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Effect of Sodium Humate on Swelling and Germination of Winter Wheat

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Vliv Na-humátu na bubření a klíčení ozimé pšenice

V práci byl studován vliv humátu sodného na bubření a klíčení ozimé pšenice Pyšelka (*Triticum vulgare* VILL.) a sledována změna intensity dýchání bubřících obilek v prvých 24 hodinách bubření.

Bylo zjištěno, že Na-humát v koncentraci 100 mg/ml urychluje v prvé fázi bubření příjem vody bubřícími obilkami. Tím, že obilky přijmou dříve dostatečné množství vody, dochází u nich dříve k aktivaci enzymatických systémů, zabezpečujících zdárný průběh klíčení, což se projeví zvýšením intensity dýchání. Energie uvolněná dýcháním může být využita k rychlejšímu růstu embrya, což se projeví morfologicky v rychlosti klíčení.

Summary

Experiments on the effect of sodium humate on the swelling and germination of the winter wheat Pyšelka (*Triticum vulgare* VILL.) and on the changes in respiration intensity of swelling seeds during the first 24 hours of swelling, are described.

It was found that sodium humate at a concentration of 100 mg./l. accelerates the uptake of water by swelling seeds during the initial phase of swelling. The fact that the seeds take up a sufficient amount of water sooner makes it possible for the activation of enzyme systems which ensure normal germination to take place, thereby bringing about an increase in respiration

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intensity. The energy released during respiration is then utilized for more rapid growth of the embryo which is morphologically reflected in the rate of germination.

Introduction

Agricultural and especially horticultural practice as well as numerous theoretical treatises by authors in all fields of agrobiology and plant physiology supply convincing evidence that humus substances, applied in the most varied form, stimulate plant growth. Since under natural conditions the plant comes into close contact with humus substances of the soil even before its development is morphologically expressed, i.e. during the swelling and germination of the seed, some plant physiologists are beginning to pay more attention to the way in which humus substances affect these processes.

FLAIG and SAALBACH (1955) maintain that at a certain concentration of thymohydroquine, taken to represent a degradation product of artificial humic acid, the uptake of water by swelling wheat seeds is enhanced. They explain this observation by assuming that the water uptake by the seed is directly related to the intensity of respiration which is increased due to thymohydroquinone. Thymohydroquinone which, in natural systems, is in equilibrium with thymoquinone and acts as a redox system (thymohydroquinone *W* hydroquinone), is a hydrogen carrier and supports dehydrogenase systems in the respiratory processes. According to these authors the energy released by respiration is utilized for the uptake of more water. The increased respiration intensity thus brings about an increase in water uptake by swelling seeds and results in accelerated germination.

TICHÝ and CHALUPOVÁ-JANOVICOVÁ (1958), who studied the effect of humus substances on the germination and growth of some crop plants, have found that the energy of seed germination depends on the amount of humus substances in the soil. Different species and varieties of plants differ in their sensitivity toward humus substances and thus possess different requirement with respect to their amount in the soil. The reaction of plants to humus substances of the surrounding substrate changes in the course of plant development which is doutless connected with the changes in their metabolism. The effect of humus substances is not reflected to the same degree in all plant organs. In the experiments of the above authors humus substances were more effective on the growth of the overground parts of the plant than of the roots.

GELLER and LITINSKAYA (1951) nad GELLER (1953) reached the conclusion that humus and other organic substances of the soil increase the germination capacity and sprouting of seeds at a certain soil humidity. The effectivity of these substances depends on the redox potential of the soil. During seed germination substances required for growth of the sprouts are synthesized at the expense of the reserve substances of the seeds which are then hydrolyzed by a number of enzymes. Under optimal conditions the processes of hydrolysis and synthesis maintain a certain equilibrium depending not only on the action of specific activators of enzyme systems but primarily on the redox potential of the medium. A medium with a low redox potential enhances the processes of hydrolysis while a high redox potential favours the synthetic processes. For this reason, both a high and a low redox potential will inhibit seed germination. The organic substances of the soil—the humus and others—display a stimulating effect only at a certain soil humidity (about 50% full water capacity of soil) and an inhibitory effect at a low water content of

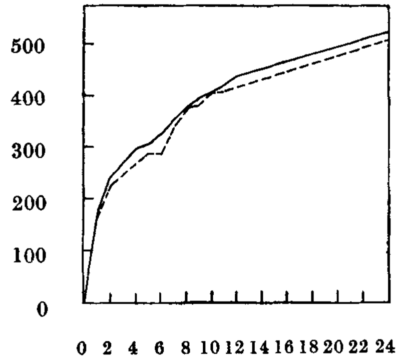


Fig. 1. Amount of water taken up by 1 g. seeds of winter wheat in mg.

Abscissa: time in hours; ordinate: mg. water/g. seeds before the experiment. Seeds swelling in distilled water - - - - - - - -; seeds swelling in 100 mg./l. sodium humate ———.

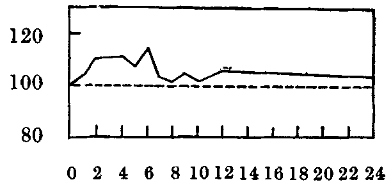


Fig. 2. Amount of water taken up by 1 g. seeds of winter wheat in % of control.

Control = 100% = amount of water taken up by 1 g. seeds swelling in distilled water. Abscissa: time in hours; ordinate: % control. Symbols as in Fig. 1.

the soil (high redox potential) as well as at a high water content (above 70 % when the soil redox potential is low).

Volná and Dlouhý (1956) and Prát (unpublished) have observed an increase in the germination capacity and rate of germination of seeds on soaking in an extract of humus substances.

As the author had previously studied and demonstrated a stimulating effect of sodium humate on the growth of young plants of winter wheat, maize and pumpkin and on the respiration of their roots (Šmídová 1960a, b) it appeared to be of interest to establish whether humate influences the swelling and germination of seeds.

Material and Methods

In the experiments carried out in 1959, seeds of winter wheat Pyšelka (*Triticum vulgare* Vill.) from the 1958 harvest were used; their germinating power under the laboratory conditions was 98—99%.

The solution of sodium humate was prepared from a commercial preparation of humic acid (Humussäure Riedel de Haen AG Selze Hannover) as described previously (Šmídová 1960b). The t-test was used for statistical evaluation (Hrubý 1950).

Swelling. One-hundred weighed seeds were left to swell in a flask with 20 ml. distilled water or solution of sodium humate (100 mg./l.) at 26° C in a thermostat. At time intervals of 30 to 60 min., the amount of water taken up by the seeds was estimated by weighing. For the sake of comparison the amount of water taken up is referred to 1 g. seed weight before the start of the experiment. The results shown represent averages from five expeeriments.

Respiration of swelling seeds. The respiration intensity of swelling seeds was determined by means of the Q_{O_2} using the direct Warburg method at 26° C. Warburg flasks contained 30 weighed seeds each. After equilibration, 2 ml. water or 100 mg./l. sodium humate was added from the side arm. During the 25 hours of the experiment hydroxide in the central well was replaced

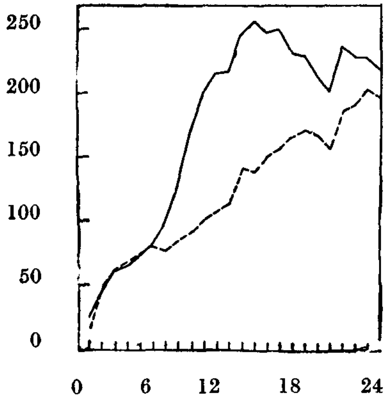
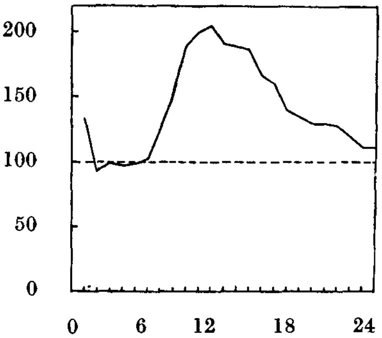


Fig. 3. Utilization of oxygen by swelling seeds of winter wheat. QO_2 in µl. O_2/1 g. dry weight/10 min.

Abscissa: time in hours; ordinate: µl. O_2/g. dry weight/10 min. - - - - - - - - QO_2 of seeds swelling in distilled water % control. ——— QO_2 of seeds swelling in sodium humate (100 mg./l.).

Fig. 4. Utilization of oxygen by swelling seeds of winter wheat in % control.

Control = 100% = QO_2 of seeds swelling in distilled water, - - - - - -; QO_2 swelling in 100 mg./l. sodium humate ———. Abscissa: time in hours; ordinate: % control.



four times. The QO_2 is expressed as µl. O_2/g. dry weight/10 min., representing an average of six estimations.

The energy of germination. The energy of germination was determined in a thermostat at 26° C. Petri dishes 9 cm. in diameter contained 100 seeds of winter wheat with 10 ml. distilled water added in the control and sodium humate (100 mg./l.) added in the experimental set. The experiment was carried out in 5 parallels. The number of seeds germinated was estimated after 12, 24 and 48 hours, starting at the time of adding the liquid.

Results

Swelling:

It follows from Figs. 1 and 2 that there is no significant difference in the amount of water taken up by seeds swelling in distilled water (control) and those swelling in a solution of sodium humate. Greatest differences (18%) were found during the period between the 2nd and 6th hour after adding the liquid. Even these differences, however, are barely on the border of significance. The differences found before the 2nd and after the 6th hour are within the variation range and thus mostly not significant. It may be concluded that if sodium humate affects water uptake by swelling seeds of winter wheat it happens mainly during the first phase of swelling.

Intensity of respiration of swelling seeds of winter wheat:

It may be seen in Figs. 3 and 4 that during the 6 hours of the experiment there are no essential differences in the uptake of oxygen by swelling seeds of the control and of the humate variant. During the 2nd to 6th hours of the experiment a higher Q_{O_2} may be found in the control variant but the differences between the control and humate variants are minute and non-significant throughout (Fig. 4). Beginning with the 7th hour the Q_{O_2} of the humate variant rises much more than in the control. The differences here are highly significant and reach a maximum during the 11th hour of the experiment when the humate Q_{O_2} is 2·04 times greater than that of the control. Beginning at the 12th hour the differences between the variants gradually decrease and during the 24th hour the difference is no longer significant even if the humate Q_{O_2} is still higher than that of the control.

Maximum Q_{O_2} was reached by the humate variant during the 14th hour whereafter the intensity of respiration gradually decreased. On the other hand, in the control variant the intensity of respiration increased much more slowly but quite uniformly for the whole duration of the experiment.

Table 1. Energy of germination of the winter wheat Pyšelka

Sodium humate mg./l.	0		100	
Hours	Number of germinated seeds	%	Number of germinated seeds	%
12	29 ± 3 . 1·00	100	33 ± 3 . 1·33	114
24	77 ± 3 . 1·33	100	85 ± 3 . 1·66	110
48	86 ± 3 . 1·33	100	91 ± 3 . 1·33	106

Germination energy:

As may be seen from Table 1 the energy of germination of winter wheat rises due to the solution of sodium humate. The differences in the number of germinated seeds between the control and the humate variants are significant for the whole duration of the experiment (48 hrs.) even if decreasing with time. Greatest differences were found after 12 hours from the beginning of the experiment when the number of seeds germinated in the humate variant amounted to 114% of the control.

Discussion

For seeds to be able to germinate it is necessary for them to take up a certain minimum amount of water, which, other conditions being optimal, will ensure full development of all the enzymic systems of this complex physiological process. It thus appears to be probable that the first to germinate will be the seed which has taken up sufficient water ensuring the progress of enzymic processes. The activation of enzymic systems participating in the germination processes will also be reflected in increased respiration intensity.

If the rate of swelling of wheat seeds, their respiration intensity and the germination energy of the control and humate variants are compared it may be seen that the greatest difference in water uptake by swelling seeds was reached during the first six hours of the experiment. During this period the water uptake by the humate variant seeds is as much as 18% higher than the control. It appears that the amount of water taken up during this time period suffices for the activation of enzyme systems and for the full development of all processes necessary for germination. The increased respiration intensity indicates that during this time the redox the enzyme systems have under gone full development. In the control variant where the uptake of water was slower, the activation of the enzyme systems proceeded more slowly as exhibited by the lower respiration intensity. This view is supported by the steep rise in respiratory intensity in the humate variant which starts during the 7th hour of the experiment. On the other hand, in the control variant the respiratory intensity of swelling seeds is slower in rising but it rises uniformly and gradually for the whole duration of the experiment. The greatest difference in oxygen uptake observed between the humate and control variant was reached during the 11th hour of the experiment when the humate variant amounts to 204% of the control. The energy produced by respiration can be used for cell division and embryo growth which it morphologically reflected in sprout growth. During the 12th hour of the experiment the number of germinated seeds in the humate variant amounts to 114% of the control. This difference, like that in the respiratory intensity, decreases in the course of the experiment. Seemingly, the percentual difference in the number of germinated seeds between the control and humate varieties (14%) does not correspond to the percentual difference in respiratory intensity (104%) but it is generally known that before any change in the organism is exhibited morphologically it must be reflected in changes in metabolic processes. Thus the increased respiratory intensity during this period points to the physiological preparatory stage of the humate variant seeds prior to germination which could not yet find its morphological expression on account of shortage of time.

The results of the present experiments with the effect of sodium humate on swelling of wheat seeds closely resemble those of Flaig and Saalbach (1955) who used thymohydroquinone. The results concerning the effect of sodium humate on the respiration of swelling seeds are at variance with those of the two authors with respect to the rate and intensity of reaction. While in their experiments, during the second hour the respiratory intensity of the thymohydroquinone variant exceeded that of the control seven fold and decreased gradually afterwards, the maximum difference in the present experiments was only 204% of the control variant value. It is thus not considered justified to accept the theory of Flaig and Saalbach (1955) that the primary process here is the increase in respiration to be followed by the increased uptake of water by the seed. On the contrary, it appears to be most probable that the accelerated uptake of water is primary to be followed by an increased respiratory intensity. The energy released by respiration is utilized for growth of the embryo, for more rapid germination.

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Влияние Na-гумата на набухание и прорастание озимой пшеницы

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В работе изучалось влияние Na-гумата на набухание и прорастание озимой пшеницы Пышелка (*Triticum vulgare* VILL.) и изменение интенсивности дыхания в первые 24 часа прорастания.

Установлено, что Na-гумат в концентрации 100 мг/л ускоряет в первой фазе набухания прием воды набухающими зерновками. Так как зерновки раньше получат достаточное количество воды, раньше у них активируются энзиматические системы, что проявляется повышением интенсивности дыхания. Энергия освобожденная дыханием может быть использована к более быстрому делению клеток и росту зародыша, что морфологически проявляется в скорости прорастания.