Potato Research 30 (1987) 477–483 SHORT COMMUNICATION

Influence of selective stolon removal and partial stolon excision on yield and tuber size distribution in field-grown potato cv. Record

K. J. OPARKA

Department of Physiology and Crop Production, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland

Accepted for publication: 21 January 1987

Additional keywords: stolon excision, primary and secondary stolons, tuber initials

Summary

The effects of excising stolon apices, or entire stolons, on tuber yield and size distribution were examined for *Solanum tuberosum* L. cv. Record. Excision of the apex of all primary stolons did not significantly affect final tuber yield and number, new tubers forming on branches of the primary stolon. Complete removal of the primary stolon, leaving only secondary stolons at each node, produced large and significant losses in tuber yield and number. Removal of tuber initials from the primary stolons significantly reduced yield but not tuber number. Although number was unaffected by removal of the primary stolon apex, tuber size grade distributions were significantly altered in all stolon excision treatments. The results point to the importance of primary stolons as tuber-bearing sites and emphasise the plasticity in tuber formation at a single node.

Introduction

Tuber size grade distribution within a crop can be manipulated by altering plant density so as to increase or decrease inter-plant and inter-stem competition (Allen, 1978); within a given density a single plant will produce a range of tuber sizes.

Reports vary as to which factors have a major influence on tuber number and/or size per plant. Wurr (1977) suggested that competition for photosynthate within and between nodes greatly influences tuber size, but he did not measure the weight of tubers at each node, the variable that is essential for determining competition for assimilates between the nodes. Wurr (1977), Gray (1973) and Kahn & Ewing (1984), but not Krijthe (1955) and Cother & Cullis (1985) have shown that tubers tend to form at nodes closest to the mother tuber, and although the reason for this basipetal tendency is unclear, it has been shown not to be due to effects of gravity, proximity to the mother tuber, or to the age of buried buds (Kahn & Ewing, 1985).

The size of a tuber may also be influenced by its position of formation within a node (Krijthe, 1955). Tubers may form on the tips of primary stolons (the central stolon arising from each node), on branches of the primary stolon, or on secondary stolons (stolons arising from the same node as the primary stolon, but not as branches). Recently, Cother & Cullis (1985) examined the effects of 'stolon pruning' by *Rhizoctonia solani* Kühn on tuber size distribution in cv. Sebago. They found that stolons arising from the top and bottom nodes of a stem had the lowest probabilities of bearing harvestable tubers but could bear large numbers when stolons in the middle of the stem profile were pruned. These findings indicate that a new 'hierarchy' of tuber sizes can develop when certain stolons are severed from a stem.

In this report, I show how the potential tuber number per stem is altered by excision of specific stolon apices pre- or post-tuberisation.

Materials and methods

Seed tubers (40–45 mm) of cv. Record were planted in the field on 30 April 1985 at a density of 4 plants m^{-2}. Two weeks after 50 % emergence the stolons were exposed by excavating the sides of the ridges. There were five treatments.

a) The terminal 1 cm of the primary stolon was removed with a scalpel leaving potential branch sites and secondary stolons untreated (Fig. 1a); all visible stolons on a plant were treated in this way.

b) The entire primary stolon was removed leaving only secondary stolons intact (Fig. 1b).

c) Four weeks after emergence tuber initials which had formed at the tips of the primary stolons were removed, leaving secondary stolons intact (Fig. 1c); this treatment was included to determine the degree to which stolons, which had previously tuberised, could subsequently form tubers.

d) Two weeks after emergence, concurrent with (a) and (b) above, the soil was excavated from the ridges but the exposed stolons were left untreated for the equivalent time taken to carry out the stolon removal treatments (soil-removed control); the soil was then replaced.

e) As a second control, a group of plants was left unexcavated and harvested with the other groups of plants.

There were twenty plants per treatment, the individual plants being selected with random number tables. All plants were harvested on 10 September.

Growth analysis
Individual tuber fresh weights were recorded for each plant and each tuber was size-graded. To differentiate between tubers which successfully initiated but failed to grow and those which reached harvestable size, a stolon tip was classified as a tuber if the sub-apical region was swollen to twice the diameter of the stolon.

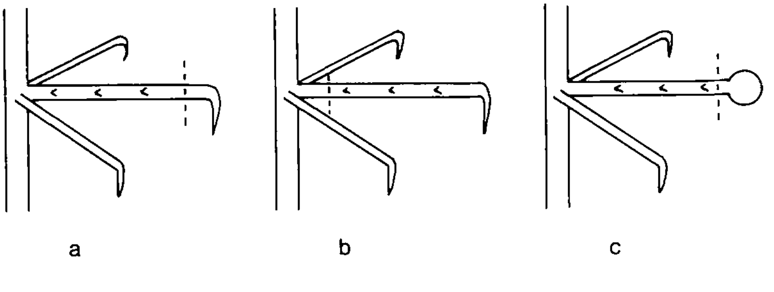

Fig. 1. Stolon excision treatments. (a) Removal of primary stolon apex. (b) Complete removal of primary stolon. (c) Removal of tuber initial from primary stolon.

Statistical analysis
Mean tuber fresh weight and mean tuber number per plant were compared by using Student's t-test. Two tailed tests of significance were used since it was not known whether the imposed treatments would increase of decrease yield and tuber number respectively. Size frequency distributions for the different treatments were compared by using the Kolmogorov-Smirnov test (Daniel, 1978), again with two-tailed significance tests.

Results and discussion

The effects of removing entire stolons, or parts of stolons, on tuber number and size distribution are shown in Fig. 2(a–e). Removal of the soil, without excision of the stolons, produced a small but significant reduction in yield but not tuber number when compared with the completely untreated controls (Table 1). Because this effect was interpreted as arising from temporary disturbance to the root system when removing the soil from the ridges, the effects of the stolon removal treatments must

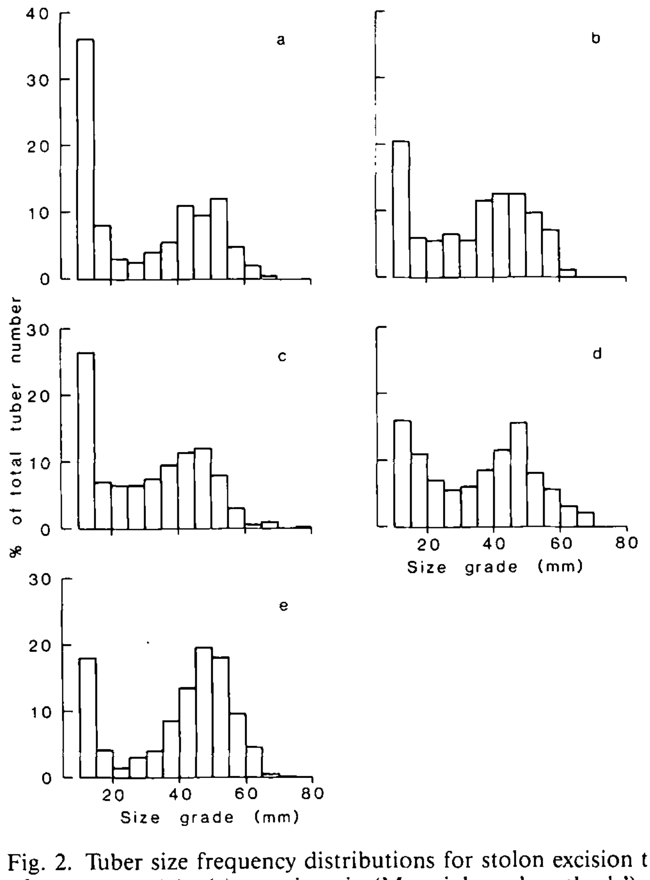

Fig. 2. Tuber size frequency distributions for stolon excision treatments and controls (details of treatments (a)–(e) are given in 'Materials and methods').

Table 1. Mean tuber yield and tuber number per plant in different stolon excision treatments (± standard error of the mean). Asterisks indicate values which are statistically significantly different from the soil-removed control (d). The soil-removed control is compared with the untreated control (e).

	Mean tuber yield per plant	Mean tuber number per plant
Treatment		
(a)	831 ± 41	19.7 ± 1.1
(b)	484 ± 46 ***	11.6 ± 0.9 **
(c)	694 ± 76 ***	18.0 ± 1.6
Control		
(d)	906 ± 57 *	17.6 ± 1.6
(e)	1083 ± 46	15.3 ± 0.8

* $P<0.05$, ** $P<0.01$, *** $P<0.001$.

be compared with treatment (d) in which the soil was removed from the ridge, but the stolons were untreated.

In treatment (a), in which the tips of the primary stolons were removed, tuber fresh weight and tuber number per plant were not significantly different from treatment (d) in which soil alone was removed from the ridge (Table 1). Tuber initials were removed from the primary stolons 2 weeks after the stolons were removed and this treatment significantly reduced tuber yield per plant but did not affect final tuber number. By contrast, complete removal of the primary stolons, leaving the secondary stolons intact (treatment b), caused a large and significant reduction in both yield and tuber number compared with treatment (d) (Table 1).

Extra plants of treatment (a), examined 2 weeks after the excision of the primary stolon apex, showed considerable lateral branching of the pruned stolon, several of the branches bearing sessile tubers. Apical excision also induced the secondary stolons to tuberise (Fig. 3). However, a new sink hierarchy appeared to be quickly established and few of the newly-formed tubers grew to reach harvestable size, many (over 35 %) remaining in the 0–15 mm size grade (Fig. 2a). Furthermore, the marked similarity in final tuber numbers between treatments involving excision of the primary stolon apex and the controls (Table 1) suggested that only a single tuber at each node became the dominant sink on the pruned stolon, most of the newly initiated tubers being absorbed or shed before final harvest. Other excision treatments also increased tuber numbers in the 0–15 mm size class (Fig. 2b, c) without influencing total tuber number. Cumulative frequency distributions of individual tuber weights were compared by using the Kolmogorov-Smirnov test (Fig. 4). All stolon excision treatments produced a highly significant difference in tuber frequency distributions relative to the 'only soil removed' control.

The results of this experiment suggest that there is much plasticity in tuber formation on a single stem and that there are abundant secondary sites for tuber formation.

Removal of soil from the ridges apparently created a disturbance sufficient to reduce final yield but not tuber number and an interaction between this effect and the

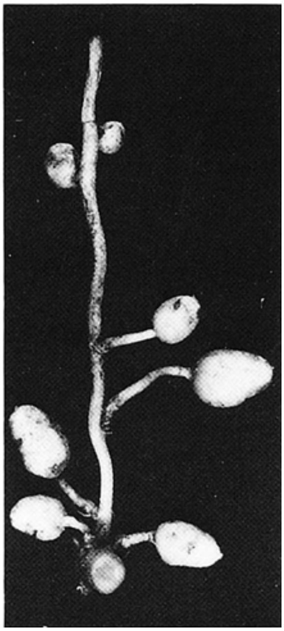

Fig. 3. Effect of removing primary stolon apex (treatment a) on tuber formation. The stolon was photographed 2 weeks after treatment. Tubers are borne on primary branch sites and on secondary stolons.

treatments imposed is a possible contributory factor to the reduced yields seen in the stolon excision treatments (b) and (c). It is thus essential to include an 'only soil removed' control in experiments involving tuber growth in situ.

Excision of the primary stolon apex did not affect final tuber number but it greatly influenced the frequency distribution of tuber sizes (weights) and these results point to the importance of the primary stolons at each node as potential tuber bearing sites. A treatment as extreme as removing all of the apices from growing primary stolons resulted in neither a significant reduction in tuber yield nor in tuber numbers provided that the stolons were lost early in the growth of the plants. These findings are in agreement with those of Cother & Cullis (1985) who found that pruning of stolons by *R. solani* resulted in no significant yield loss in cv. Sebago, new initials branching from pruned stolons escaped infection and continued to grow. Our results show, further, that although removal of the tuber initials from primary stolons caused a significant yield reduction, it did not affect final tuber number. This result could be explained if a single branch site became the dominant sink at a particular node but the new tubers had insufficient time to grow relative to controls. Damage to the primary stolons thus removed all potential branch sites and caused severe reductions in tuber yield and number indicating that secondary stolons are not effective in bearing tubers.

The similarity in final tuber numbers between treatments a and c, in which the stolon apex was removed, and d, the soil-removed control, suggests that it is unlikely

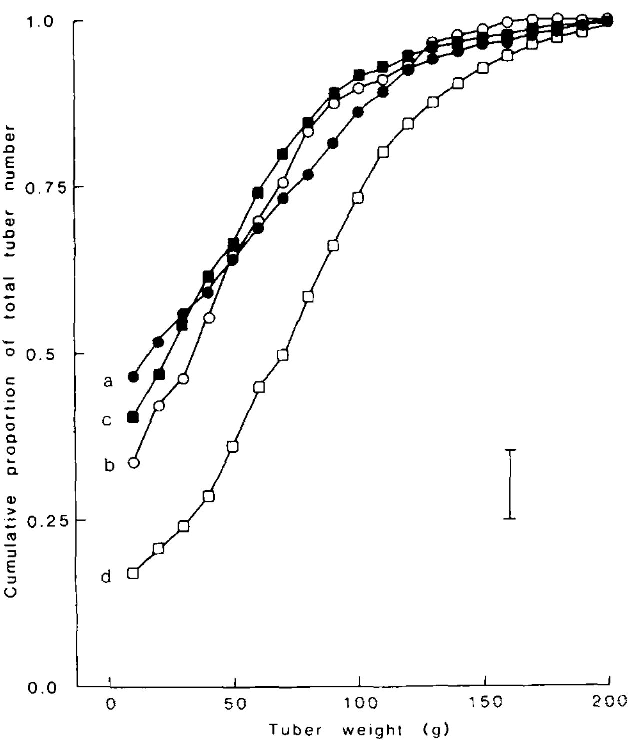

Fig. 4. Cumulative frequency distributions of tuber size for treatments (a)–(c) and the soil-removed control (d). The vertical bar represents the Kolmogorov-Smirnov quartile for the comparison between treatments (b) and (d). The distributions are significantly different ($P<0.05$) where their curves are separated by this distance.

that mechanical or biological removal of dominant tuber sites could lead to an effective increase in marketable (>35 mm) tuber numbers, apical dominance at a particular node being restored following excision of the stolon apical meristem. It is physiologically possible but chemically improbable that a growth regulator might be synthesised that could inhibit selectively the activity of certain stolon apices and so influence final tuber number.

Acknowledgements

I am grateful to D. Prior for excellent technical assistance and to Dr R. A. Jefferies and J. McNicol for statistical advice.

References

Allen, E. J., 1978. Plant density. In: P. M. Harris (Ed.), The potato crop: the scientific basis for improvement, Chap. 7, p. 278–326. Chapman & Hall, London.

Cother, E. J. & B. R. Cullis, 1985. Tuber size distribution in cv. Sebago and quantitative effects of *Rhizoctonia solani* on yield. *Potato Research* 28: 1–14.
Daniel, W. W., 1978. Applied non-parametric statistics, p. 267–275. Houghton Mifflin Co., Boston.
Gray, D., 1973. The growth of individual tubers. *Potato Research* 16: 80–84.
Kahn, B. A. & E. E. Ewing, 1983. Factors controlling the basipetal pattern of tuberisation in induced potato (*Solanum tuberosum* L.) cuttings. *Annals of Botany* 52: 861–871.
Krijthe, N., 1955. Observations on formation and growth of tubers on the potato plant. *Netherlands Journal of Agricultural Science* 3: 291–304.
Wurr, D. C. E., 1977. Some observations of patterns of tuber formation and growth in the potato. *Potato Research* 20: 63–75.