Temperature effect on fructan storage and regeneration of Canada thistle (*Cirsium arvense* (L.) Scop*)*

L. Nkurunziza[1] and JC. Streibig[2]

[1] *Department of Production Ecology, Swedish University of Agricultural Sciences, Ulls väg 16,* PO Box 7043, SE-75007 Uppsala (libere.nkurunziza@slu.se); [2]*Department of Plant and Environmental Sciences, University of Copenhagen,* Højbakkegård Allé 13, 2630 Taastrup, Denmark

Implications

Organic farming is challenged by perennial weeds such as Canada thistle. The increasing CO_2 concentration levels causing temperature increase may lead to an increased photosynthesis and as a consequence elevated storage in underground perennating organs. In this study, we analyzed fructan, the main storage in Canada thistle, in juvenile and mature plants treated with different temperatures. Low temperatures caused higher concentrations of fructan in four weeks old plants. Proximal root fragments had higher amount of fructan than distal fragments. Regenerative ability from roots with different fructan concentrations was also associated to temperature and age. This implies that the timing of root fragmentation in autumn should occur earliest four weeks before low temperatures for each location. Otherwise, new shoots would accumulate fructan causing sprouting the subsequent spring.

Background and objectives

The effect of soil disturbance and fragmentation of underground organs of herbaceous perennial weeds have been studied (Håkansson 2003). Repeated autumn cultivation reduces spring perennial weed infestation because it breaks paradormancy and depletes the root/rhizome carbohydrate reserves accumulated in late summer and early autumn. However, repeated mechanical control measures conflict with the organic farming principles because of its high energy input (Tzilivakis *et al.* 2005) and nutrient losses (Honisch *et al.* 2002). Optimal timing of the interventions is highly recommended to avoid waste of energy during the time when underground vegetative propagules are endodormant.

The elevated CO_2 concentration levels cause temperature increase and may lead to an increased photosynthesis and a subsequent storage in underground perennating organs (Patterson 1995). Temperature becomes, therefore, a crucial factor to be integrated into perennial weed management in the autumn. Variations in seasons and latitudes dictate different phenological events in perennials, such as carbohydrate source and sink dynamics. Fructan storage is known in Canada thistle (Hendry 1993) but the time of its storage and the main factors driving its storage are not yet elucidated. To manage the control of Canada thistle, more insights into fructan storage determinants are required.

The objective of this study was to investigate which developmental stage and temperature regime favour fructan storage and subsequent sprouting rate and biomass production in Canada thistle. The first hypothesis was that there is a relationship between the ambient temperatures and the storage of fructan in roots. The second hypothesis was that sprouting rate and shoots biomasses, after regeneration, are related to fructan storage.

Key results and discussion

At low temperature, the three weeks old juvenile plants did not produce horizontal roots. This is in agreement with previous finding on compensation point (Zimdahl 1993) when perenniality is resumed. At low temperatures, photo-assimilates were not enough to exceed the respiration and growth .This indicates that if disturbance is done before the occurrence of low temperatures, compensation point would not be reached. Storage of fructan would be low and the disturbance would reduce infestation in the subsequent spring. Nkurunziza and Streibig (2011) found that carbohydrate translocation to roots starts around 21 to 23 days after emergence

The degree of polymerization (DP) of fructan in plants within the age between 4 and 17 weeks, showed a variation in relation to temperature. The DP of fructan of both juvenile and mature plants decreased with temperature increase. The negative regression slope of DP of fructan on temperature increase was significantly steeper for mature plants with -0.85 (± 0.16) compared to that of the juvenile plants with -0.49 (± 0.08). In case of higher DP of fructan, replanted roots yielded higher shoot biomass 28 days after emergence. In addition, the emergence rates observed in fructan rich roots were higher than of fructan poor. However, there were differences of DP fructan in relation to the position of the fragment taken as already found on *Imperata cylindrica* (L.) Beauv.(Ayeni & Duke 1985).

In conclusion, the stubble cultivation has to be done within three to four weeks before low temperatures arrive. In that way, fructan storage would not be possible. Temperature being location specific, in practice, farmers need to rely on average temperatures over years. Further studies on various sizes of fragments would probably add some value to the knowledge on the fructan storage here reached and the temperature effect.

How work was carried out?

One experiment was conducted twice (2008 and 2009) at the experimental station of the University of Copenhagen, Taastrup, Denmark (55° 40´10N; 12 ° 18´32E). Each experiment consisted of three main steps: i) initial growth was in the greenhouse to produce plants of different ages, ii) temperature treatment of the plants in growth chambers and iii) vegetative regeneration from roots taken from temperature treated plants in the greenhouse. The determination of carbohydrate concentrations followed the method described by Nkurunziza and Streibig (2011).

References

Ayeni AO and Duke W B 1985. The Influence of Rhizome Features on Subsequent Regenerative Capacity in Speargrass (*Imperata cylindrica* (L) Beauv)", Agri. Ecosyst. Environ.13:309 - 317.

Håkansson S 2003. *Weeds and weed management on arable land: an ecological approach*, CABI Publishing, Wallingford, pp. 158-196.

Hendry GAF 1993. Evolutionary Origins and Natural Functions of Fructans - A Climatological, Biogeographic and Mechanistic Appraisal. New Phytol. 123: 3-14.

Honisch, M., Hellmeier, C., & Weiss, K. (2002) Response of surface and subsurface water quality to land use changes. Geoderma105:277-298.

Nkurunziza, L. & Streibig, C. J. (2011) Carbohydrate dynamics in roots and rhizomes of Cirsium arvense and Tussilago farfara. Weed Res.51: 461-468.

Patterson, D. T. (1995) Weeds in a changing climate. Weed Sc. 43: 685-700.

Tzilivakis, J., Warner, D. J., May, M., Lewis, K. A., & Jaggard, K. (2005) An assessment of the energy inputs and greenhouse gas emissions in sugar beet (Beta vulgaris) production in the UK. Agr. Syst.85: 101-119.

Zimdahl, R. L. 1993, "Weed Biology: Reproduction and Dispersal. In *Fundamentals of Weed Science*, R. L. Zimdahl, ed., Academic Press, Inc., pp. 59-90.