in reducing the incidence of branching. Therefore, initial trials in 200/04 were developed based on plant physiology theory rather than attempting to identify a change in nursery or field crop management practice that may have occurred over the past 10 years.

The rapid elongation of axillary branches commences shortly after transplanting. The transition from the speedling environment or growth pattern to the field environment or growth pattern may contribute to the initiation of axillary branch elongation. The speedling environment (restricted root volume, cyclical wetting and drying, reductions in nutrition when plants need to be held for an extra week or two) is likely to result in a restriction in apical meristem activity (low mitotic index or slow rate of cell division). Apical dominance is exerted during this phase with little resource allocation to axillary buds (therefore low meristematic activity in these buds) but the restricted overall plant growth rate reflects low resource availability or requirement. According to this theory, the speedling phase may be thought of as a ‘limiting’ environment, although the processes limiting growth may be internal rather than external resource (nutrients, light, water) availability. When transplanted, a shift from ‘limiting’ to ‘less limiting’ environment could be occurring. Good seed bed preparation and transplanting technique allow rapid root development and exploration of soil surrounding the plug, while good irrigation management maintains soil moisture close to field capacity (reducing any root derived signals restricting growth rate). An increase in photosynthetic rate would be expected shortly after transplanting. This increase in resource availability would support an increase in apical meristem activity, but if apical meristem activity is initially quite low then ‘excess’ resource may be partitioned to axillary meristems (source capacity exceeds apical sink demand, allowing an increase in axillary meristem activity). If the transition from the ‘limiting’ to ‘less limiting’ environments is more gradual, or the activity of the apical meristem is greater at the time of transplanting, the incidence of axillary branching would be reduced. A gradual transition between environments, allowing the apical meristem to adjust to increased resource availability without ‘source capacity’ exceeding ‘sink demand’, may occur with increased transplanting stress or low light intensity (would also have expected low temperatures to have an impact, but this doesn’t seem to be the case). Increased apical meristem activity may be induced by increasing transplant container size, application of fertilizer (nitrate nitrogen?) close to transplanting time, or possibly shading of transplants.

The trial tested the theory that branching occurs in response to rapid changes in plant growth rate at transplanting. The main growing point (and growing points for all side branches) in the plant is growing very slowly in the speedling trays, but when transplanted the capacity of the plant to grow increases rapidly – if the main growing point is not able to increase it’s growth rate rapidly enough after transplanting then the side shoot growing points get a chance to begin developing more rapidly. While conditions in the nursery might not be considered limiting to plant growth (ie all nutrients are supplied and plants irrigated regularly to prevent water stress) the growth rate of plant is obviously lower than in plants growth in the field or larger pots, so some factor(s) restrict growth. Two sets of treatments were used to test the theory. The first group aimed to alter the growth rate of the main growing point prior to transplanting – faster apical growth rate at transplanting may then allow the growing point to 'use' the increased growth capacity after transplanting and thus reduce the capacity of the shoot growing points to develop. The second group of treatments aimed to restrict the growth capacity of the plants after transplanting and thus allow the main growing point to increase its growth rate after transplanting without lots of resources being available to the side shoots.

Materials and Methods

Broccoli seedlings in speedlings trays were germinated at Hills Transplants at Don and transferred to the University of Tasmania glasshouse complex. Plants received standard fertilizer applications and overhead watering and were held on benches outside the glasshouse for approximately 6 weeks. Treatments were then imposed and speedling were transplanted 2 weeks later. The first set of treatments were:

2. Control
3. Additional nitrogen added
4. Plants shaded
5. Plants transferred to warm glasshouse conditions
6. Warm glasshouse conditions plus additional nitrogen
7. Speedlings in larger plug size trays (Lannen 104 trays)
8. Larger plug size plus additional nitrogen

Changes in leaf number were determined over the two week period between treatment application and transplanting.

At transplanting, 25 plants from each treatment were moved to pots and grown under shadehouse conditions. In addition to the above treatments, a further 40 control plants were used to assessment post transplanting treatments. 10 plants were potted as controls, 10 had approximately 50% of their leaf area removed (each transplant was bunched and the top half of the leaves was cut off), 10 were potted into 50:50 sand:potting mix, and 10 were exposed to 2 weeks water stress after transplanting. The aim of the treatments was to reduce growth capacity of the plants after transplanting.

Plants were destructively harvested five weeks after transplanting. The number of plants with side shoots, number of side shoots per plant, average length of side shoots and average leaf number per plant were recorded.

Results

Plants in the larger plugs (greater volume of potting mix for the root system to develop in) had a higher number of leaves at the commencement of the treatments and at transplanting, with nitrogen application stimulating only a small increase in leaf number in these plants. Shading decreased leaf number slightly while nitrogen application increased leaf number compared to control plants. Transferring plants to warm glasshouse conditions resulted in the greatest increase in leaf number, and additional nitrogen had little effect. Plants in glasshouse conditions displayed much greater elongation growth prior to transplanting.

At harvest, high incidence of branching was evident in all treatments except for leaf trimming after transplanting (Table 1). This treatment also had fewer side shoots per plant and reduced side shoot length.

Treatments imposed prior to transplanting	Number of plants with side shoots	Number of side shoots per plant	Average length of side shoots	Average leaf number per plant
Control	15/15	1.8	1.34	7.9
Control + nitrogen added 2 weeks prior to transplanting	12/15	1.3	1.05	7.9
Control + shaded 2 weeks prior to transplanting	15/15	1.6	1.35	7.3
Moved to warm glasshouse conditions 2 weeks prior to transplanting	15/15	1.8	1.29	8.0
Moved to warm glasshouse conditions + nitrogen 2 weeks prior to transplanting	15/15	2.1	1.22	8.2
Larger plug size (104 plug tray)	13/15	1.5	0.83	8.9
Larger plug size + nitrogen added 2 weeks prior to transplanting	13/15	1.7	1.27	8.9
Treatments Imposed after transplanting				
Control	10/10	1.9	1.44	7.6
Leaf cut	4/10	0.5	0.62	7.6
Sandy soil	10/10	1.5	1.28	8
Water stress	8/10	1.1	0.25	6.5

Conclusions

Small reductions in the incidence of branching, and in the number and size of side shoots on affected plants, were recorded when growth rate was increased prior to planting by increasing rate of nitrogen application and growing seedlings in larger sized plugs of potting media. The effects were, however, too small to be considered feasible for commercial production. The results do provide evidence to support the hypothesis that changes in growth rate at transplanting are important in the regulation of branching. In addition, reducing growth rate after transplanting by reducing leaf area significantly reduced incidence and severity of branching. If this effect can be repeated in the field, it would provide a physiological explanation for branching and therefore form the basis for development of commercially feasible strategies to reduce branching.

6. 2003/04 Trial 2: Assessment of nursery and field treatments to reduce branching

Introduction

The glasshouse trial conducted in the 2003/04 season provided evidence that reducing the size of the transition in growth rate following transplanting may reduce branching in broccoli. Treatments aimed at increasing growth rate in the nursery were less effective than the reduced growth rate (leaf cutting) treatment applied after transplanting. Root restriction in the transplant plugs may contribute to the inability to stimulate increased growth rate in the nursery. The first field trial in the 2003/04 season therefore aimed to assess the effect of a range of treatments imposed to regulate growth rate or modify root restriction on branching and yield.

Materials and Methods

The trial was conducted in Autumn 2004 at the Forthside Research Station. The following treatments were included in the trial:

1. Application of limil after transplanting (white washing of leaves to reduce growth rate)
2. Application of the plant growth regulator prohexadione-calcium (reduce growth rate)
3. Seedlings raised from non-heat treated seed (heat treatment is a standard commercial treatment that may be influencing seedling growth rate)
4. Bare root transplants (seedlings raised without root restriction)
5. Seedlings raised in longer, thinner cells (Williams 198 trays) than the commercial trays (reduced root restriction in the nursery)
6. Seedlings raised in Williams 198 trays on capillary matting to reduce root restriction
7. Seedlings raised in standard trays on capillary matting to reduce root restriction
8. Reduced P application in the nursery
9. ‘Omni-start K’ applied at transplanting (stimulate root growth)
10. ‘Supa start’ applied at transplanting and again 1 week later(commercially available product promoted as an enhancer of root growth)
11. ‘Seed Starta’/’Nutri Kelp’ applied at transplanting and again 1 week later(commercially available product promoted as an enhancer of root growth)

Heads were harvested at maturity and plants were assessed for branching and head weight.

Results

None of the treatments significantly reduced side shoot number compared with control plots. The highest main head yield, and lowest weight of side shoots, was recorded from the bare rooted transplants. This treatment also had the highest number of side shoots. Several treatments had a detrimental effect on main head yield without influencing side shoot number. The results are summarised in Table 1. The LSD (Least Significant Difference) row at the bottom of the table is used to determine which differences are statistically significant – if the difference between two treatments is larger than the LSD figure for that column then the difference is significant.

Treatment	Mean head wt. (g)	Side shoot no.	Side shoot wt. (g)	Stem length (cm)	Hollow stem (%)
Limil	351	6.1	462	392	88
PGR	302	6.2	445	373	68
seed heat treatment	381	6.6	551	413	79
bare-rooted transplants	408	9.5	319	387	87
Williams 198	344	7.0	507	408	71
Williams 198 + capillary mat	331	6.3	479	393	75
1 kg/m3 P compost & no P foliar	335	6.6	499	396	74
Omnistart K	329	6.2	497	395	73
air pruning (capillary mat)	377	6.7	589	418	75
Supa Start	346	6.7	493	404	75
Seed Starta/Nutri Kelp	305	6.2	436	376	89
Control	352	6.4	514	414	77
LSD	**28**	**0.5**	**45**	**12**	**Not sig.**

Table 1. Effects of nursery and field treatments on side shoot growth, head yield and quality.

Conclusions

Despite application of a diverse range of treatments, a strategy to reduce the incidence of branching was not identified. A significant increase in yield was recorded in the bare root transplant treatment, but this treatment also had the highest number of side shoots. Clearly reducing side shoot number is not a prerequisite for increasing yield. The bare root transplant treatment did have reduced side shoot weight, suggesting allocation of a greater proportion of the plants resources to the main head rather than the side shoots. Given the difficulty in finding a treatment to reduce side shoot number and/or growth rate, an alternative strategy would be to focus on increasing yield without altering side shoot development as this trial has demonstrated that yield and side shoot growth may not be closely linked.

7. 2003/04 Trial 3: Monitoring growth in commercial crops

Introduction

Following the failure to identify a treatment that would consistently reduce branching, and results that indicated increased yields could be achieved with reducing the number of side shoots on plants, the focus of the project broadened to include strategies to improve yield and profitability for growers. Removal of side shoots increased main head yield and rate of maturation, but the presence or absence of side shoots is obviously not the only determinant of yield. In addition, at a whole crop level uniformity in maturity can be achieved with branching in the crop provided that the degree of branching is consistent between plants in the crop. Identifying key management practices that contribute to production of high yielding, uniform crops of cultivar ‘Marathon’ would reduce the need to identify strategies to reduce branching.

Changes in management practices in broccoli crops have occurred over the past 10 years, a number of which have been investigated in this project as possible contributors to branching in broccoli. While these management practices have resulted in on increase in average yield across all crops, there is still considerable variability in yield between growers. Fine tuning of crop management offers the opportunity to improve yield, particularly for those growers that have been achieving lower than average yields. Crop agronomists have been employed by many of the more successful broccoli growers in Tasmania and have considerable experience in broccoli crop management. Serve-ag is one of the companies providing agronomic support for growers and were engaged as collaborators in this project to monitor growth of commercial crops.

The crop monitoring undertaken by Serve-ag focussed on three broccoli crops grown under contract for McCains. Recommendations for crop management were made by senior agronomist Peter Aird. Soil moisture levels were monitored using ‘G bug’ gypsum block loggers. Soil and plant tissue nutrient testing was performed during growth of each crop. In addition to standard management recommendations, the effects of a range of nutrient treatments and proprietary growth enhancer products on growth, branching and yield were assessed. Results were compiled and presented to growers as a summary of findings.

Chronology of Events for 2004 Paddock Trials

Trial sites

- Craig Medwin (linear irrigator)
- Brian Munday (gun irrigator)
- Darren Wigg (gun irrigator)

Timeline

January 2004	Soil test paddocks
Prior to planting	N-check test, soil penetrometer measurements, soil structure score, sieve test. Fertiliser recommendations by Peter Aird Broadcast fertiliser applications (by grower) Install G bugs in paddocks
Day of transplanting	Leaf trimming, drenching with SupaStart (depends on treatment) A maximum of 4 different treatments will be in the paddock trials: commercial standard, leaf trimming, 2 different nutritional programs. Position G bugs according to crop planting.
2 wks after transplanting	NU test. Download G bug. Visual assessments of branches, shoots and roots (photographs).
4 wks after transplanting	NU test. Identification of growth stage with microscope. Download G bug. Visual assessments of branches, shoots and roots (photographs). N-check test.
6 wks after transplanting	NU test. Identification of growth stage with microscope. Download G bug. Visual assessments of branches, shoots and roots (photographs).
12 wks after transplanting	Harvest assessment on 100 plants per treatment. Head weight, branch number, root development. Record % harvestable on first cut. Determine need for 2nd assessment. Download G bug. N check test.

Key Findings from 2004 Paddock Trials

Side Shoot (SS) Production

- There was a lack of consistent evidence to show a decrease/absence of SS results in increased yields. Eg. Number of SS typically averaged 7 to 8 per plant. This was the same number observed in spring crops where SS were perceived to be impacting on yield. Good yields in 2005 autumn have not been associated with decreased SS production.

- The variation in number of side shoots within treatments suggested the genetics of the seed line are the most important factor affecting SS production.

- The majority of treatments evaluated slightly reduced SS production. NutriSmart + Kelp was probably the most effective treatment. Microscopic observation of SS growing points showed delayed reproductive development in NutriSmart plants. There was also a slight delay in reproductive development of prespread plants.

- Typically trial treatments that were most effective at reducing SS production also resulted in a yield decrease.

- Average number of SS produced per plant tended to vary between paddocks. Eg. There were more than 6 SS per plant on more than 80% of plants in Wigg's paddock. Less plants had this many SS in Medwin's paddock. Possible that increased SS in Wigg's paddock related to additional nutrition from previous pea crop. Pre-plant N-check of 165 kg/ha vs 61 kg/ha at Munday's and 81 kg/ha at Medwin's.

Yield

- Plants with prespread fertiliser typically got away quicker and had a stronger frame at harvest. Yields with prespread fertiliser were higher in 2 out of 3 paddocks.

- Kelp tended to have a +ve effect on yield.

- Trimming tended to have a –ve effect on yield.

- NutriSmart alone had a –ve effect on yield, this is expected because it is normally recommended with other fertilisers. It was included as a means of reducing nutrition to determine effect on SS.

Quality

- Hollow stem increased with banded fertiliser
- Hollow stem decreased with prespread fertiliser and kelp.
- Typically prespread fertiliser resulted in earlier maturity, and greater potential for 1st cut yields.
- Recovery assessment at Wigg's showed no real differences between treatments. Typical recoveries of 75%.

Medwin - Yield

Head Weight Range	Standard Banded	Banded + Kelp	Banded + Trim	Banded + Kelp + Trim	Prespread	Prespread + Kelp	NutriSmart/Prespread	NutriSmart/Prespread + Trim	NutriSmart/Prespread + Kelp + Trim
<500 g	35%	19%	64%	53%	22%	16%	15%	35%	25%
500-1000 g	65%	74%	36%	46%	75%	82%	78%	63%	71%
>1000 g	0%	7%	0%	1%	3%	2%	6%	2%	4%

Munday – Yield

Head Weight Range	Standard Banded	Banded + Kelp	Banded + Trim	Banded + Kelp + Trim	Prespread	Prespread + Kelp	Prespread + Trim	Prespread + Kelp + Trim	NutriSmart	NutriSmart + Kelp
<500 g	30%	54%	35%	64%	14%	46%	5%	23%	72%	30%
500-1000 g	66%	40%	65%	36%	82%	52%	55%	68%	28%	68%
>1000 g	4%	6%	0%	0%	4%	2%	40%	9%	0%	2%

Wigg - Yield

Head Weight Range	Standard Banded	Banded + Kelp	Banded + Trim	Banded + Kelp + Trim	Prespread	Prespread + Kelp	Prespread + Trim	Prespread + Kelp + Trim	NutriSmart	NutriSmart + Kelp
<500 g	35%	43%	35%	28%	46%	38%	43%	62%	56%	52%
500-1000 g	65%	57%	63%	69%	54%	62%	56%	38%	44%	48%
>1000 g	0%	0%	2%	3%	0%	0%	1%	0%	0%	0%

Medwin – SS distribution

Number of SS	Standard Banded	Banded + Kelp	Banded + Trim	Banded + Kelp + Trim	Prespread	Prespread + Kelp	NutriSmart/Prespread	NutriSmart/Prespread + Trim	NutriSmart/Prespread + Kelp + Trim
<2	6%	7%	4%	5%	2%	4%	2%	4%	6%
2 - 6	26%	46%	28%	35%	31%	56%	22%	23%	27%
>6	67%	47%	68%	60%	67%	40%	76%	73%	67%

Munday – SS distribution

Number of SS	Standard Banded	Banded + Kelp	Banded + Trim	Banded + Kelp + Trim	Prespread	Prespread + Kelp	Prespread + Trim	Prespread + Kelp + Trim	NutriSmart	NutriSmart + Kelp
<2	6%	6%	4%	4%	4%	2%	2%	6%	4%	4%
2 - 6	16%	23%	37%	12%	12%	35%	28%	23%	18%	24%
>6	78%	71%	59%	84%	84%	63%	70%	71%	78%	72%

Wigg – SS distribution

Number of SS	Standard Banded	Banded + Kelp	Banded + Trim	Banded + Kelp + Trim	Prespread	Prespread + Kelp	Prespread + Trim	Prespread + Kelp + Trim	NutriSmart	NutriSmart + Kelp
<2	0%	1%	2%	4%	0%	1%	1%	0%	1%	0%
2 - 6	17%	5%	13%	13%	2%	6%	1%	6%	6%	5%
>6	83%	94%	85%	83%	98%	93%	98%	94%	93%	95%

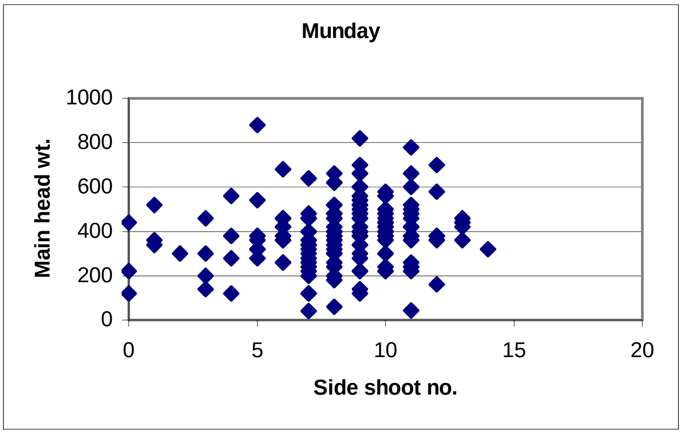
8. 2003/04 Trial 3: Analysis of individual plant data

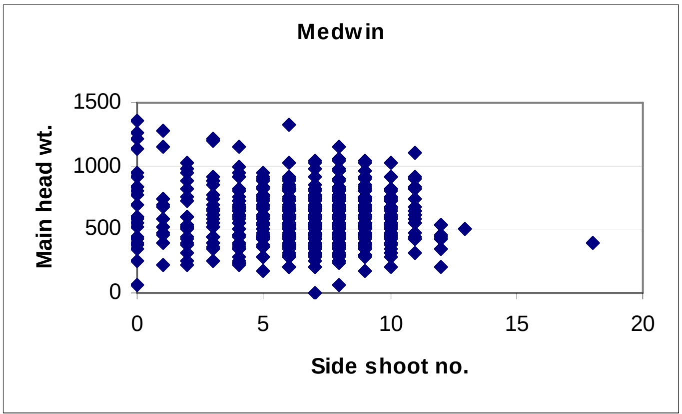
Introduction

Side shoot number and main head weight measurements were collected for a large number (400 to 1000) of individual plants in each of the three crops monitored in 2003/04. Analysis of the individual plant data was undertaken to investigate the effect of branching on yield.

Does main head weight decrease with increasing side shoot number?

When shown graphically, higher head weight numbers would be expected for plants with lower side shoot numbers if the side shoots affected the head weight.

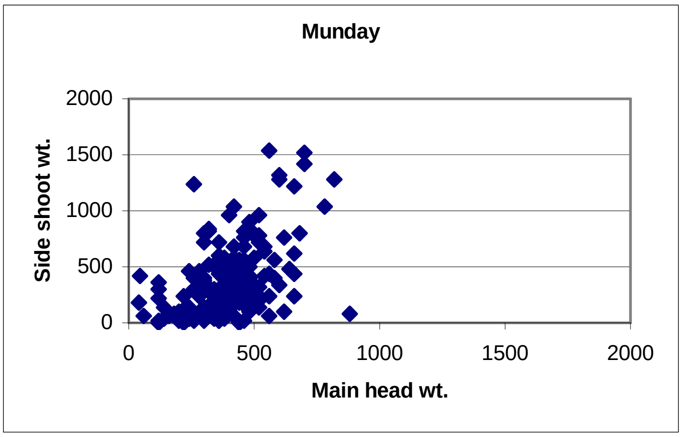


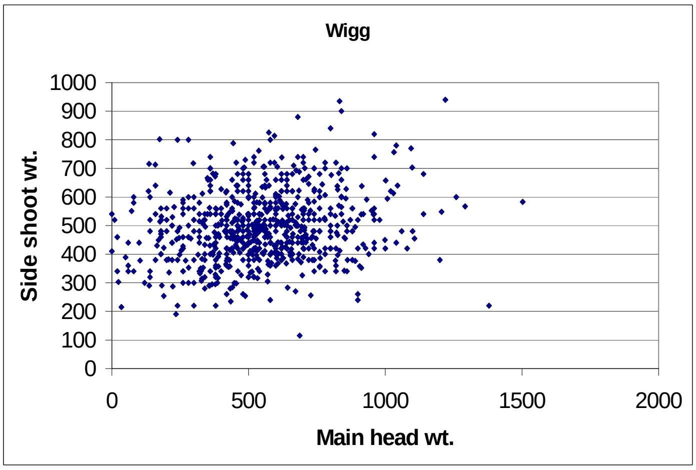


The main head weight was not related to the number of side shoots in each of the three crops.

Does main head weight decrease with increasing side shoot weight?

Side shoot weight was recorded in the Munday and Wigg crops.



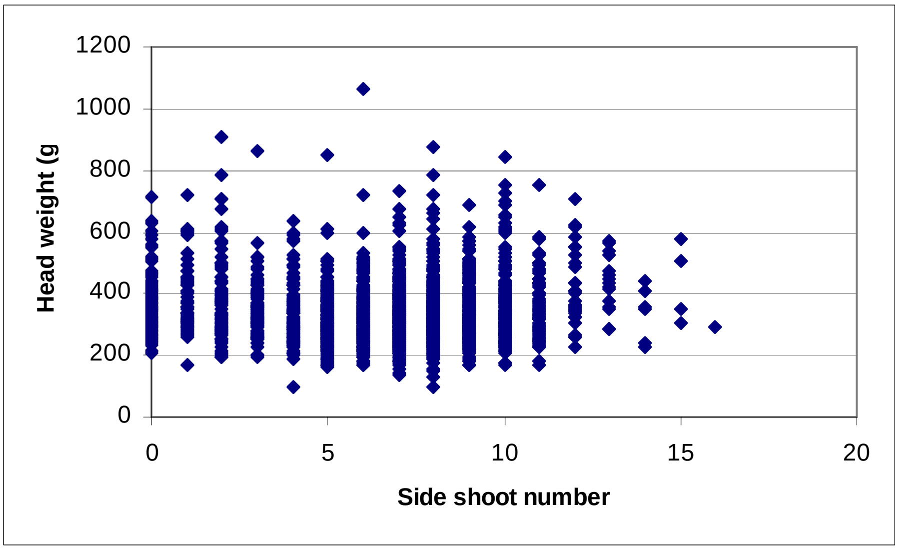


There is a weak trend towards higher main head weight with increasing side shoot weight.

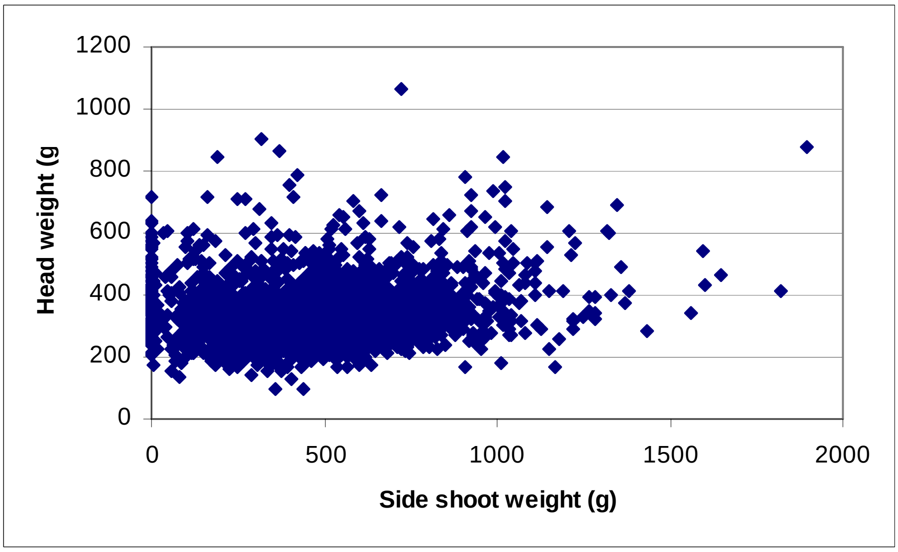
Hollow stem evaluations were also undertaken in the Munday and Wigg trials. The average main head weight from plants with hollow stem was significantly higher than the head weight of plants without hollow stem. The mean values in the Munday trial were 782g and 397g (with and without hollow stem) and in the Wigg trial 657g and 496g.

In total, 2202 individual plants were harvested, with head weight, side shoot weight, side shoot weight, stem length, and presence or absence of hollow stem measured on each plant. The total data set was analysed to identify any relationships between the measured characteristics.

Main head weight was not influenced by the number of side shoots or the weight of side shoots. Graphs of side shoot number against main head weight (graph 1), and side shoot number against side shoot weight (graph 2), clearly show that head weight did not vary significantly as number or weight of side shoots increased.



Graph 1 Side shoot number v main head weight



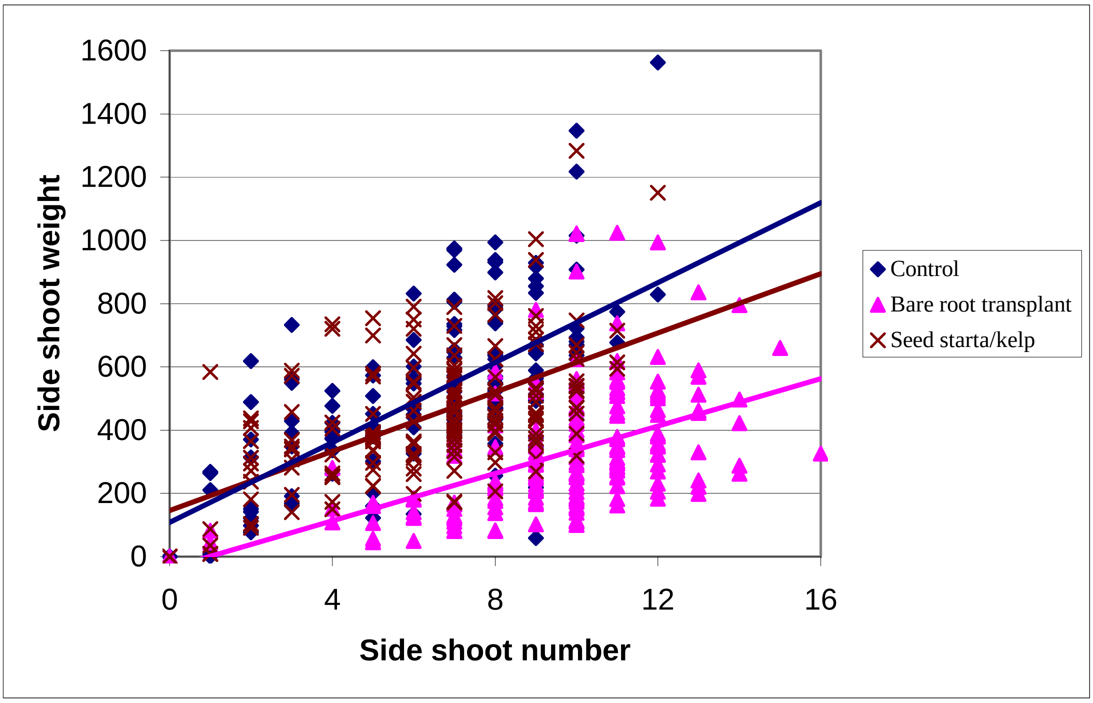
Graph 2 Side shoot weight (total weight of all side shoot material) against main head weight

Measurements from all plants harvested in the trial were pooled to generate these graphs. As the plants were exposed to different treatments and were harvested on a number of different days, analyses of relationships between side shoot number and main head weight, and side shoot weight and main head weight, were done for plants within each treatment and for each harvest date. In all cases main head weight was not linked to side shoot number or weight.

It can be concluded that the main head yield in broccoli was not affected by side shoot number or size under the growing conditions of this trial.

While there were no significant differences between treatments in the incidence of hollow stem, analysis of the individual plant data revealed a link between main head weight and incidence of hollow stem. The average main head weight of plants with hollow stem (total of 1698 plants) was 364g while the average weight of those without hollow stem (total of 504 plants) was 272g. This is consistent with the theory that hollow stem is induced during periods of rapid growth – plants with larger heads are more likely to have gone through periods of rapid growth. It is interesting to note that the Seed Starta/Nutri Kelp treatment had low head weight but a high incidence of hollow stem. It is possible that the treatment may have retarded plant growth after transplanting but allowed rapid growth late in crop development, resulting in small heads but high incidence of hollow stem.

Side shoot number was, as expected, related to total side shoot weight. The relationship was however weak for the pooled data (all plants), but stronger within treatments. The regression lines in graph 3 have different slopes, indicating different relationships between side shoot number and weight for the three treatments plotted.



Graph 3 Relationship between side shoot number and weight for three treatments

This is consistent with the timing of initiation of side shoot growth and/or the rate of side shoot growth varying with treatment. The objective in applying the treatments in the trial was to influence timing and/or growth rate of side shoots, so it is interesting to note that differences did occur. This indicates that there is some scope to manipulate side shoot development with treatments applied at transplanting. However, the lack of a relationship between side shoot number or weight and main head weight suggests that manipulating of side shoot growth will not have a major impact on main head yield.

9. 2004/05 Trial: Commercial crop monitoring

Introduction

Activity in the final season of the project again focussed on commercial crop monitoring as well as cultivar evaluation. Serve-ag were responsible for the crop monitoring and cultivar evaluation trials undertaken in 2004/05 and compiled the following report for growers.

Review of Work Up Until Autumn 2005 - Focus on Side Shoots

- Initial trials focused on limiting side shoots, but yield was not assessed in most trials.
- Replicated trial at Forthside Vegetable Research Station in 2004 found that the main head yield in broccoli was not affected by side shoot number or size under the growing conditions of that trial.
- Data from the three paddock trials in 2004 showed that bigger plants will have heavier main heads as well as side shoots.
- Data from spring and autumn paddock surveys showed that typically 92-95% of Marathon plants will have side shoots. There is no difference between seasons.
- McCains variety trial included Yates, SPS and Ruben varieties, which had no side shoots.
- Side shoot production in broccoli is under genetic control. A varietal change away from Marathon is the only way to achieve a crop with no side shoots. However, for a lot of other reasons, Marathon is key variety for the processing industry. The best way to reduce the impact of the side shoots is to grow the best possible crop.

Changed Focus To Monitoring For A Better Understanding Of Broccoli Agronomy

- Monitoring across more paddocks will give a better understanding of how the crop is performing and alternative management strategies eg. in 3 paddock trials, monitoring work indicated that high soil nitrates at planting (eg. following peas) led to increased side shoot production and increased yields. Monitoring also indicated increased Ca and Mo uptake with pre-spread fertiliser application.
- Good growers appreciate value of monitoring and manage their crop according to the information, eg. soil moisture and nutrient uptake monitoring.
- Monitoring will also be important for a better understanding of any new varieties being trialled eg. Yates processing variety.

Grower Paddock Monitoring 2005

- Soil test before planting. Fertiliser program based on soil tests and nitrate testing.
- Typically crops were planted with banded blend of NPK 1:2:1or 1:3:1. Some planted with straight triple super if adequate N, K. Low soil K levels required additional K.
- Early monitoring was critical to coincide with change from vegetation to reproductive growth. Fertiliser application had to be timed to this growth change.
- Early plant nutrition was critical.
- Crop inspection – intensively monitored at least 50 plants for disease, nutrition, insects, etc.
- Monitoring is the only way to see how crop is tracking. Eg. one of the highest yielding crops was grown in a paddock with high soil N, and very little N was applied. If this paddock had not been monitored, normal N recommendations would have resulted in excessive N levels and a crop that was susceptible to head rot and insect pressure.
- Minimise fertiliser scald to floret. Damage to pectin layer on floret can lead to increased incidence and severity of head rot.
- Top dressing blends: urea, calcium nitrate, muriate of potash, potassium nitrate.
- Trace elements blends: Solubor or Supabor.
- Calcium applications: Microgyp
- Molybdenum: sodium molybdate

For further information on fertilisers, rates and timings, please contact Jason Lynch, Serve-Ag Agronomist, on 0409979428.

The following desirable ranges from broccoli nutrient uptake are based on collation of data from 2005 paddock monitoring, as well as previous monitoring work conducted by Serve-Ag Analytical Services.

McCain Food Australia provided yield data for all monitored paddocks. This data is not provided here, but is available from report authors.

All growers in the 2005 Paddock Monitoring Trials were part of the McCains Broccoli Growers Discussion group. This group met at the completion of the season to discuss the nutrition and yield data collected during the 2005 monitoring season, and adjusting their future cropping regime accordingly.

Paddock monitoring data

CLIENT DATA ENTRY

NU-test nutrient uptake

Beswick - Dowling (A)

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	11/02/2005	10100	150.65	3520.13	1820.00	239.04	1.69	0.43	312.28	1.65	0.90	0.59	255.20	0.01	
2- vegetative & head initiation	2.4 - 40% final frame size	25/02/2005	7880	233.69	3436.97	1345.50	219.44	1.97	0.67	336.32	0.97	1.54	0.74	263.68	0.00	4.3
4- early head development	4.1 - Buttoning	4/03/2005	6990	207.76	2746.04	1327.20	183.33	1.56	0.63	329.02	1.04	0.63	0.40	267.04	0.01	
4- mid head development	4.3 - 30% expected head size															
4- late head development	4.7 - 70% expected head															

Beswick - Dowling (D)

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	11/02/2005	12200	134.37	3555.61	2112.00	339.73	2.12	0.30	291.35	1.67	1.09	1.15	120.01	0.02	
2- vegetative & head initiation	2.4 - 40% final frame size	25/02/2005	7360	188.36	3179.15	1094.50	288.48	1.93	0.86	282.96	1.22	1.52	0.96	176.59	0.01	3.9
4- early head development	4.1 - Buttoning	4/03/2005	7940	183.25	2673.60	1408.00	271.72	1.54	0.79	277.12	1.17	1.03	0.43	91.03	0.00	
4- mid head development	4.3 - 30% expected head	1/04/2005	4430	235.15	1923.98	1157.62	193.33	1.30	0.58	353.90	1.45	0.51	0.85	207.79	0.01	4.6
4- late head development	4.7 - 70% expected head															

Nichols - Pippets

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	11/02/2005	11400	128.91	3918.16	1655.00	439.64	1.58	0.21	375.89	1.27	1.14	1.03	167.92	0.01	
2- vegetative & head initiation	2.4 - 40% final frame size	25/02/2005	10800	152.78	4825.56	1052.30	361.29	2.51	0.46	311.74	1.34	1.76	1.88	202.63	0.02	3.1
4- early head development	4.1 - Buttoning	4/03/2005	9600	126.13	4281.07	1217.20	282.84	1.54	0.44	267.30	0.95	1.21	0.71	125.04	0.02	
4- mid head development	4.3 - 30% expected head															
4- late head development	4.7 - 70% expected head															

Spinks - Carver 1st

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	16/02/2005	5570	372.93	3068.51	436.37	166.03	5.21	0.73	549.66	1.03	0.68	3.98	146.94	0.03	4.6
2- vegetative & head initiation	2.4 - 40% final frame size	1/03/2005	5130	247.95	3936.27	763.04	255.54	1.91	0.73	434.23	1.37	0.67	0.69	188.67	0.01	4.3
4- early head development	4.1 - Buttoning	17/03/2005	3070	248.98	2571.25	641.64	205.69	1.65	0.38	388.46	1.24	0.59	0.90	168.65	0.00	4.1
4- mid head development	4.3 - 30% expected head	31/03/2005	1510	5.82	29.91	322.27	32.03	0.16	0.12	1.06	0.81	9.05	8.59	2.33	0.02	5.4
4- late head development	4.7 - 70% expected head															

Spinks - Carver 2nd

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	1/03/2005	4460	345.67	3026.60	535.17	183.16	3.94	0.96	656.12	1.71	0.95	3.29	191.80	0.02	4.9
2- vegetative & head initiation	2.4 - 40% final frame size	17/03/2005	2820	271.83	2911.09	463.56	168.10	1.79	0.33	361.47	1.22	0.62	1.03	96.61	0.00	4.1
4- early head development	4.1 - Buttoning	31/03/2005	2490	7.41	24.02	284.29	28.51	0.15	0.09	1.11	0.42	7.53	5.55	5.95	0.02	5.2
4- mid head development	4.3 - 30% expected head															
4- late head development	4.7 - 70% expected head															

Odgers - Lileah 1st

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	17/02/2005	6620	354.79	4439.83	720.27	325.77	5.14	1.40	560.30	1.55	1.64	4.21	173.18	0.06	4.5
2- vegetative & head initiation	2.4 - 40% final frame size	4/03/2005	7420	210.93	3777.53	574.86	349.00	1.99	0.99	312.59	1.17	0.94	0.72	132.84	0.02	4
4- early head development	4.1 - Buttoning	18/03/2005	5010	308.63	3702.76	504.32	268.51	1.83	0.87	378.71	1.28	0.78	1.20	220.42	0.01	4.3
4- mid head development	4.3 - 30% expected head	31/03/2005	2120	7.41	25.08	289.86	29.28	0.15	0.10	1.12	0.47	8.04	5.85	6.13	0.02	5.2
4- late head development	4.7 - 70% expected head															

Odgers - Nabengena 2nd

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	9/03/2005	9900	223.39	5084.07	1371.07	280.62	2.21	0.86	231.12	1.03	1.12	1.47	268.74	0.05	3.3
2- vegetative & head initiation	2.4 - 40% final frame size	22/03/2005	8670	193.22	4371.04	1349.90	303.55	1.74	0.60	172.63	1.40	0.77	0.90	352.53	0.03	4
4- early head development	4.1 - Buttoning	6/04/2005	5380	235.73	3314.86	797.09	211.41	1.55	0.72	252.20	1.23	0.51	0.92	387.08	0.03	4.2
4- mid head development	4.3 - 30% expected head															
4- late head development	4.7 - 70% expected head															

Smith - 1st Planting

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	1/03/2005	8580	202.77	5192.81	1126.70	417.83	3.46	1.17	676.31	1.32	1.49	3.07	427.82	0.02	3.7
2- vegetative & head initiation	2.4 - 40% final frame size	16/03/2005	8650	214.95	4187.35	707.43	304.89	1.86	0.38	262.54	1.10	0.95	0.85	491.18	0.00	3.2
4- early head development	4.1 - Buttoning	30/03/2005	6690	194.00	3424.50	635.57	306.75	1.69	0.32	318.81	1.30	0.59	0.78	384.61	0.01	4.7
4- mid head development	4.3 - 30% expected head															
4- late head development	4.7 - 70% expected head															

Smith - 2nd Planting

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	9/03/2005	11700	224.80	5097.21	1549.76	579.34	4.11	0.53	551.32	1.13	2.37	3.71	773.04	0.02	3.5
2- vegetative & head initiation	2.4 - 40% final frame size	22/03/2005	11100	239.16	4338.31	1547.70	525.82	2.51	0.37	558.06	1.73	1.53	1.85	698.15	0.02	3.4
4- early head development	4.1 - Buttoning	6/04/2005	6940	254.86	3669.08	686.79	331.31	2.35	0.44	402.51	1.25	1.13	0.81	395.19	0.01	4.1
4- mid head development	4.3 - 30% expected head	28/04/2005	4090	220.43	2489.55	514.75	268.94	1.33	0.26	346.08	0.91	0.94	0.70	292.94	0.00	
4- late head development	4.7 - 70% expected head															

Medwin Ent - Mt Pleasant

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	16/02/2005	5840	306.70	3567.17	531.11	131.77	5.68	1.36	591.53	1.32	1.17	5.15	167.61	0.04	4.1
2- vegetative & head initiation	2.4 - 40% final frame size	1/03/2005	7880	227.46	4176.50	1241.50	214.05	2.39	0.92	408.78	1.20	1.49	1.01	223.89	0.01	4.1
4- early head development	4.1 - Buttoning	16/03/2005	5320	293.79	2469.38	825.92	192.30	2.16	0.53	411.42	1.40	0.85	0.84	417.99	0.00	4
4- mid head development	4.3 - 30% expected head	30/03/2005	5280	250.70	2354.68	845.44	216.58	1.90	0.46	365.33	1.50	0.59	0.91	339.01	0.01	5.2
4- late head development	4.7 - 70% expected head															

Medwin Ent - Mt Pleasant

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	1/03/2005	6790	176.63	4885.09	1087.40	201.54	5.09	1.63	673.07	1.47	3.60	2.76	234.93	0.03	3.7
2- vegetative & head initiation	2.4 - 40% final frame size	16/03/2005	6360	231.46	3395.74	760.64	165.79	1.61	0.46	326.60	1.15	0.72	0.72	292.62	0.02	3.6
4- early head development	4.1 - Buttoning	30/03/2005	5890	211.60	2469.03	988.85	208.17	1.71	0.29	367.02	1.62	0.89	0.54	404.23	0.00	4.8
4- mid head development	4.3 - 30% expected head															
4- late head development	4.7 - 70% expected head															

Korpershoek - 1st Planting

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	18/02/2005	6430	260.86	3448.87	686.72	213.56	2.90	0.67	344.84	1.23	1.71	1.29	276.01	0.01	
2- vegetative & head initiation	2.4 - 40% final frame size	1/03/2005	4630	271.40	3324.77	758.03	247.54	2.11	0.83	457.43	1.83	0.81	0.92	321.26	0.01	4.4
4- early head development	4.1 - Buttoning	16/03/2005	3690	283.39	2414.31	552.06	179.24	1.85	0.40	435.76	1.01	1.27	1.16	379.04	0.01	4.1
4- mid head development	4.3 - 30% expected head	30/03/2005	2870	234.67	2346.69	665.67	193.05	1.39	0.29	399.75	1.66	0.81	0.55	309.26	0.01	4.8
4- late head development	4.7 - 70% expected head															

Korpershoek - Dallas

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	4/03/2005	11400	135.50	4038.62	1804.60	260.87	3.06	0.90	387.02	1.02	1.60	3.57	234.24	0.05	3.5
2- vegetative & head initiation	2.4 - 40% final frame size	18/03/2005	7940	237.02	5064.57	869.71	195.00	1.78	0.48	338.20	1.09	0.89	1.04	210.63	0.01	3.7
4- early head development	4.1 - Buttoning	1/04/2005	5430	187.85	3444.99	863.59	143.82	1.33	0.42	297.47	1.37	0.98	0.87	135.49	0.01	4.4
4- mid head development	4.3 - 30% expected head															
4- late head development	4.7 - 70% expected head															

RD Thorp - 1st Planting

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	1/03/2005	7200	204.36	5630.95	993.46	216.78	2.17	0.66	412.58	1.29	1.11	1.06	185.33	0.02	3.5
2- vegetative & head initiation	2.4 - 40% final frame size	17/03/2005	3750	250.50	3544.60	678.10	184.29	1.59	0.47	346.32	0.99	0.69	1.06	153.80	0.01	4
4- early head development	4.1 - Buttoning	31/03/2005	870	5.42	42.92	404.25	41.88	0.17	0.16	1.09	0.94	8.20	7.10	3.99	0.02	5.9
4- mid head development	4.3 - 30% expected head															
4- late head development	4.7 - 70% expected head															

RD Thorp - 2nd Planting

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	9/03/2005	8210	225.38	5436.53	1174.02	204.87	2.78	0.55	394.34	0.90	1.26	2.52	225.30	0.00	3.5
2- vegetative & head initiation	2.4 - 40% final frame size	22/03/2005	7180	242.07	4008.08	1140.50	190.02	1.84	0.36	308.71	1.43	0.82	0.83	313.88	0.02	3.7
4- early head development	4.1 - Buttoning	6/04/2005	4830	266.15	3492.85	734.78	190.15	1.85	0.41	404.37	1.13	0.42	0.75	316.49	0.01	3.9
4- mid head development	4.3 - 30% expected head															
4- late head development	4.7 - 70% expected head															

RS Medwin - 1st Planting

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	16/02/2005	6500	277.95	3795.74	449.88	165.92	4.64	1.16	522.33	1.06	2.20	4.23	151.62	0.04	4
2- vegetative & head initiation	2.4 - 40% final frame size	1/03/2005	5180	286.98	4116.48	587.19	222.90	2.56	1.13	481.04	1.19	2.11	1.38	180.58	0.01	4.4
4- early head development	4.1 - Buttoning	16/03/2005	3010	322.76	2892.84	465.33	166.90	1.44	0.47	408.50	1.37	0.86	1.02	211.65	0.01	4.1
4- mid head development	4.3 - 30% expected head	30/03/2005	877	304.29	2244.15	539.11	143.75	0.82	0.35	415.99	1.66	0.80	0.58	150.21	0.00	5.7
4- late head development	4.7 - 70% expected head															

Dobson - Middle (A)

primary growth stage	secondary growth stage	analysis date	NO3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn	Na	Mo	brix
2 - vegetative	2.2 - 20% final frame size	25/02/2005	10100	177.78	4663.54	1407.10	294.35	1.90	0.26	319.21	1.51	0.77	1.56	175.94	0.04	2.8
2- vegetative & head initiation	2.4 - 40% final frame size	4/03/2005	9240	160.66	4069.86	1256.30	323.67	1.71	0.36	279.99	1.04	0.65	1.50	106.82	0.01	
4- early head development	4.1 - Buttoning	18/03/2005	6540	216.94	3833.82	899.67	318.13	1.58	0.12	304.81	1.59	0.62	0.73	200.47	0.01	
4- mid head development	4.3 - 30% expected head	1/04/2005	4230	192.64	2603.82	1032.62	267.99	1.12	0.19	294.78	1.34	0.66	0.64	180.14	0.02	
4- late head development	4.7 - 70% expected head	6/04/2005	3730	236.09	3041.19	1339.70	331.57	1.15	0.21	537.17	1.16	0.58	0.63	258.58	0.01	4.6

NU-test nutrient uptake

BROCCOLI DESIRABLE LEVELS

SERVE-AG

Growth Stage (GS)	GS	NO3 upper level	NO3 lower level	P upper level	P lower level	K upper level	K lower level	Ca upper level	Ca lower level	Mg upper level	Mg lower level	Zn upper level	Zn lower level	B upper level	B lower level
2 - vegetative	GS 2.2	7500	5500	450	250	6500	4500	1500	1000	420	260	1.5	1	5.00	2.00
2- vegetative & head initiation	GS 2.4	7500	5500	430	240	6200	4200	1420	920	410	250	1.45	1	5.00	2.00
4- early head development	GS 4.1	7000	5000	410	230	6000	4000	1370	870	400	240	1.4	1	5.00	2.00
4- mid head development	GS 4.3	5500	3500	380	220	5500	3500	1300	800	380	220	1.35	1	5.00	2.00
4- late head development	GS 4.7	3000	1500	360	220	4800	2800	1250	750	350	200	1.3	1	5.00	2.00

Growth Stage (GS)	GS	S upper level	S lower level	Cu upper level	Cu lower level	Fe upper level	Fe lower level	Mn upper level	Mn lower level	Na upper level	Na lower level	Mo upper level	Mo lower level	brix upper level	brix lower level
2 - vegetative	GS 2.2	400	200	1	0.5	2	1	4.00	1.00	300.0	all levels under 300	0.1	0.05	14	10
2- vegetative & head initiation	GS 2.4	430	230	1	0.5	2	1	4.00	1.00	300.0		0.1	0.05	14	10
4- early head development	GS 4.1	450	250	1	0.5	2	1	4.00	1.00	300.0		0.1	0.05	14	10
4- mid head development	GS 4.3	470	270	1	0.5	2	1	4.00	1.00	300.0		0.1	0.05	14	10
4- late head development	GS 4.7	500	300	1	0.5	2	1	4.00	1.00	300.0		0.1	0.05	14	10

The information within this report should be used as part of a crop-monitoring program and take into consideration, management practices and environmental conditions. NU-test® and N-check® are based on specific sampling, sample handling, extraction and analytical procedures. Results cannot be explained using interpretation aides developed via different procedures (sampling, sample handling, extraction and/or analytical). Serve-Ag Analytical Services does not accept liability for any loss or damages arising in any way from the use of interpretation aides not explicitly developed for NU-test® or N-check® or approved by Serve-Ag Analytical Services. For advice on interpretations and recommendations, contact your crop nutrition advisor.

Broccoli Variety Trial Assessment 2005

The following report refers to a review of the autumn 2005 broccoli variety trials carried out at Craig Medwin's Mt Pleasant farm (Forest, Smithton).

All trials planted on the 24th January 2005.

Irrigated method: Linear Move

Fertiliser Program:	At planting	10-17-8	500 kg/ha
	Topdress	Urea 100 kg/ha	
	Solubor	1 kg/ha	

Trial assessments include;

- Presence of lateral branching
- Length of lateral branches (if present)
- Comment on amount of amount foliage present in the canopy
- Curd quality, and size at time of assessments

10 plants were sampled from each variety.

Varieties assessed include;

- TTB185
- TBR7708
- TBR7709
- TBR7724
- TBR7703
- Marathon
- YBR5782

Assessment Explanation

1. **Presence of lateral shoots**: Yes or No, if yes then a rating from 1 to 5 (1 being light to 5 being heavy)
2. **Length of lateral shoots**: the longest and shortest laterals, measured in cm
3. **Foliage comment**: rating from 1 to 5 (1 being light to 5 being heavy)
4. **Curd size** measured in mm

Assessment -1

Date: 7/3/05

Variety	Presence of lateral branches	Length of lateral branches	Foliage comment	Curd Size
TTB185	Y4	6-18	3	8
TBR7708	Y4	5-14	3	11
TBR7709	Y2	5-11	4	13
TBR7724	Y5	4-16	5	6
TBR7703	N		3	5
Marathon	Y4	8-20	4	7
YBR5782	N		3	7

General Comment

The stand out varieties at this stage include; YBR5782 and TBR7703. Both these varieties have a rather open frame, with less foliage in the canopy and no lateral branching.

The remaining varieties including; TTB185, TBR7708, TBR7709, TBR7724 and Marathon all have significant numbers of lateral branches, and appear to be developing a lot of foliage and a thick canopy.

Assessment -2

Date: 8/4/05

Variety	Presence of lateral branches	Length of lateral branches	Foliage comment	Curd Size
TTB185	Y5	16-34	5	850
TBR7708	Y5	15-29	5	970
TBR7709	Y3	14- 26	5	1020
TBR7724	Y5	4-16	5	880
TBR7703	N		4	940
Marathon	Y5	20-38	5	950
YBR5782	N		3	1050

General Comments

The stand out variety at this stage is YBR5782. This variety has an open frame, with less foliage in the canopy and no lateral branching.

TBR7703 has produced more foliage relative to the YBR5782 variety and have developed a denser canopy. No lateral branching is present.

The remaining varieties including; TTB185, TBR7708, TBR7709, TBR7724 and Marathon all have significant numbers of lateral branches, and have lot of foliage and a thick canopy. In comparison to the Marathon variety the TTB185, TBR7708, TBR7709, and TBR7724 are no better in terms of lateral shoot development and canopy density.

10. Conclusions

At the onset on the project, the objective was to develop strategies to reduce the incidence of branching or side shoot growth in broccoli crops. Increasing incidence and severity of branching in the dominant processing cultivar ‘Marathon’ had been noted by McCain field staff over several seasons. This was of concern to the industry as it was considered that excessive branching reduced crop yield. The initial trial undertaken in the project demonstrated that removing side shoots could increase yield by up to 16%. This finding was confirmed the following season when side shoot removal boosted yield by more than 20%. These results provided further impetus to develop methods to eliminate side shoot growth in broccoli crops as it was concluded that significant yield increases in crops could be achieved by reducing branching.

Examination of crop management practices over the past 10 years identified a number of changes that could have contributed to increased incidence in branching. These changes occurred both in nursery production of seedlings and in field production following transplanting. Trials examining effect of transplant age, Zn and B nutrition, P nutrition, root growth promoters and transplant plug size all failed to identify a treatment to reduce branching.

Investigation into the physiological basis of ranching in broccoli provided evidence that the rapid transition in growth rate, or potential for growth, associated with transfer from a nursery environment where growth is limited by the small plug size to the field environment where high levels of nutrition and water allow rapid growth, is likely to initiate side shoot growth. Changes in crop management over the past 10 years are likely to have promoted more rapid growth following transplanting. The overall effect of these improvements in crop management is therefore likely to have been an increase in the stimulus for branch development following transplanting. Increasing seedling growth rate in the nursery or reducing growth rate immediately after transplanting could reduce the stimulus for side shoot development. Unfortunately management practices aimed at manipulating these responses are not likely to economically feasible and may also reduce overall plant growth and therefore crop yield. It was concluded that as the cultivar ‘Marathon’ is particularly susceptible to branch development under the transplant production system used in Tasmania it is unlikely that strategies to reduce branching can be developed without having a detrimental affect on overall plant growth rate and yield.

Given that reducing branching was unlikely to be possible, the focus of the project shifted to strategies to increase overall growth rate and yield. While removal of branches had been demonstrated to increase main head yield, increasing branch number or weight had not been linked to reduced main head yield. Examination of individual plant size, yield and branch number data from commercial crops revealed that increasing branch number did not reduce yield. In fact, the trend observed was that as plant size increased the yield of both the main head and the side shoots increased. The ratio of main head weight to side shoot weight varied between crops, probably reflecting differences in the stimulus promoting branch development after transplanting. These differences were small, and it was concluded that the greatest potential for main head yield increases were associated with increasing overall plant size rather than the weight partitioning between the main head and side shoots.

Monitoring of commercial crops by crop agronomists allowed growers to achieve better than average yields. Optimising nutritional and irrigation inputs can increase crop yields without reducing branching. Thus, branching has been demonstrated to be a less significant issue than originally thought. Branching does, however, influence crop productivity in areas other than yield. Reduced uniformity in crops and increased disease susceptibility can still be problems in commercial 'Marathon' crops. In the longer term it is likely that a shift in cultivars to those with lower susceptibility to branching and high yield potential will benefit industry. Initial cultivar evaluation trials in this project identified one promising cultivar that will be further examined by industry. While this outcome was not foreseen at the commencement of the project, it has provided a solution to the problem of branching in broccoli crops.

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