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SEED GERMINATION RATES OF DIFFERENT COOL SEASON LEGUMES

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ABSTRACT

Temperature is the main factor affecting plant growth and development. Seed germination and seedling establishment are the most critical stages in the life cycle of plants For the purposes of the study, the germination temperatures of six cool-season legumes (*Vicia faba*, *Lens esculentus, Vicia sativa, Lupinus albus, Pisum sativum, and Lathyrus sativus*) important cultivars were determined. Seed germination rate was measured at different temperatures in the range 4-10 °C in a growth chamber with constant parameters (light, water) at three-day intervals for a period of three weeks. Each treatment was repeated four times for each temperature value, where 100 seeds were placed in five different separate glass made containers. The measurements were taken at three-day intervals. A seed was deemed to have germinated when at least 1 mm of radicle was visible. It was found that pea germinated faster than the rest cultivars under low temperatures, whereas *Vicia sativa* and *Lathyrus sativus* showed the slowest germination rates. The descending order of germination rate *Pisum sativum> Vicia faba > Lens esculentus> Lathyrus sativus >Vicia sativa>Lupinus albus*. Germination rate increased with increasing temperature for all cultivars. *Lupinus albus* was the legume seed with the less germination percentage. Therefore, temperature is the most limited factor on germination process and the increase of 4 degrees is enough to give better germination results. As a general conclusion, *Pisum sativum* and *Vicia faba* may satisfactorily germinate in rather cool micro-environments, and their sowing in the fall may be postponed for some weeks without substantial germination risk comparing to the rest legume cultivars.

Keywords: *germination rate, cool season legumes, temperature.*

INTRODUCTION

There are many factors affecting plant growth and most of them are important, but there is a primary one affecting the rate of plant growth and development and this is the temperature. There is a range of temperatures that differ among crop species throughout their life cycle and are primarily the phenological stages. Seed germination and seedling establishment are the most critical stages in the life cycle of plants (Walck et al., 2011; Baskin and Baskin, 2014). For each species, a defined range of maximum and minimum temperatures form the boundaries of observable growth. There is an index of cardinal temperature values for selected annual crops which are given fromHatfield et al. (2008, 2011, 2015) for different species. Legumes are crops that develop in cropping systems with relatively low inputs and are suitable to a more sustainable agriculture. Successful crop establishment, which is crucial for reliable plant production, depends on seed quality, environmental factors and genotypes. A review of the literature on legumes confirmed that the differences in the responses of the legume seeds and seedlings to different temperatures were associated with their geographic origin. The need for more sustainable cropping systems has attracted interest in growing such crops over larger areas in Europe. Seedling establishment is a crucial stage in crop production which influences variations in yield. A major change in the past 20 years in legume production has been to adapt earlier sowing dates to shift successful crop establisment (Vocanson and Jeuffroy, 2008). A consequence of earlier sowing is the exposure of seeds and seedlings to stressful cold conditions. A trend in the crop improvement is to breed seed legumes for frost tolerance during winter to enable even earlier sowing (Bourion et al., 2003; Vocanson and Jeuffroy, 2008).

Besides ecological factors, some seed characters are effective in legume crops growing in order to obtain a desirable yield and quality.

Since germination speed is very important for about earliness in the plant growing it can differ according to species, soil structures, sowing methods and especially temperature and soil moisture ratios. Knowledge of seed germination response to environmental factors is required not only for understanding and predicting the ecological adaptation of the species but also for formulating effective strategies for restoration.

The effect of temperature can be modeled by thermal time and predict seed germination progress well but also to provide “a measure of physiological time” and yield coefficients (Bradford, 2002).

The purpose of this study was to quantify the germination temperatures of six cool season legumes (*Vicia faba, Vicia sativa, Lens esculentus, Lupinus albus, Pisum sativum and Lathyrus sativus*) in a range of temperatures.

MATERIALS AND METHODS

This research was carried out in the laboratory of Agronomy and Applied Crop physiology in the University of Thessaly, Greece. The study was performed in a growth chamber adjusted to 4 different temperatures (4, 6, 8, 10°C) for six cool season legumes. Seeds were exposed daily to 12 hours of light with a mean photon flux density of 60 μmol m^{-} s^{-} (400-700nm). Each treatment was repeated four times for each temperature value. For each temperature treatment, 100 seeds were placed in five different separate glass made containers -11cm diameter- lined with 2 sheets of Watman No. 1 filter paper and closed with drying paper. The filter paper was moistened with a solution of 2 mmol/L $CaCl_2$ to facilitate imbibition. The trial was commenced as soon as the seed was exposed to the moist filter paper. The measurements were taken at three-day intervals. A seed was deemed to have germinated when at least 1 mm of radicle was visible. The number of germinants was measured at frequent and regular intervals by the rate of germination. The maximum germination percentage for each temperature treatment was calculated as the average of the four replicates. The rate of germination was taken as the reciprocal of the time at which 50% of this maximum germinant number was reached.

RESULTS AND DISCUSSION

As shown in Figure 1, the germination of six cool season legume seeds (*Vicia faba, Vicia sativa, Lens esculentus, Lupinus albus, Pisum sativum and Lathyrus sativus*) at 4 ^{o}C varied at different levels. The pea presented top germination as from the 3rd day showed rapid germination of seeds (about 23%), and on day 15 reached the final percentage. All the other legume seeds hierarchical followed: *Vicia faba* > *Vicia sativa* > *Lathyrus sativus* >*Lens esculentus* >*Lupinus albus*. Their germination percentage was about 98, 92, 65, 62, 58 and 50% respectively in the testing period of 21 days.

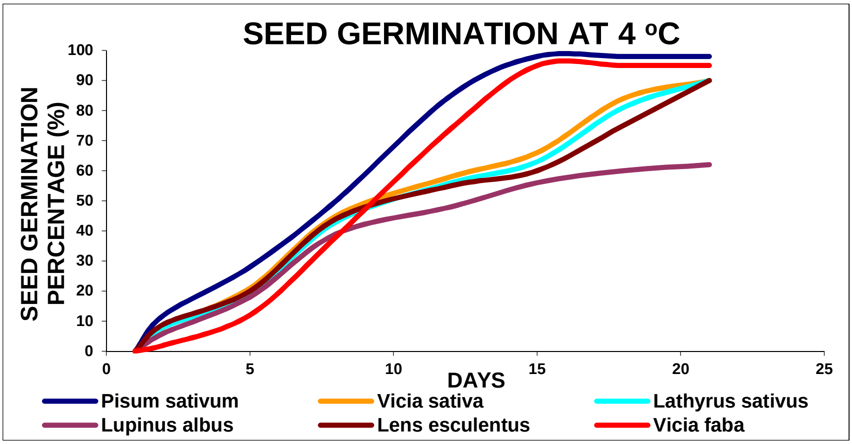

Figure 1. Seed germination percentage of six cool season legumes (*Vicia faba*, *Vicia sativa*, *Lens esculentus*, *Lupinus albus*, *Pisum sativum* and *Lathyrus sativus*) at 4°C.

Increasing the temperature by 2 degrees of Celcium (up to 6°C), the germination of the above six legume seeds (Figure 1) varied at different levels. Pea presented top germination as from the 3rd day increased the germination percentage up to 30%, while on the 15th day 15 reached the final percentage (98%). During the period of the first week (seven days) the germination of the seeds followed the above scheme: *Pisum sativum* >*Lens esculentus* > *Lathyrus sativus* > *Vicia sativa* > *Vicia faba* >*Lupinus albus*. The above scheme changed at the final percentage to: *Pisum sativum* > *Vicia faba* >*Lens esculentus* > *Lathyrus sativus* > *Vicia sativa* >*Lupinus albus, and their* germination percentage was about 98, 95, 95, 84, 74 and 65% respectively in the testing period of 21 days.

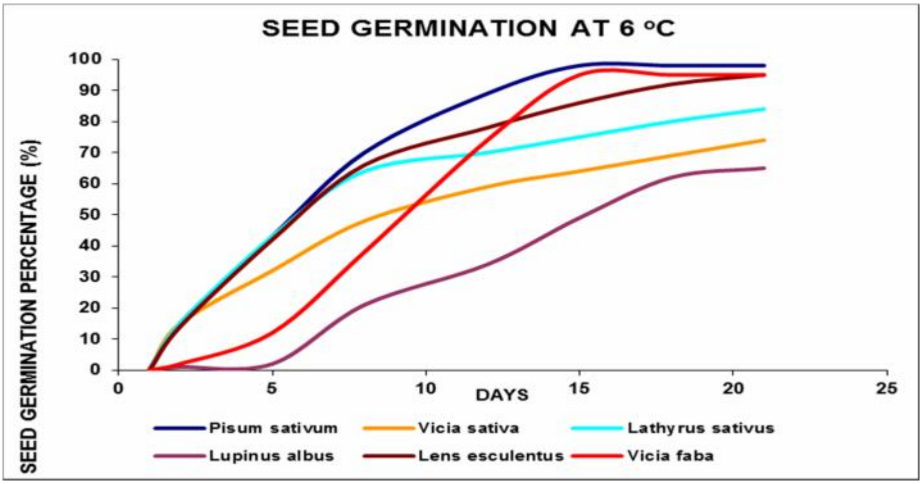

Figure 2. Seed germination percentage of six cool season legumes (*Vicia faba, Vicia sativa*, *Lens esculentus*, *Lupinus albus*, *Pisum sativum* and *Lathyrus sativus*) at 6°C.

As shown in Figure 3, the placement of seeds at a temperature of 8 ^{o}C showed similar results for the pea where at the 9th day germinated 83 % of seeds while in case of vetch only the 50% of the seeds were germinated and in case of *Lupinus* the germinated percentage was even lower (25%). The hierarchy followed *Pisum sativum* at day 21 was: *Lens esculentus* > *Lathyrus sativus* > *Vicia faba* > *Vicia sativa* >*Lupinus albus*, while the germination percentages were 98, 91, 90, 84 and 81 %.

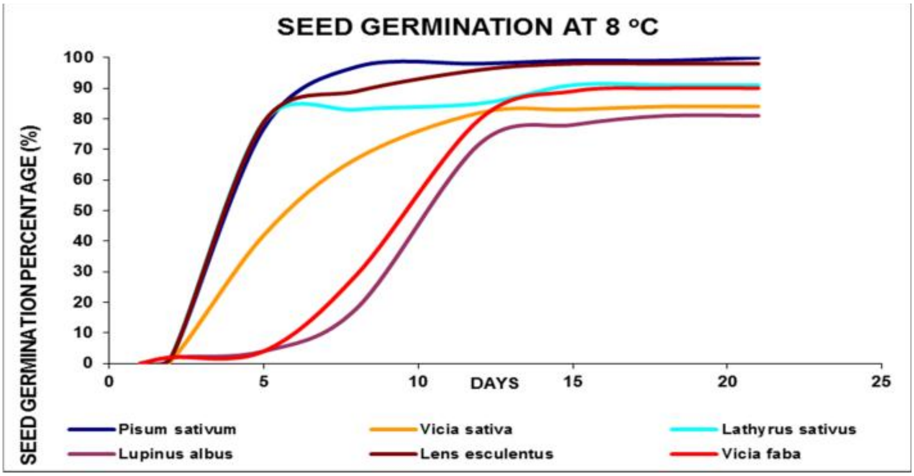

Figure 3. Seed germination percentage of six cool season legumes (*Vicia faba*, *Vicia sativa*, *Lens esculentus*, *Lupinus albus*, *Pisum sativum* and *Lathyrus sativus*) at 8°C.

Finally, increasing the temperature at 10°C as shown in Figure 4 accelerate the germination rate for all species. Specifically, all legume seeds reached the 50% of germination on the 4th day. In this case, the hierarchy that was noticed is: *Pisum sativum >Vicia faba > Lens esculentus > Lathyrus sativus > Vicia sativa >Lupinus albus.* In each temperature was noticed that pea reached the maximum germination while *Lupinus* the minimum. Moreover, only in the case of 10°C*Lupinus* was able to reach the final germination percentage of 82%.

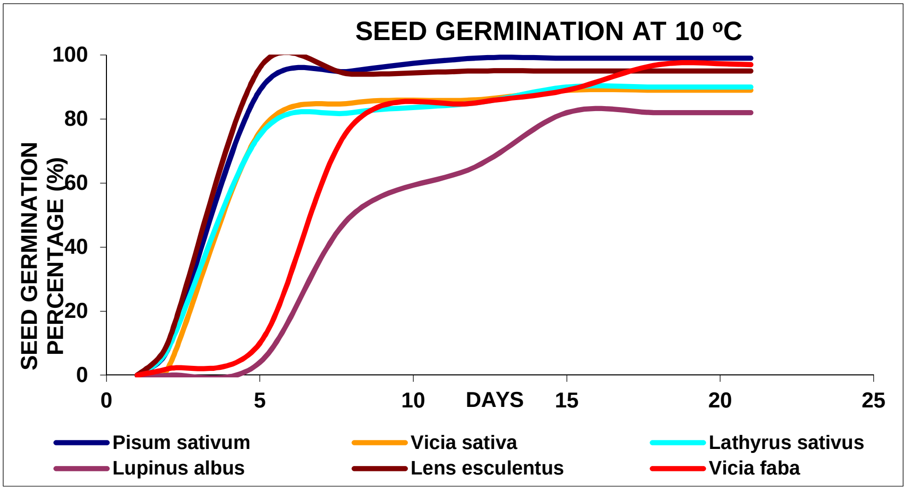

Figure 4. Seed germination percentage of six cool season legumes *(Vicia faba, Vicia sativa, Lens esculentus, Lupinus albus, Pisum sativum* and *Lathyrus sativus*) at 10°C.

CONCLUSIONS

Pisum sativum is the most vigorous seed at tested temperatures (4, 6 8, 10°C) of cool season legumes. On the other hand, *Lupinus albus* was found to have less seed germination percentage, and only at temperatures of8 and 10°C reached 80%.

In case of *Vicia faba* an important postpone appeared (a period of week to reach 50%) in germination. According to the above results, it is concluded that the temperature of 6°C represents the limit for the 50% of seed germination in a period of 15 days for *Vicia sativa, Lens esculentus, and Lathyrus sativus.*

The descending order of germination rate was *Pisum sativum>Vicia faba>Lens esculentus>Lathyrus sativus>Vicia sativa>Lupinus albus*.

As a general conclusion, *Pisum sativum* and *Vicia faba* may satisfactorily germinate in rather cool micro-environments, and their sowing in the fall may be postponed for some weeks without substantial germination risk comparing to the rest legume cultivars

Finaly, mostly *Pisum sativum* could be proposed as cultivation in Greece, especially in areas with altitude above 400m where the average temperature during the seedling period is about 5 to 6°C.

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