

ABSTRACT 1.15

THE ROLE(S) OF PLANT GROWTH REGULATORS IN TRIGGERING AND ENHANCING BULKING IN DICER CARROTS



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INTRODUCTION

The Processing Carrot Industry is a vital part of Nova Scotia's agricultural sector. With more than 1500 acres under production, combined revenue from dicer and slicer crops exceeds 10 million dollars. However, long, cool springs, reduced summer irradiance and early frosts prevent dicers from reaching their full potential in the Nova Scotia region.

Uniform crops of roots are highly desirable to the processor. The ideal dicer root should be cylindrical in conformation and above 1.5 inches in diameter throughout. This reduces processing waste and such crops would bring premium prices to the producer.

Plant Growth Regulators (PGRs) are frequently used in agriculture in assisting crops to optimize their potential, improving crop uniformity, preventing physiological disorders and so on (Thomas, 1976). In carrots, PGRs have been used to reduce or increase shoot growth and manipulate root growth (Thomas et al, 1973; Currah and Thomas, 1979; Thomas, 1982; Thomas et al, 1983; Thomas, 1993). Endogenous production of PGRs has been studied in relation to root development (Biddington and Dearman, 1987).

The critical phase of storage root development in the carrot occurs during the formation of the second and third true leaves (Esau, 1940). While the secondary tissues such as the cambium are establishing, the potential for expansion and growth becomes evident. Early secondary cambium formation is linked to greater root to shoot ratios at maturity. It is from this cambium that the phloem parenchyma cells, which provide storage for photosynthate arise. Manipulation of the formation of the cambium and subsequent cambial cellular divisions should allow for manipulation of the bulking rate and capacity of the root.

Ethylene is associated with increased cambial activity in woody species and cereals (Lurssen, 1987). As well, carrots exposed to mechanical stress which induces ethylene evolution have shown a cambial response (Biddington and Dearman, 1987).

It is hypothesized that exogenous application of Ethrel™ (ethephon), which releases ethylene at physiological pH (4.0), will increase cambial activity in dicer carrots thus increasing overall bulking.

MATERIALS AND METHODS

Objective: To determine the role of ethylene in root bulking under field conditions

In summer 2000, a dicer variety, Red Core Chantenay (RCC) was seeded at a rate of 16 seeds per square foot in two locations. The two locations were diverse and representative of the processing carrot industry in Nova Scotia: Great Village, located in Colchester Co, Northern Nova Scotia and Avonport, located in Kings Co, Annapolis Valley, Nova Scotia. Carrots were subjected to typical growing conditions, fertilizers, and pesticide application (rain irrigation).

A plot, representing one repetition of one treatment, consisted of 7 rows across (approximately 3.5 m) and 30 m deep. The spray area in each plot encompassed the centre three rows allowing 2 drift rows on either side. Each plot was further subdivided into three sub-plots of 10 m. These sub-plots represented the second factor: stage of application.

Application of ethephon (Ethrel™) at 0, 1, 10, 100, 1000 ppm occurred at 2, 2 and 4, or 2, 4, and 8 weeks post-emergence. Treatments were applied with a pump action back-pack type sprayer until the foliage was saturated.

30 cm samples were taken from each replication under each treatment prior to each application and sealed in polyethylene bags. A sub-sample of 5 plants were measured for crown root girth and fresh root and shoot weights. At 10 weeks post-emergence, top growth was monitored using an LAI 2000 leaf area metre. At harvest, one meter samples were taken from each replication under each treatment. Root yield, root grades such as, 3/4-1 1/2", 1 1/2-2", 2-3", >3" were measured.

This experiment used a two-factor factorial design (factor 1= ethephon, factor 2= stage of application) with one blocking factor run at two levels (blocking factor= location). Each treatment was replicated three times in each of the locations, with treatments randomized within the reps. The data was analysed using SAS v8, a General Linear Model procedure and LSD, except in the case of interactions between factors when LSMeans was used.

RESULTS

Figure 1a and b: Treatment effects at 4 weeks post-emergence, 2 weeks after the first spray. Significant effects are denoted by different letter groupings on the bars and are compared by measurement. Note the differing results from field to field: Great Village experienced a slight increase in leaf weight (p<0.001), root weight(p<0.001) and root girth (p<0.001) with Ethrel™ at 10, 100 and 1000ppm; Avonport experienced a slight decrease in leaf weight with Ethrel™ at 100 and 1000ppm(p=0.114) but the only increases in root girth and weight occurred at 1000 ppm (p<0.001).

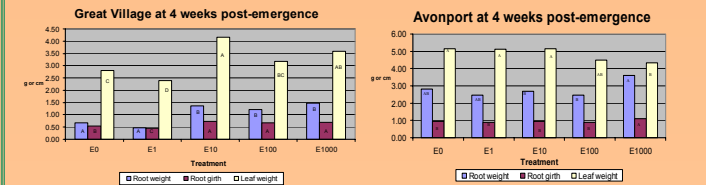


Figure 2a and b: Treatment effects at 8 weeks post-emergence, 4 weeks after the first spray and 2 weeks after the second. The significant effects seen earlier at 4 weeks post-emergence have diminished and disappeared entirely in Great Village (p=0.605). The only significant treatment effect is seen in Avonport as a reduction in leaf weight at 100 and 1000ppm (denoted by *, p<0.001).

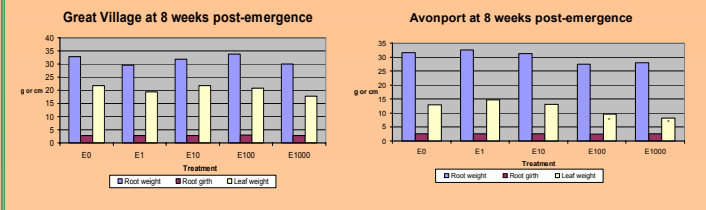


Figure 3a, b, c and d: Treatment and stage of application effects at harvest on root weight. In Great Village, there was no significant differences seen in root weight due to Ethrel™ concentration or stage of application or interaction effects of the two. However, in Avonport, the stage of application became significant (denoted by letter groupings) with a decrease in root weight happening with more than one application.

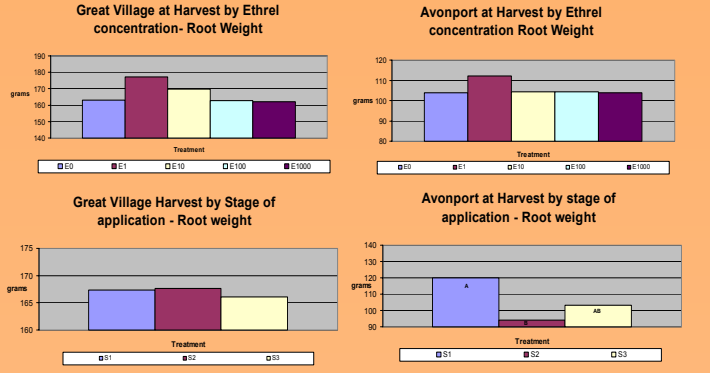


Figure 4a and b: Treatment and stage of application effects at harvest on root girth. The most complex effects on root girth at harvest were seen in Avonport. Ethrel™ concentration, stage of application and the interaction effects of the two were all significant. Ethrel™ at 1 ppm increased root girth overall (LSD=0.27 cm, indicated by large star). Applying once and thrice increased girth over applying twice (indicated by *), however, there was no difference between applying once and three times. There was some interaction between the factors at the E1000 level. At this high concentration, additional applications of Ethrel™ proved detrimental.

Only treatment effects were significant for Great Village with 10ppm increasing girth (LSD=0.46cm). There was no significant effects seen for yield, root grade distribution or roots recovered per metre at either field.

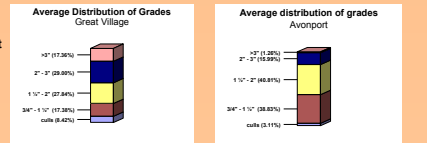


DISCUSSION

The results stated here are not consistent with results seen in 1999 (Lada, unpublished data). In 1999 an increase in root weight and yield was seen at Ethrel™ at 10ppm, applied three times. The increases in yield over controls in 1999 were as much as three-fold. However, 1999 was marked by high amounts of sunlight which were not seen in 2000. Thus, early gains as seen in Figures 1a and 1b may have been due to increased cambial activity. However, as the season progressed, the phloem parenchyma cells thus created may not have been filled by photosynthate as cloudy weather decreased photosynthetic rate. The lack of cell filling becomes evident when one considered the increase in crown girth at harvest, but not yield or root weight.

The differences in the two fields, Avonport and Great Village, were quite obvious. Significant differences in climatic conditions between the two locations likely contributed to the variation in response to treatment. The field in Avonport was located very near the ocean and was subjected to constant ocean breezes. This was thought to mimic the brushing effect as seen by Biddington and Dearman (1987) which increased endogenous ethylene. Such an increase may exceed optimum ethylene concentrations thus upsetting the delicate balance within the plant this could cause the stunting in topgrowth that was observed in the Avonport field. Without abundant topgrowth, photosynthetic activity would be reduced thus causing smaller roots which is evident in Figure 5a, showing a lesser amount of higher grade roots in Avonport, compared to Figure 5b, the grade distribution in Great Village.

Figures 5a and b: Average distribution of root grades in Avonport (a) and Great Village (b). Notice the greater amount of >2" roots in Great Village (p<0.001)



CONCLUSION

Ethephon (Ethrel™) does stimulate early bulking in Red Core Chantenay dicer carrots. However, this effect may not be carried through to the time of harvest if photosynthetic rate is not adequate to fill the phloem parenchyma cells created in early bulking. Also, an optimum concentration of endogenous ethylene appears to exist and once this level is surpassed, growth may be inhibited by subsequent additions of ethylene.

Future research must consider the persistence of early bulking activity and seek to encourage sink activity towards the root. Consideration must also be given to prevailing climatic conditions in areas where ethephon is applied so as to not exceed the optimum endogenous ethylene levels.

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