Influence of soaking periods and temperatures on germination and respiration of pea seeds

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Summary: Samples of 50 wrinkled-seeded pea (*Pisum sativum* cv. 'Farida') were soaked for 0.5, 1, 4, 8, 24, 48 and 72 hours at temperature of 5, 10, 15 and 20 °C in distilled water before germination. Water absorption, percent of germination, vigorous seedlings and dry weight of normal seedlings were assessed after 8 days. Respiration of short and long seedlings were checked by IRGA, LI-COR 6200 photosynthesis system. Most plants had more or less respiration but some of them already had photosynthesis. Differences in the amount of water absorbed were evident after one hour, only. Water amount was increased by increasing soaking temperatures and times. The maximum was achieved after 24 hours. Normal germination percent was not improved at any soaking time and temperature combinations but it was significantly declined at 10 °C with soaking time combinations and at 20 °C for 72 hours. The seedling vigour values were not very different at the higher soaking temperatures, but the treatments at 20 °C temperature with 8 and 24 hour soaking periods are proved to be optimal for seedling vigour. At the low soaking temperature the increase of the soaking period influenced the seedling vigour. Reduction of dry weight percent was noticeable by any soaking time related to temperature and compared with the control.

Introduction

Pisum sativum L. is a cool season crop having a mean optimum temperature of growth at 13–18 °C. Seeds germinate slowly at 16 °C or at lower temperature starting with dry seeds. Seed germination can start after certain amount of water has been imbibed by the hydrophilic components of the seed. The amount of water taken up by seeds depends largely upon the seed condition (moisture content and coat conditions) and upon environmental factors as temperature and water status to a certain extent. A minimum of moisture (60%) is necessary for germination but at the same time seeds absorbing water lost soluble materials by leakage as reported by Larson (1968).

In nature, seeds absorb water slowly against the water potential of the surrounding soil, therefore they are usually imbibed for less or more time before planting to accelerate the germination and to make it more uniform. When seeds are treated in such a way, the imbibition can be rapid and disrupt the germ axis (Larson, 1968, Woodstock and Tao, 1981). Pea seeds do not exhibit dormancy and are more likely to be injured by prolonged soak than seeds exhibiting some kind of dormancy. Pre-soak of pea seeds in distilled water will hasten germination within limits. Factors as length of soak time, temperature of water, aeration during soak and amount of

water absorbed must be taken in consideration in the evaluation of the effect of soak on germination and subsequent seedling growth.

During soaking, injuries may occur from a lack of free oxygen during imbibition, harmful effect of pure water on imbibing tissues, sub-optimal temperature during soak, cellular disorganisation (membrane integrity) because of drying process of seeds, leaching out of essential compounds and bacterial action or any combination of these. The reported effects of soak can vary in germination and subsequent in variable growth of seedlings according to treatments and other conditions (Kidd & West, 1919). Perry & Harrison (1970) stated that a prolonged soak period up to 24 hours increased the damage in the axis of the germ or killed the seeds. This injury was aggravated by low temperatures as well as in seed lots of low-vigour.

During the desiccation of seeds, cell membranes lose their integrity and imbibing them a short period is taken before membrane integrity for the reformation, during which solutes can leak out the cell (Simon and Raja Harun, 1972). According to our knowledge, in dry pea seeds the membrane phospholipids are formed in a porous hexagonal organisation so the leakage can occur rapidly. When dry seeds are first placed into water further leakage is depressed by reforming the

normal bilayer structure of the membranes following rehydration, in this way solutes from inner cells also may be limited by the increased length of diffusion path (Simon, 1974).

Bramleg (1950) suggested the leakage period is a time of membrane reorganization and imposing low temperature during this period prolongs the rapid leakage resulting in delayed membrane reorganization. Powell and Matthews (1978) found the intact seed absorbed little water in the first 3 hours after which the rate of absorption revealed a more rapid increase up to 8 hours when the rate of increase of moisture content decreased slightly. Water intake was not completed by intact seed after 24 hours. Powell and Matthews (1978) also suggested the reduction in the growth of seedlings from damaged seeds was also associated with a slower rate of nutrient movement from the cotyledons to the growing points, however, nutrient mobilization would be reduced in tissues of dead cells (Simon, 1974).

Norton (1988) found that 21-hour soak of seeds significantly reduced emergence of seedlings in vermiculite. Addition of oxygen to the soak water decreased the subsequent emergence, while adding urea peroxide increased the emergence from 3% to 41% after 72-hour soak. He suggested that injury can either be due to take in free oxygen for oxidation of metabolites or due to a very high oxygen pressure resulting a great membrane rupture and consequent leakage. Petruzzelli et al. (1994) found when pea was germinated at 5 °C for the initial 8 hours of imbibition and then moved them to 20 °C, germination and growth were significantly delayed and, at the same time, the burst of ethylene was delayed and much less intense. Russo and Biles (1996) stated the low germination rates of cucumber at suboptimal temperatures were related either to a leakage of minerals and/or to a lack of formation or denaturation of proteins associated with germination and root elongation.

The aim of this work is to determine the effect of seed soak at various periods and different temperatures and to study their effect on the germ quality.

Materials and methods

Samples of 50 wrinkled-seeded pea (*Pisum sativum* L.) cv 'Farida' were used to determine the influences of water soaking times and temperatures on pea seed quality. The study was conducted at the laboratories of Natural Institute for Agricultural Quality Control, Budapest, Hungary. Each 50 seeds were weighed and soaked for 0.5, 1, 4, 8, 24, 48 and 72 hours at 5, 10, 15 and 20 °C in distilled water in four replicates. Following the treatments seeds were removed from water, surface was dried and reweighed to determine the amount of water absorbed (expressed as percentage of a fresh weight gain during each imbibitional period). Unsoaked seeds were used as control. Germination tests were carried out between wet papers and incubated at 20 °C for 8 days. After 8 days, seedlings were classified by measuring of shoot length as vigorous (hypocotyle length = 5 cm) or non-vigorous (hypocotyle length < 5 cm). Fresh and dry weights

of normal seedlings were measured. Respiration of short and long seedlings of 6–6 samples were checked by LI-COR-6200 Infra Red Gas Analyser at the end of experiment. Normal germination percent, vigorous seedling percent and dry material percent of normal seedlings were calculated.

Data were analysed as a completely randomised design with two factors and 4 replicates. Statistical analysis were performed by a two-way analysis of variance followed by LSD mean separation test.

Results and discussions

Respiration-measurements. Measurements of long and short seedlings indicated the most seedlings after 8 days had more or less respiration, but some of them already had started photosynthesis. Significant relationship among the different treatments was not found. The checking of respiration of the treated germs must be repeated in a younger age of samples.

Water intake. Temperature and period of soaking factors, and their interactions had significant effects on water intake (Fig. 1). The increasing temperature from 5 to 15 or 20 °C

Figure 1 Water intake of imbibing pea seeds at different temperatures and soaking periods (+ significant differences are marked when compared with the lowest temperature, n=200)

increased significantly the rate of water intake after 4 and 8-hour imbibitions. At the higher temperatures the water absorption was similar. The effect of temperature on imbibition of pea seeds 'Farida' in this study can be accounted for primarily by changes in the viscosity of soak water and seed properties. This confirms the supposition by Murphy & Noland (1982) that imbibition should be dependent both on properties of the water as well as the seed.

Percent of germination. According to our results the treatments of seeds decreased the germination percents in general (Fig. 2). The greatest significant reductions at 10 °C with all soaking periods were established. The overall effect of increasing soaking temperatures, was an increased the percent of germination. At high soaking temperature the germination rate was higher compared with other samples of lower temperatures, but the percentage decreased at 20 °C

Figure 2 Germination percent of imbibed seeds after treatments at different soaking temperatures and periods (n=200, values related to the unsoaked control)

Figure 3 Seedling vigour of the treated germs imbibed at different soaking temperatures and periods (n=200, values related to the unsoaked control)

Figure 4 Dry matter content of the treated germs imbibed at different soaking temperatures and periods (n=200, values related to the unsoaked control)

with long (48 or 72 hours) soaking period. It seems that the optimal soaking temperature is 15 °C (Fig. 2).

Seedling vigour. The seedling vigour was not very different at the higher soaking temperatures, but the treatments at

20 °C temperature with 8 and 24 soaking periods proved to be optimal for seedling vigour (Fig. 3). At low soaking temperature the increase of the soaking period enhanced seedling vigour, but when the soaking time was short the vigour was low. We suppose that the low temperature and the short imbibition time can cause a leakage of the stored nutriment from the seeds resulting weak seedlings. Numerous authors suggested this explanation for the insufficient seedling vigour, but they found weak seedlings, only (Larson, 1968, Perry & Harrison, 1970, Murphy & Noland, 1982, Russo & Biles, 1996). Contrasting to our data, the higher soaking temperature resulted in better seedling vigours.

Mass of organic matter. Dry weight was determined in every treatment and no significant difference have been discovered (Fig. 4). A faint decreasing tendency of the mass loss appeared with increasing soaking time. However, the soaking temperature did not affect the change of in dry weight. Any significant relation between dry material content and seedling vigour percent could not be noticed.

References

- Bramleg, W. J. (1950): Relation of different gases to the soaking injury of seeds. Contr. Boyce Thompson Inst. P.L. Res., 16, 55-71.
- Kidd, F. and West, C. (1919): The influence of temperature on soaking of seeds. New Phytol., 18: 35-39.
- Larson, L. A. (1968): The effect of soaking pea seeds with or without seed coat on seedling growth. Plant Physiol., 34: 255-269.
- Norton, C. R. (1988): Change in survival of *Pisum sativum* seeds under water by free gaseous nitrogen, oxygen and carbon dioxide by urea peroxide addition to the soak water. Seed Sci. Technol., 16: 167-173.
- Perry, D. A. & Harrison, J. G. (1970): The deleterious effect of water and low temperature on germination of pea seed. J. Exp. Bot., 21: 504-512.
- Petrucelli, L., Perrino, P. & Herren, F. (1994): Ethylene and pea germination. Acta Hort., 362: 159-166.
- Powell, A. A. & Matthews, S. (1978): The damaging effect of water on dry pea embryos during imbibition. J. Exp. Bot., 29: 193-197.
- Russo, V. M. & Biles, C. L. (1969): Incubation temperature affects changes in cucumber seed proteins and mineral content. Seed Sci. Technol., 24: 339-346.
- Simon, E. W. (1974): Phospholipids and plant membrane permeability. New Phytol., 73: 377-420.
- Simon, E. W. & Raja Harun, R. M. (1972): Leakage during seed imbibition. Exp. Bot., 23: 1076-1085.
- Woodstock, L. W. & Tao, K. J. (1981): Prevention of imbibitional injury in low-vigour soybean embryonic axis by osmotic control of water intake. Plant Physiol., 51: 133-139.