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Plant Physiology

Effects of Temperature and Gibberellic Acid (GA3) on seed Germination of *Vicia sativa, Chenopodium album and Physalis minima*

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Abstract

The interactions between temperature and GA3 are well known for their capacity to induce germination in dormant seeds of several weed plant species. In the current study, we investigated the effect of various temperature (10, 15, 20 and 25°C) and gibberellic acid (GA3) concentrations (50, 150, 250 and 350 ppm) on germination of *Vicia sativa, Chenopodium album and Physalis minima* seeds incubated under continuous dark or light were carried out in 8/16 hr light and dark. Germination counts were taken until Day 13. We found that incubation temperature and GA3 significantly enhanced seed germination, as maximum germination was observed for *V. sativa* (79% at 20°C), *C. album* (69.8% at 15°C), and *P. minima* (62% at 20°C) in such treatments. Exogenous GA3 significantly promoted germination of *V. sativa, C. album* and *P. minima*. It was found that GA3 was more effective in the presence of light as compared to dark condition and lowest germination was found in weed seeds at control.

Highlights

Interaction effects of temperature and GA3 of different concentrations with light and darkness breaks the dormancy of winter weed species.

Keywords: Germination, temperature, light, GA3

Not all seeds in the seed bank germinate in each growing season. A number of seeds will not be exposed to the correct combination of factors such as temperature, light, water and oxygen to cause germination. Seeds which are alive, but unable to germinate are considered dormant. Knowing how dormancy induction can be affected by environmental factors can help in the management of seed bank. Temperature substantially affects the dormancy level of weed seeds (Vidotto *et al.,* 2013). Some weeds require periods in which the temperature either increases or decreases slowly, whereas other species require daily temperature fluctuations or chilling to break dormancy (Baskin and Baskin, 2004). Dormancy is induced by darkness and keeps seeds from germinating in the fall immediately after dispersal (Pons, 1991). The induction of dark dormancy is faster at higher temperatures, but varies between species (Keshtkar *et al.,* 2008).

Plant-hormones are naturally occurring organic substances, which influence physiological processes at very low concentrations either in distant tissues to which they are

transported or in the tissue where synthes is occurred. Due to their structural simplicity, plant hormones are not specific enough to match the variety of controlled reactions. Gibberellins have a great effect on breaking the seed dormancy (Sawada *et al.,* 2008). Gibberellic acid (GA3) is also reported to reprogram plants to higher growth and significantly ameliorate the adverse effects of salt stress and rescue the productivity and quality of soybean (Hamayun *et al.,* 2010). This project aims to increase the information on the effect of temperature and Gibberellic acid (GA3) on seed germination rate and breaking dormancy of *Vicia sativa*, *Chenopodium album* and *Physalis minima*.

Materials and Methods

Preparation of seeds for treatment

The seeds of *Vicia sativa*, *Chenopodium album* and *Physalis minima* were collected from lentil field in BCKV farm, Nadia, West Bengal, India in the year 2012. Seeds were then dried at a moisture level of 35% for 10 days at laboratory and kept in air tight glass containers at 5°C. Hundred seeds of each weed species were placed in Petri plates with three layers of filter paper (Whatman No. 1) and moistened with 10 ml of distilled water. The Petri plates were wrapped in aluminum foil, covered with a black color cloth and transferred to incubator set at 20°C (Tang *et al.*, 2012). Germination tests were conducted for a period of 12–15 days. Each treatment comprised 4 replicates and was repeated thrice.

Experiment 1: GA3 concentration

The test seeds were soaked overnight in water between paper towels before the test. Samples were then placed in separate petri dishes with 3 filter papers wetted with different concentrations of gibberellic acid (50, 150, 250 and 350 ppm). In the control, filter papers were moistened with demineralised water. Germination tests were carried out in 8/16 h light and dark as well as under complete darkness. Germination counts were taken until Day 13.

Experiment 2: Application of temperature

The temperature treatment comprised temperatures ranging from 10 to 25°C at 5°C intervals.

Statistical analysis

The means and standard errors for all treatments were compared using Factorial RBD in order to define whether the differences were significant.

Results and Discussion

Effect of different temperature regimes on germination of winter weedy plant species

The degree of dormancy of a seed population establishes the width of the range of environmental conditions that allow germination. A low dormancy level is characterized by a wide range of environmental conditions permissive for seed germination, while seeds presenting a high dormancy level showed a narrow range of environmental conditions permissive for seed germination. Temperature has been identified as the main factor governing changes in the degree of dormancy in temperate environment.

From the experiment it revealed that the seeds of *Vicia sativa* and *Chenopodium album* germinated at 10 ^{0}C and the rate of germination was increased with temperature and highest germination was found at 20 ^{0}C for *Vicia sativa* and 15 ^{0}C for *Chenopodium album*. However, with a further increase in temperature the germination rate slowly declined and the least germination was observed when the seeds were placed at 25 ^{0}C. From the experiment it was clear that *Vicia sativa* seeds lost their ability to germinate < 10 ^{0}C or > 25 ^{0}C (Figure 1). While *Chenopodium album* seeds had the ability to germinate below < 10 ^{0}C due to some inherent characters but failed at > 25 ^{0}C (Figure 2). In case of *Physallis minima,* similar result was found as *Vicia sativa* (Figure 3). It was previously reported that at temperatures below the optimum, germination rate increases linearly with temperature (Kruk and Benech-Arnold, 1998); however, the current study showed that in weeds, at temperatures above the optimum, germination rate decreases linearly an increase in temperature. Our current findings confirm previous report on favorable role of temperature in seed germination Maraghni *et al.*,(2010).

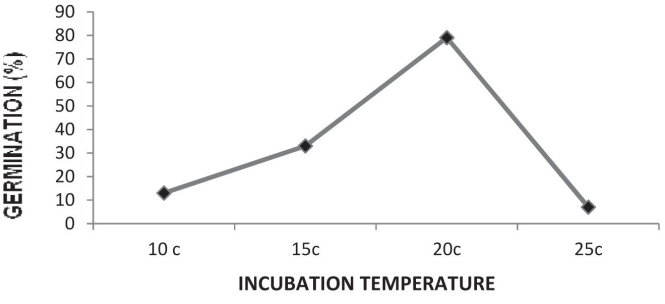

Fig. 1: Germination of *Vicia sativa* seeds at different temperature regimes.

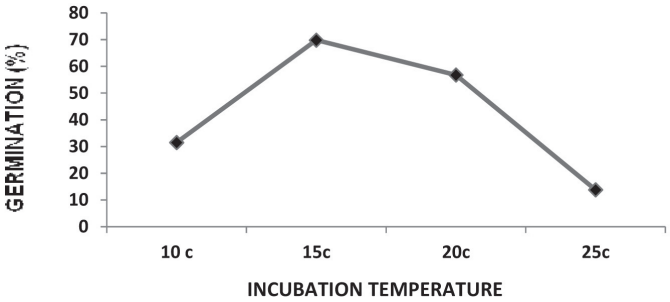

Fig. 2: Germination of *Chenopodium album* seeds at different temperature regimes.

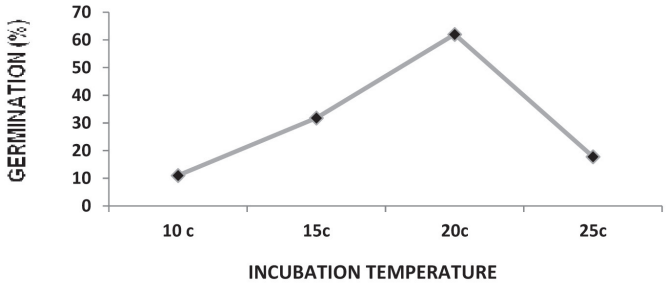

Fig. 3: Germination of *Physallis minima* seeds at different temperature regimes.

Effect of different GA3 concentration on germination of winter weedy plant species

GA3 is known for inducing seed germination in a wide range of plant species and when combined with light significantly affects seed germination. In the current study, exogenous GA3 applications induced higher germination in *Vicia sativa, Chenopodium album and Physallis minima*. All the concentration of GA3 (50 ppm, 150 ppm, 250 ppm, 350 ppm), significantly increased the germination of three winter weedy seed in complete darkness over the control.

Under light the GA3 concentration at 150 ppm, 250 ppm and 350 ppm had no significant effect on germination of those weedy seeds (Figs 4, 5 and 6). But at 50 ppm concentration of GA3, the germination under light was significantly higher than dark in all the cases. It reasoned the additive effect of GA3 over and above the light effect. Similar result was found by Laxman *et al.*, (2011) in *Solanum viarum*. Whereas under control condition the rate of germination observed very negligible in both dark and light (Figure 4, 5, and 6). Lack of germination in untreated seeds was the result of a combination of physiological dormancy and restricted water uptake caused by the funicular envelope, as reported earlier Orozco-Segovia *et al.*,(2007). The experiment coined that GA3 can almost totally replace the light requirement provided the concentration is high enough. GA3 concentration somewhat higher than 350 ppm may be required to gain highest germination but much lower than 1000 ppm concentration revealed by Hammond (1959). The current study found that the light and GA3 were highly interactive in germination of weed seed which was coincide with Tang *et al*., (2008).

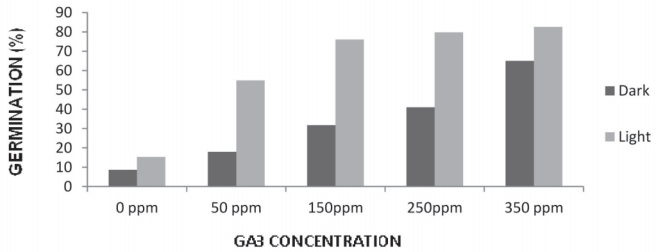

Fig. 4: Germination of *Vicia sativa* seeds at different GA3 concentration.

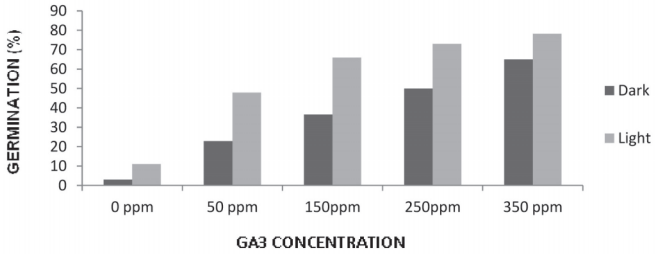

Fig. 5: Germination of *Chenopodium album* seeds at different GA3 concentration.

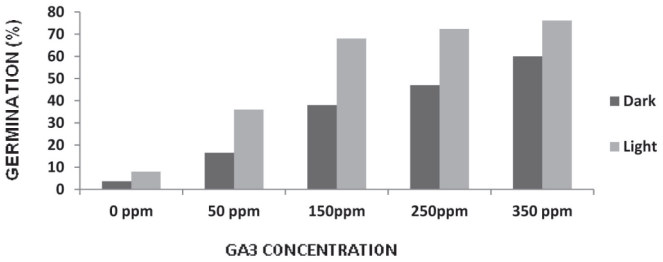

Fig. 6: Germination of *Physallis minima* seeds at different GA3 concentration.

Conclusion

Removal of weed from soil weed seed bank is a difficult task due to seed dormancy and can survive for many years. Thus the destruction of seed bank can be possible by breaking the seed dormancy either through environment or artificially. The current study will help in understanding the efficient role of temperature, GA3 of different concentrations along with light and darkness to break the dormancy of three winter weed species.

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