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Growth of One and Two Year Old American Ginseng in an Arid Environment of British Columaia, Canada

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Abstract□A field experiment was conducted to examine the growth of one and two year old American ginseng (*Panax guinguefolium* L.) in the arid interior of British Columbia, Canada. For both years of plants, early season growth was characterized by rapid stem and leaf dry matter production. Root growth commenced in early June and continued until early September. One year old roots had a dry weight of 0.1 to 0.2g at the end of the growing season. The two year old roots commenced the growing season at 0.1g and increased in dry matter by a factor of ten-fold. Dry to fresh weight ratios for both years were similar for root, leaf and stem samples at the end of the growing season. Leaf area index for both years showed similarities in progression over the growing season. As a consequence of the effectiveness of the microclimate modification employed to permit American ginseng cultivation (elevated shade cloth and surface mulch), plant growth and development was extremely good. This indicates the potential for the cultivation of American ginseng in dryland environments.

Keywords□*Panx guinguefolium* L., root growth

Introduction

In the fall of 1982, a large commercial American ginseng (*Panax guinguefolium* L.) farm commenced operation in the arid interior of British Columbia, Canada. American ginseng is not native to British Columbia, rather it is an herbaceous perennial that is native to the understory of the deciduous forests of eastern North America. American ginseng prospers where it receives diffuse solar irradiance and adequate soil moisture during the growing season. For the commercial cultivation of American ginseng, this unique microclimate must be emulated. This is accomplished through the use of an elevated shade canopy and a surface covering of organic mulch. The former protects the plant from direct solar irradiance that causes necrosis. The latter helps to conserve soil water in summer and mitigates the effects of cold air temperatures in winter. The success of this microclimate modification technique is becoming more evident as American ginseng is now grown in many regions well outside its native range.[1)]

Little documentation on American ginseng seasonal growth exists.[1)] As it is highly prized throughout many parts of the world for its herbal and medicinal attributes, further research is merited for this high value crop. The objective of this study was to examine the seasonal growth of one and two year old American ginseng in the arid interior of British Columbia. Attention was focused on the seasonal trends of leaf, stem and root dry matter production in a large comercial planting.

Experimental Procedure

The field research was conducted at Lytton, British Columbia, Canada during the 1984 growing season. The one year old plants were seeded in September 1983 and the two year old plants one year previous. Lytton is located in the arid interior of British Columbia and is one of the hottest and driest environments in Canada during the summer months.[2)] The maximum temperatures for April,

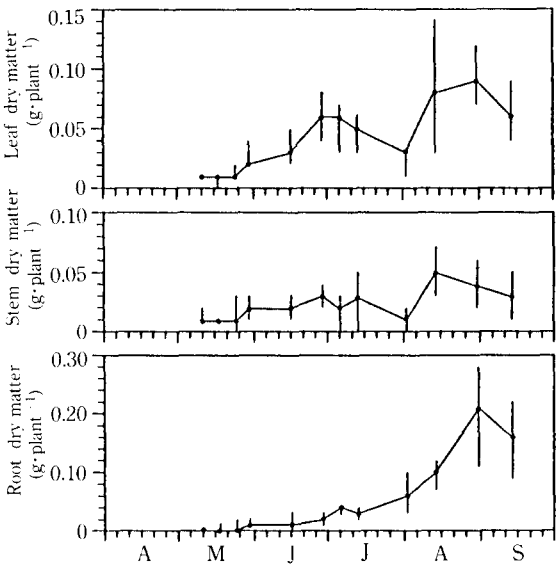

Fig. 1. Root dry matter, stem dry matter and leaf dry matter for one year old American ginseng for Lytton, British Columbia, Canada. The vertical lines denote the sampling range in the data.

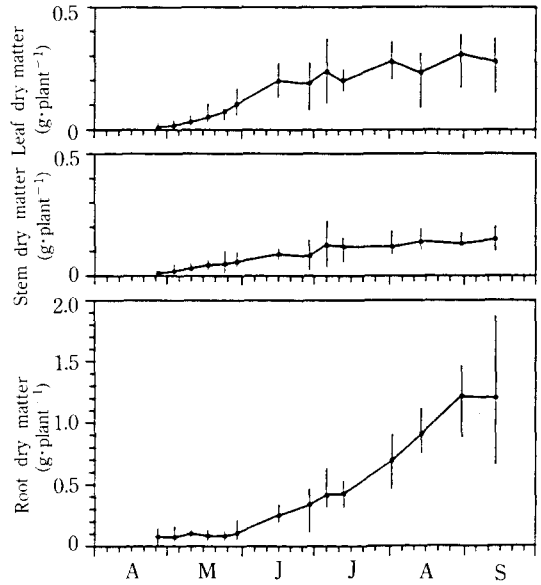

Fig. 2. Root dry matter, stem dry matter and leaf dry matter for two year old American ginseng for Lytton, British Columbia, Canada. The vertical lines denote the sampling range in the data.

May, June, July, August and September 1984 were 25.4, 27.9, 32.6, 40.5, 34.6 and 28.1℃ and the monthly precipitation totals were 3.7, 19.0, 33.8, 3.6, 8.8 and 21.9 mm respectively for the same months.

During the growing season, sampling was done in one and two year old gardens. The gardens were 135 m by 155 m and were covered with black polypropylene shade canopy (Chicopee Lumite Fabric) that was suspended approximately 2 m above the ground. The garden soil has a silty clay texture and a bulk density ranging from 1.0 to 1.3 Mg m^{-3}. The plants were grown in raised beds which were covered with 50 to 100 mm of straw mulch. The beds were 1.35 m wide and ran the length of the garden in a north-south direction. plants were grown at a high density of approximately 180 per square meter of garden bed. The unique seasonal trends in soil temperature and moisture in this modified environment have been described previously.[3,4] The shade canopy and the mulch almost decouple the soil environment from the atmosphere. This results in low soil temperatures and high soil moisture throughout the growing season.[3,4]

Plants were sampled throughout the growing season. For the one year old plants, samples were taken 12 times during the growing season and for the two year old plants, samples were taken 14 times. At each sampling period, five plants were selected randomly and extracted. Ths size of the sample was a compromise between the concerns for a representative sample size and the concerns of the producer.[5] The latter's chief concerns were over the loss of the plants and the consequences of the destructive sampling program. After plants were extracted from the garden, they were thoroughly washed. Plants were then sectioned into roots, stems and leaves. These were fresh weighed, dried at 70℃ for 3 days and then dry weighed.

Results and Discussion

The seasonal course of leaf, stem and root dry matter for the one and two year old plants is presented in Fig. 1 and 2 respectively. Also shown on the graphs are the ranges (low extreme to high extreme) for the data. For the one year old plants, the leaf and stem dry mater data illustrate a general increase throughout the growing season. In sp-

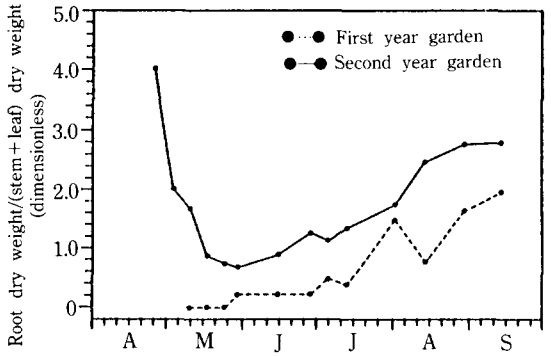

Fig. 3. The ratio of root dry matter to above ground (stem plus leaf) dry matter for one and two year old American ginseng for Lytton, British Columbia, Canada.

ring, the stem is first to grow, after which the leaves open and expand in size. The scatter in the trend seen is reflective of the sampling program as weel as the small weights of the plant components being studied. This makes the data subject to large relative errors but on an absolute scale, these are still quite small. For root dry matter, a seasonal growth curve is found. Negligible dry matter increase occurs in April and May. In early June, growth commences. There is increasing growth until early September when it ceases due to seasonal senescence. The scatter in the data is small until after mid-August.

For the two year old plants, there is a constant rate of stem dry matter increase until July. After this, the stem weight remains almost constant. Leaf growth is quite similar, with a rapid increase until July after which it remains almost constant. Root growth follows a characteristic logistic growth curve. Root dry weight is approximately 0.1g during April and May and this is a result of the previous year's growth. In early June, root growth commences and continues until early September. After this, growth ceases as seasonal senescence commences. The approximate ten-fold increase in dry matter over the growing season gives a final root dry matter similar to that described for a commercial planting in Ontario.[6] and a high plant density experimental plot in North Carolina.[7] Seasonal senescence is visually acknowleedged in the field through the physiological and morphological changes noted in the leaves. This is first seen as leaf discolouration and later as dieback of the above ground matter. It is also interesting to note that at the end of their first growing season, the one year old roots had a dry mater ranging between 0.1 to 0.2g. At the start of the second year, the two year old plants had an average dry weight of approximately 0.1g. This small discrepancy can be explained by two possible factors. The first rests with the 1984 growing season being slightly better than the 1983 growing season, hence the slight increase in dry matter. Second, the initial two year growth exploits some of the roots' dry matter reserves for early season stem and leaf growth and development. This may also contribute to the slightly lower initial two year old root weights.

The relationship betwen root dry weight and above ground (stem plus leaf) dry matter for the one and two year old plants is shown in Fig. 3. For the one year old plants, a steady progression throughout the season is seen. The slightly larger value in early August is likely associated with sampling and measurement errors. For the two year old plants, a characteristic of the plants' seasonal growth is denoted. As a consequence of rapid leaf and stem growth in early spring and no root growth (together with a possible loss of root dry mater), a rapid decline in the ratio is exhibited. After this period, with the initiation of root growth in June, the trend begins to rise. This indicates that from June onwards, photosynthetic production is predominately used, no longer for stem and leaf growth (Fig. 2), but rather for root growth throughout the rest of the growing season.

As the most valuable part of the plant is the dried root, it is worthwhile to examine the seasonal course of dry to fresh weight ratios (Fig. 4). Further, it is worthwhile also considering the dry to fresh weight ratios of leaf and stem tissue. Both of these contain extractable ginsenosides[1] which can be used for the preparation of ginseng products. For the leaf and stem, and excluding the early season data, the dry to fresh weight ratios remain quite similar for both years throughout the growing season. For the leaves, the ratio ranges between 0.20 and 0.40. For the stem, the seasonal variation

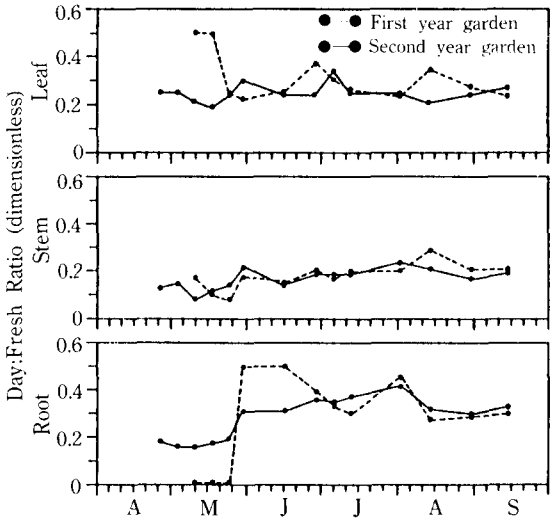

Fig. 4. Dry to fresh weight ratios for root, stem and leaf matter for one and two year old American ginseng for Lytton, British Columbia, Canada.

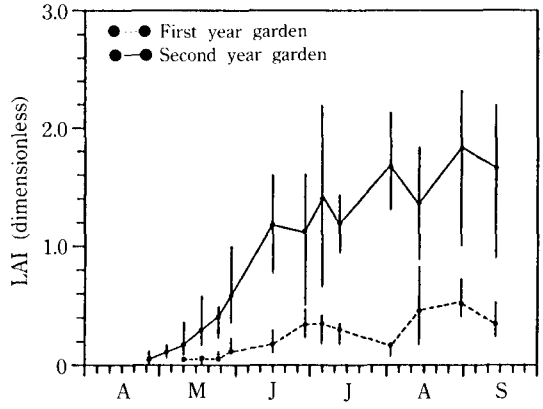

Fig. 5. Leaf area index for one and two year old American ginseng for Lytton, British Columbia, Canada. The vertical lines denote the sampling range in the data.

is less and the end of the season value is approximately 0.20. For the one year old roots, the initial value is almost zero. Once growth initiates, the value rapidly increases. A great deal of growing season variation is seen, due in part to the small absolute weights of the tissue samples. At the end of the season, the value is approximately 0.30. For the two year old roots, dry to fresh weight ratios range between 0.15 and 0.42. Values near the end of the growing season approach 0.30.

The seasonal trends in leaf area index for the one and two year old gardens are presented in Fig. 5. The leaf areas were evaluated from a linear regression relating leaf area (LA in mm^2) to leaf dry matter (DM in g). The expression evaluated is given by $LA = -20.3 + 3.29 \times 10^4 DM$, $r = 0.85$. The general form of the trends for the one and two year old gardens is similar. After rapid early season growth during May and June, leaf area index essentially plateaus throughout the remainder of the growing season. However, in the two year old plants, a suggestion of a slight increase is noted. However, the wide scatter found in leaf dry matter data (Fig. 1 and 2) is similarly found in this figure as a consequence of the linear regression expresion. The data presented is similar to results previously presented.[8]

For both one and two year old ginseng plants, the seasonal growth strategy is similar. Initial growth is primarily in the stem and the leaves. The growth and development of these predominate until June. In June, root growth commences. Root growth is almost linear with time throughout the growing season. Root growth ceases when annual senescence commences in September.

Conclusions

This research demonstrates the potential for the successful cultivation of American ginseng in arid environments. Further work is needed and particular attention should focus on other production years of ginseng plants as well as other growing locations. In addition, research should be undertaken to assess the impact of field environmental conditions on ginseng growth and development. Other research[3,4] and straw mulch have on the seasonal evironment of the soil. The development of models of plant growth for these man-modified environments is merited as a consequence of the high economic value associated with this crop.

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References

1. Proctor, J.T.A. and W.G. Bailey: *Horticultural Reviews* **9**, 187 (1987).
2. Hare, F.K. and M.K. Thomas: *Climate Canada.* Wiley Publishers, Toronto, Canada, p.256 (1974).
3. Bailey, W.G., R.J. Stathers and A.G. Dobud: *Korean Journal of Ginseng Science* **12**(1), 53 (1988).
4. Stathers, R.J. and W.G. Bailey: *Agricultural and Forest Meteorology* **37**, 1 (1986).
5. Gin, H., W.G. Bailey and S.T. Wong: *Korean Journal of Ginseng Science* **13**(2), 147 (1989).
6. Proctor, J.T.A.: *Proceedings of the 5th International Ginseng Symposium.* Korea Ginseng and Tobacco Research Institute, Seoul, Korea, p.129 (1988).
7. Konsler, T.R. and J.E. Shelton: *Proceedings of the Sixth North American Ginseng Conference.* University of Guelph, Guelph, Ontario, Canada, p.23 (1984).
8. Hughes, B.R. and J.T.A. Proctor: *Journal of the American Society for Horticultural Science* **106**, 167 (1981).