Seed Dormancy in Sugar Beet (*Beta vulgaris*)

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Abstract


Studied in this paper was how germination energy, germinability and absolute 1000-seed mass of sugar beet seeds was affected by ten different growing locations and seed storage in controlled and uncontrolled conditions for 150 days following harvesting. Over the three study years, significant differences were obtained within each of the factors studied, with no interaction among the factors. The uncontrolled conditions of seed storage in silos produced a highly significant positive difference in seed quality relative to the controlled conditions of laboratory storage. The same difference was obtained with the storage times of December, November and September relative to July. Highly significant differences were found among most of the growing locations, while in a smaller number of them the differences were not significant. The significant differences consisted in increased germination energy and germinability and decreased absolute seed mass.

*Key words*: dormancy of sugar beet seed, germination energy, germinability, absolute 1000 seed mass

Introduction

Seed dormancy has been attracting the attention of researchers for a long time. The phenomenon has been studied in a large number of plant species and has been shown to be affected by a great number of factors. Dormant seeds are also called sleeping or hard seeds, and sometimes the phenomenon is referred to as delayed maturation (Miric et al., 2004).

Generally speaking, seed dormancy depends solely on genes (Foley and Fennimore, 1998). Many dormant genes for seed desiccation have been isolated and are important for seed longevity (Bailin and Foley, 1997).

Seeds capable of germinating may lapse into dormancy under the influence of unfavorable environmental factors. Dormancy induced by delayed action of an environmental factor is called secondary dormancy. Secondary dormancy is most commonly caused by unfavorable, often high temperatures (Stokes, 1965). Under the influence of a high temperature of 45
630°C, the seed coat of *Helianthus annus* becomes impermeable to oxygen, preventing a normal exchange of gases between the inside of the seed and the environment. *Helianthus annus* seeds can germinate at 40°C, but the seedlings lose the ability to grow (Gay et al., 1991). In some plant species, the period of seed dormancy may be shortened if the seeds are exposed to low temperatures in a sufficiently moist state for a certain period of time. This procedure is known as stratification. *Lythrum salicaria* seeds, for example, were exposed to temperatures below 15°C during autumn and winter in wet conditions (Klips and Penalosa, 2003). Low temperatures can be used to promote and speed up processes and shorten the duration of seed dormancy. Seeds have their annual dormancy cycles. In six species of *Carex* spp. sown at 10 and 15°C in the light and dark, the seeds germinated in late autumn and winter and became dormant in late spring and summer (Schutz, 1997). In *Purshia tridentata*, the genotype of the endosperm and embryo required that the seeds be cooled before they could end their dormancy (Meyer and Pendleton, 2000).

Treating seeds of a number of plant species with different temperatures for 12/12 hours by day and night showed that most of the species were not dormant, while a minority never germinated (Baskin et al., 1989). A study on the effects of temperature, light and pesticides on seed quality in *Amaranthus hypochondriacus* showed that >80% of germinability was controlled by cultivar (Aufhammer et al., 1998). In the dark, the seed of some plant species (*Nicotiana tabacum, Sinapis alba, Daucus carota*, etc.) exhibits very little or no germination at all. By contrast, there are some plant species in which germination is inhibited by light (Esashi et al., 1987). Finally, there are species, such as *Phaseolus vulgaris* or *Pisum sativum*, whose seed germinates equally well in the dark and in the presence of light.

In hard seeds, the seed coat often has low permeability to gases, which may lead to the accumulation of carbon dioxide in the seed. In addition, this hinders the uptake of oxygen, which is necessary for oxidative processes during seed germination. The removal of the heavy seed coat of *Prosopis ferox* by scarification causes the seed to germinate even before the period of dormancy has ended. After passing through the digestive tract of donkeys and goats, the seeds of *Prosopis ferox* had very poor germinability (Baes et al., 2002). However, plants grown from the seeds lagged in growth and exhibited great many anomalies in their development, leading to the conclusion that significant changes occur in seed physiological and biochemical processes in the course of stratification and delayed maturation. When the respiration of dormant and nondormant seeds were studied during seed imbibition and germination using the Fourier transformation and spectrophotometer, it was found that there was no difference in CO₂ levels between the seeds that were dormant and those that were not, and the level of CO₂ increased only at germination (Booth and Sowa, 2001).

In some plant species, seed dor-
Seed Dormancy in Sugar Beet (Beta vulgaris)

mancy may be caused by the presence in the seed of substances that inhibit germination. After the incrustation of stratified Prunus persica seeds at 10 °C for 72 days, the cress test showed the presence of the Rf 07-0.9 inhibitor. Beta vulgaris seeds often have difficulty germinating, as the fruit of this species contains germination-inhibiting substances. The presence of inhibitors is confirmed by the fact that the seeds will germinate quickly once the inhibitors are removed from the seed ball by immersion in water or rinsing (Kastori, 1984). This is the hormonal theory, which argues that the state of dormancy depends on the amount of inhibitors and activators. These substances differ greatly in their chemical composition and the most commonly mentioned ones are the derivatives of benzoin acid. They may accumulate in the seed coat, endosperm or embryo. Seed treatment with plant hormones to break dormancy has been used on Helianthus annus seeds (Corbineau et al., 1990).

Materials and Methods

The objective of the study was to investigate seed dormancy of modern rhizomania-resistant sugar beet hybrids between primary and secondary seed processing in order to reduce seed processing time and seed losses occurring during the processing.

The dormancy of sugar beet seed produced by ten different growers from Backi Petrovac, Despotovo, Pivnice, Selenca, Bezdan, Kolut, Gunaros, Novi Knezevac, Backo Gradiste, and Novi Sad (Factor A) was analyzed over three years. The seed was kept in controlled laboratory conditions (at 20 °C and 65-75% relative humidity in a thermostat chamber with forced air circulation and electronic temperature regulation ± 0.5 °C, LTH Skofja Loka, Slovenia) and in uncontrolled conditions in silos between July and December, 2002, 2003, and 2004 (Factor B). Germination energy, germinability and absolute 1,000-seed mass after harvesting were analyzed according to ISTA standards over a period of 150 days for the months of July, September, November and December (Factor C). Three-factor analysis of variance was done according to Hadzivukovic (1977).

Results

All three factors-A (grower), B (storage location), and C (storage time)-had significant influence on the qualitative characteristics of sugar beet seed. No interaction among the factors was recorded (Table 1). With Factor A, highly significant differences were observed among most of the growers for all the characteristics involved (Table 2). In the case of Factor B, the difference between silo and laboratory storage was highly significant for germination energy and significant for germinability and 1,000-seed mass (Table 2). For Factor C, a highly significant difference in germination energy was recorded between the months of September, November and December and the month of July (Table 2). Another highly significant difference was found for germinability between December and July. The rest of the differences were significant. The absolute 1,000-
seed mass decreased with increasing time of storage, while germination energy and germinability increased (Table 2). Highly significant differences in absolute 1.000-seed mass were observed between July, on the one hand, and November and December, on the other, as well as for September relative to November and December.

**Discussion**

Seed dormancy caused by a hard seed coat and an endosperm impervious to water and oxygen (which is necessary for oxidative processes occurring during germination) is often found in some species of the families Malvaceae, Chenopodiaceae, Liliaceae and Solonaceae (Kastori, 1984). The theory of hard seeds has relevance for modern sugar beet hybrids as well. In the present study, the effect was particularly pronounced in the case of seed storage in the laboratory compared with storage in silos, when significant differences in germination energy and germinability were recorded. The reduction of seed quality we observed after six months of storage in the laboratory at 20 °C and 65-75% relative humidity in relation to uncontrolled conditions in silos confirmed the findings of Kulik et al. (1967), who kept grass seeds for eight months at 35-75% relative humidity and a temperature of 10-35 °C.

Differences among seed production locations often hamper sugar beet seed processing. The goal of seed processing in this crop is large seed size, which is difficult to obtain due to the influence of various factors during the seed production process (Saboljevic and Miric, 1992). These include differences in soil type, production technology and environmental conditions (Baskin and Baskin, 1998). In our study, significant differences were observed among a number of seed growers with respect to all of the seed qualitative characteristics studied.

Seeds capable of germination may
become dormant under the influence of unfavorable environmental factors. Dormancy caused by delayed action of an environmental factor is called secondary dormancy. It is most commonly induced by temperatures that are unfavorable, often being too high (Bewley and Black, 1982). The effects of high temperatures were confirmed in our study of sugar beet seed storage over a period of 150 days. At the time of seed sugar beet harvesting in our country, temperature exceeds 30 °C, which sometimes leads to a significant increase in seed breakage. In the present study, no significant differences were found between the months of July and September, as this is too short a period of time in most plant species from the point of view of seed development physiology (Hilhorst et al., 1996). Differences among the other months were significant, however. Highly significant ones were recorded between the months of July and December with regard to germination

| Table 2 | Factors and their effects on sugar beet seed dormancy |
|---|---|---|---|
| ANOVA | Germination energy | Germinability | 1.000-seed mass |
| A | 79.08 | 80.66 | 11.1 |
| | 79.66 | 82.2 | 12.4 |
| | 71.7 | 75.87 | 13.21 |
| | 80.79 | 82.04 | 11.2 |
| | 83.04 | 85.08 | 10.82 |
| | 79.37 | 82.08 | 10.04 |
| | 83.08 | 84.54 | 10.5 |
| | 82.45 | 85.75 | 10.83 |
| | 82.54 | 85.33 | 12.82 |
| | 84.04 | 85.5 | 11.56 |
| CD 5 % | 2.03 | 2.32 | 0.74 |
| 1% | 2.68 | 3.07 | 0.98 |
| B | 81.35 | 83.5 | 11.28 |
| | 79.8 | 82.31 | 11.61 |
| CD 5 % | 0.91 | 1.04 | 0.33 |
| 1% | 1.2 | 1.37 | 0.43 |
| C | 79.13 | 81.76 | 11.99 |
| | 80.16 | 82.51 | 11.57 |
| | 81.08 | 83.31 | 11.31 |
| | 81.93 | 84.03 | 10.93 |
| CD 5 % | 1.28 | 1.47 | 0.46 |
| 1% | 1.7 | 1.94 | 0.62 |
energy and germinability. Similar results were reported by Finch-Savage et al. (2002), who treated cherry seeds with low temperatures occasionally substituted with high ones for 15 weeks. Such treatment did not reduce the physical characteristics of the seed and enabled long-lasting seed development.

The absolute 1,000-seed mass decreased significantly between July and December, since it is assumed that as the seed is germinating protein synthesis increases and seed mass is reduced (Klerk and Willekens, 1985). Outside temperatures played a much greater role in the reduction of 1,000-seed mass in the silos compared with the controlled relative humidity and temperature in the laboratory. In a number of plant species, such significant differences in the seed mass are obtained after as little as three to four days as a result of action of different temperatures (Ballarin-Denti and Cocucci, 1979).

Conclusion

Looking at the factors under study, it can be seen that it was Factor B, storage location, that had the greatest effect on seed dormancy, followed by Factor C, the time of storage. Factor A, the seed grower, had the smallest influence. These findings support the idea that favorable conditions are needed for certain physiological and biochemical processes enabling unimpeded seed embryo development (Bewley and Black, 1982).

Based on our study, it can be concluded that secondary seed processing in sugar beet can begin 150 days after the seed crop is threshed. This will shorten the length of seed processing and reduce seed losses.

References


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