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STUDIES ON THE LIGHT SENSITIVITY OF PLANTAGO MAJOR L. SEEDS
I. THE EFFECT OF GIBBERELLIN, KINETIN AND POTASSIUM NITRATE

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Introduction

Plantago major L. seeds have been proved to be light-sensitive in such a way that they do not germinate practically in darkness (Tadros and Rezk, 1966). Stearns (1966) has also examined *P. major* seeds and has found that they germinated only at the rate of 4 % and 0 % in complete darkness at 60° F in two successive seasons.

Thus, it was thought convenient to study this phenomenon in some more details in order to elucidate the response of these seeds to the different agents. In this paper the effect of the most famous dormancy-breaking chemical substances will be experimented. These substances are gibberellic acid (GA_3), kinetin and potassium nitrate.

It is now a well accepted idea that the gibberellins especially gibberellic acid (GA_3) have a pronounced effect on the promotion of germination of dormant seeds, elongation of certain hypocotyls and stem segments. Thus Lockhart (1958) worked on the responses of higher plants to gibberellic acid and light and arrived to the conclusion that gibberellin reverses the light inhibition of etiolated stem growth in certain species. Alcorn and Kurtz Jr. (1958) found that the germination of Carnegiea gigantea seeds was promoted by red light and gibberellin (500—1000 p.pm.). Kahn (1960) working on the effect of gibberellin on lettuce seed germination reported also a similar favourable effect which was further reported by Lona for wild lettuce *(Lactuca scariola)* seeds having its dark germination promoted by gibberellin (citation from Kahn, 1960). This was confirmed by Ikuma and Thimann (1960).

In an article on the „Applied Aspects of the Gibberellins", Stuart and Cathey (1961) stated that the application of the gibberellin to dormant seeds promoted germination in an otherwise unfavourable en-

vironment. The also stated that the germination of light-requiring seeds of lettuce, *Parthenium argentatum* and *Lepidium virginicum* occurred in total darkness with an optimum concentration of gibberellin and that *Lepidium* seeds required a higher and very restricted range of gibberellin concentration for the promotion of germination. In another article on the „Dormancy in Higher Plants" Vegis (1964) described gibberellins as being the substances that may bring about temperature range widening for seed germination and bud break which are able to remove the block that prevents growth activity in wide limits of several conditions. He also stated that in usual cases, gibberellin might substitute for light in the promotion of germination of light-requiring seeds in darkness. Mittal and Mathur (1965) working on the effect of white light and gibberellin on tomato seed germination found that the latter promotes the germination of tomato seeds in dark and light and that the inhibitory effect of light was overcome by GA_3 treatment. Mc Donough (1965) found that both red light and GA_3 treatment increased the germination of *Verbascum thapsus* seeds in proportion to the doses applied. Westra and Loomis (1966) could break the dormancy of *Uniola paniculata* seeds by the application of GA_3 in a concentration of 100 p.p.m. They came to the conclusion that the gibberellic acid treatment accelerated and increased the germination of freshly harvested seeds in a moderate proportion to the concentration of GA_3 applied. Amen (1967) could break the dormancy of the completely dormant *Luzula spicata* seeds by scarifying the hylar end of the seed and applying gibberellin. Anyone treatment of these proved to be useless.

The work on the effect of kinetin (6-furfuryl-aminopurine) is rather more recent. Miller (1956, 1958 and 1961) gives a full report on this compound and its possible role in the promotion of seed germination. He suggested a similarity of the action of both red light and kinetin on lettuce seed germination with the only difference that the kinetin effect was not reversible by far red light. Skinner et al. (1958) stated that not only kinetin is effective in lettuce, carpet grass and clover seed germination but also some other 6-substituted purines have this property. Haber and Luippold (1960) found that lettuce seed germination could be stimulated by gibberellin, kinetin and thiourea, and concluded that kinetin can be considered as a true cell division factor. Khan and Tolbert (1965) found that red light and kinetin were able of reversing the effect of inhibitors of seed germination. Khan (1966) found that kinetin could break the dormancy of the upper seeds of *Xanthium pensylvanicum*. Knypl (1967) showed that kinetin in a concentration of 10^{-4}M is more effective than gibberellin at the same concentration in the reversal of the inhibiting effect of phosphon D (10^{-3} M) on the seeds of *Brassica oleracea* var. *acephala* and that kinetin was about 2.5 times more effective than gibberellin in the reversal of the synergistic inhibition of coumarin (100 p.p.m.) plus phosphon D on the germination of the same seed.

Potassium nitrate solution was also applied by some authors for the break of the light-sensitivity of some seeds (Toole et al. 1955; Alcorn et al. 1959).

Thus, the three substances were tested for their effect on the germination in darkness of *Plantago major* L. seeds.

Materials and Methods

In all the following treatments, seeds of *Plantago major* L. were provided from the University botanic garden in Szeged, a crop of 1967.

Gibberellic acid (GA_3, Phylaxia brand, Budapest) was used in this test. A series of concentrations expressed in p.p.m. was prepared beginning with a stock solution from which lower concentrations were prepared by appropriate dilutions. The concentrations were: 1000, 900, 800, 700, 600, 500, 200, 100, 50, 20 and 10 p.p.m.

Germination was carried out in 9.0 cm Petri-dishes in each of which were fitted two thicknesses of filter paper wetted with 6 ml of distilled water for the test solution. Fifty seeds were sown on each filter paper. Each treatment consisted of four replicates thus using 200 seeds, and the whole experiment was repeated twice. The Petri-dishes were kept in light-proof containers placed in an incubator the temperature of which was maintained at 25± 1°C for 10 hours and at 20± 1°C for 14 hours. The incubator contained fluorescent lamps delivering white light of 2000 lux for 10 hours daily serving as a light source for the control experiment. Two control sets with distilled water as imbibition medium were run simultaneously with the original experiment. The one was put in the light-proof container and the other was outside it, thus receiving 10 hours of white light per day.

After 15 days the germinated seeds were counted and their percentages thus calculated.

The above procedure was followed for testing the effect of kinetin on the germination in the dark of Plantago major seeds. Kinetin was „Sigma brand U.S.A.". Five concentrations were prepared in p.p.m. also for the sake of comparison. The concentrations were 100, 50, 20, 10 and 1 p.p.m. The experiment was run in the same number of replicates and controls as described before for the gibberellic acid experiment.

Working with potassium nitrate only one concentration (0,2 % solution) was prepared as recommended by Toole et al. (1955).

Results and Discussion

The effect of gibberellic acid treatment is graphically expressed in Fig. 1. Each of the points is the mean of eight replicates. It is clear from the figure that there is an increase in the dark germination of *P. major* seeds with the increase of gibberellic acid concentration to a maximum of 96 % attained at the concentration of 800 p.p.m. The changes at higher concentrations are negligible. It was noticed that although the highest concentrations of gibberellic acid gave the highest germination percentages yet they resulted in a restricted growth of the emerged radicles in such a sense that the seedlings produced at lower concentrations were larger in size. The control values were 4 % and 87 % germination in dark and light respectively.

The response of *Plantago major* seeds to gibberellic acid treatment resembles that previously achieved by *Lactuca sativa* seeds var. „Grand Rapids" which were the field of many research works because of their

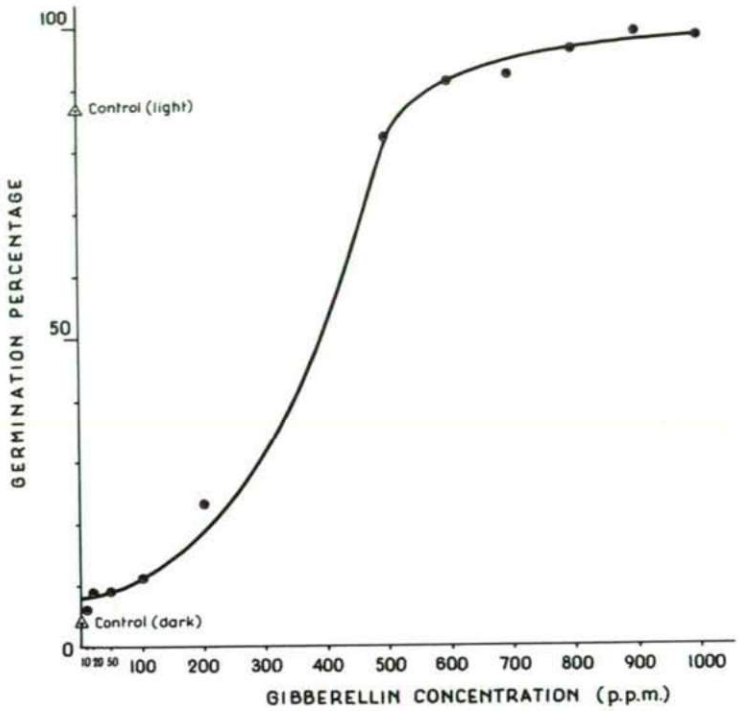

Fig. 1. Effect of gibberellic acid concentrations on the germination of *Plantago major* seeds in the dark.

light sensitivity. The results iven here coincide with those arrived at by many other authors. Thus Kahn (1960), Lona (1956) and Ikuma and Thimann (1960) emphasised the promoting effect of gibberellic acid on the germination of seeds of different species of *Lactuca*. The latter authors mentioned that a maximum germination was attained in the dark by imbibing the seeds of *L. sativa* in 100 p.p.m. gibberellic acid. But the seeds of *Plantago major* required a higher concentration of gibberellic acid and in this respect resemble those of *Saguaro cactus (Carnegiea gigantea)* as mentioned by Alcorn and Kurtz Jr. (1959). These latter seeds needed a concentration of gibberellic acid of 500—1000 p.p.m. to show a rise in the germination percentage.

The same promoting effect of gibberellic acid has been reported for seeds of *Verbascum thapsus* L. by Mc Donogh (1965), for tomato by Mittal and Mathur (1965), and for *Uniola paniculata* by Westra and Loomis (1966). The seeds of the latter species needed only 100 p.p.m. of gibberellic acid for the promotion of their germination, a concentration that raised the germination percentage of *P. major* seeds in the dark from 4 % to 11 % only. But with *Luzula spicata* seeds gibberellic acid failed to promote germination unless a hylar scarification was carried out (Amen, 1967).

Thus gibberellic acid has promoted the germination of *Plantago major* seeds in darkness which normally does not occur. In this respect it coincides with the statement of Stuart and Cathey (1961) in

that it promotes germination in an otherwise unfavourable environment. According to these authors *Lepidium virginicum* seeds needed a hight concentration of gibberellic acid and thus resembling those of *Plantago major* seeds in darkness which normally does not occur. In this respect requirement of these seeds thus confirming the statement of Vegis (1964) in this respect.

Table I. The effect of different concentrations of kinetin solutions on the germination of *Plantago major* seeds in the dark.

Concentrations of kinetin solutions (p.p.m.)	Germination Percentages
100	1,50
50	0,50
20	0,50
10	1,50
1	1,50
Dark control	4,00
Light control	86,75

The experiment with kinetin gave different results. These are shown in Table I. It can be observed that kinetin did not promote the dark germination of *P. major* seeds and even has expressed an inhibitory effect in such a way that the percentages of germination were lower than that of the dark control imbided in distilled water. In this respect these results differ from those given by other authors working on the effect of kinetin on the dark germination of many seeds like Miller (1956, 1958, 1961), Skinner et al. (1958), Haber and Luippold (1960), Khan and Tolbert (1965) and Khan (1966). Anyhow kinetin is not always a promoting agent for different plant tissues. It has been reported to have an inhibitory effect on the elongation of stem sections (De Ropp, 1956). This is in concordance with our results arrived at here with *Plantago major* seeds.

Potassium nitrate solution (0,2 %) gave no effect at all. This result does not coincide with those previously reported for *Carnegia gigantea* seeds by Alcorn and Kurtz Jr. (1959) who could break the light sensitivity of those seeds by imbibing in solutions of 0,05—0,4 % KNO_3. Also Toole et al. (1955) mentioned that the use of KNO_3 solution alone could promote the germination of seeds of *Lepidium* species.

From the foregoing discussion it can be concluded that *Plantago major* seeds have their own needs of germination promotion. While their germinaton is largely promoted in the dark by high concentrations of gibberellic acid, we find that kinetin and potassium nitrate solutions had no promoting effect at all and the former had even an inhibiting effect.

Abstract

Plantago major L. seeds do not germinate normally in complete darkness. Three different chemical germination promoting agents were used in order to fulfill this light requirement.

Gibberellic acid (GA_3) gave a promoting effect that increased with increase of concentration.

Kinetin did not promote the germination of these seeds and even an inhibiting effect was observed.

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