EFFECT OF VERNALIZATION ON HEAT RESISTANCE IN TWO VARIETIES OF PEAS [1]

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Practically all studies of vernalization have been concerned with the induction of a reproductive system. In a few cases, however, it has been shown that a period of cold given during germination will affect the subsequent growth and developmental behavior of the plants, independent of the flowering response. In winter Petkus rye, Gregory and Purvis (2) have shown that there is a reduction in tiller number as a consequence of a cold treatment. Although it is difficult to separate the flowering effects from the vegetative ones in this grass, there are indications that the effect on vegetative development may in fact be independent of the flowering behavior. Highkin (3^3) has shown that in peas vernalized in such a manner as to prevent the hastening of flowering, growth is suppressed as a result of that vernalization treatment.

The after effects of a cold treatment are also apparent in the response of oats to high temperature. Coffman (1) has shown that spring varieties are less heat resistant than winter varieties. His data also show that a cold treatment given prior to a high temperature treatment will increase the heat tolerance of the winter varieties.

Thus it appears that the changes occurring in the plant during vernalization, of which we know literally nothing, have a profound effect on the plant as a whole and are apparently independent of the effects on flowering behavior.

The present paper is concerned with the relationship between vernalization and heat resistance in two varieties of peas.

Materials and Method

Two varieties of peas were used in these studies: one a vernalizable, heat sensitive variety, Unica, the other a non-vernalizable, heat resistant variety L_5. The plants were grown in the controlled environmental conditions of the Earhart Laboratory of the California Institute of Technology. Seeds of both varieties were soaked in water until completely imbibed (4 to 5 hours). They were then planted in individual 9 ounce containers in a 50-50 mixture of vermiculite and crushed rock (based on volume). This mixture was watered with Hoagland's solution whenever necessary. The planted containers were stored in the dark at 4° C for 25 days. This period has already been shown (3^3) to be of sufficient length to elicit maximum flowering and growth response in the vernalizable variety, Unica.

After 20 days the control seeds of both varieties were soaked in water and put to germinate at 23° C. In five days the control seeds had germinated to approximately the same degree as the cold-treated seeds had germinated in 25 days, i.e. they had just emerged.

After 25 days at 4° for the treated plants and 5 days at 23° for the controls both groups of plants were randomized and put into an artificially lighted chamber set at 26° C ± 1° C with a 16-hour photo period. The light intensity was approximately 1,000 to 1,200 ft-c. The number of leaves and stipules showing necrosis was taken as a measure of heat damage.

Results

The results of these experiments are shown in table I. Vernalized plants were considerably less necrotic than controls in both varieties (columns 1 and 2 of table I).

The data presented in columns 3 and 4 show that the first node to flower in the heat susceptible variety

Table I.

Effect of Vernalization Treatment on Heat Injury and Flowering in Vernalizable and Non-vernalizable Strains of Peas

Variety	Heat injury*		1st flowering node**	
	Exp. 1	Exp. 2	26°	20/14
Unica				
Vernalized	6.5 ± 0.38	5.9 ± 0.44	19.0 ± 0.75	16.0 ± 0.57
Unvernalized	18.3 ± 1.01	16.1 ± 0.69	19.5 ± 1.0	18.6 ± 0.52
L_5				
Vernalized	8.2 ± 1.93	10.0 ± 0.46	9.6 ± 0.17	9.3 ± 0.52
Unvernalized	17.1 ± 0.77	19.9 ± 0.67	9.2 ± 0.16	9.1 ± 0.1

* Grown at 26° C. Figures given are mean number of necrotic leaves and stipules/plant ± standard error. Minimum number of plants/treatment = 18.

** Average 1st flowering node ± standard error. Minimum number of plants/treatment = 9.

[1] Received April 4, 1959.

[2] This work was supported in part by the National Science Foundation (grants G-1385 and G-6153).

[3] All figures in the 1956 paper, reference (3), should have read "cm" instead of "mm".

Unica, was significantly lowered when grown at 20° C day temperature with a 14° C night following vernalization. The vernalization treatment was without effect when the treated plants were subsequently grown at 26° C due to devernalization at this high temperature (3^3). The data also show that vernalization had no effect on the flowering of the heat resistant variety L_5 at either of the temperature environments.

Thus it seems that the physiological effects of an inductive cold treatment on flowering and on development of heat tolerance are independent.

The variety L_5 is classified as being heat resistant primarily because of its ability to complete a life cycle at high temperatures (as high as 30° C in artificial light) in a relatively short time—approximately four weeks. Nevertheless, heat resistance seems to break down with the onset of flowering, in that necrosis develops and the resulting seed are inviable. The physiological events leading to this inviability must have occurred prior to pod formation for high temperature grown plants which were removed to a normal temperature (20° C day, 14° C night) immediately following flower formation, failed to produce viable seed.

The breakdown of heat resistance in L_5 is prevented by vernalization just as in the case of the heat susceptible variety Unica, where vernalization reduces the high temperature damage and permits the development of viable seed. In the unvernalized controls of Unica, no seeds are formed at high temperature.

In both varieties, each plant that had been previously vernalized, formed at least one pod at the high temperature. There was an average of three viable seeds per plant. The size of the seeds was approximately one half that of seeds from plants grown at 20° C day, 14° C night.

Discussion

The experiments reported here extend those of Coffman (1), Gregory and Purvis (2) and Highkin (3^3) in showing that vernalization has a much more profound effect on the plant than has been generally recognized. Vernalization leads to changes in the plant other than those associated with the process of reproduction. The present experiments show that at least one of these changes is a marked increase in heat resistance. That the induction of heat resistance is independent of the induction of the floral stimulus is indicated by the fact that even in the strain considered to be non-vernalizable so far as flowering is concerned, vernalization does have an effect in decreasing heat damage to the leaves and stipules as well as permitting the development of viable seeds.

Again, independence of heat resistance from the induction of flowering is indicated in the response of the susceptible, vernalizable variety, Unica. In this variety the first node to flower is not lowered, as would be expected from vernalized plants when these plants are subjected to a high temperature immediately following the cold treatment. Thus devernalization with respect to flowering occurs, while devernalization with respect to heat resistance is not observed under the same treatment.

Summary

The effect of a cold treatment on the response of pea plants to high temperature has been studied. It was found that there is a marked increase in heat resistance as a result of a cold treatment. The induction of heat resistance as a result of vernalization appears to be independent of the induction of the floral stimulus resulting from such a treatment. This is indicated by two observations: 1) Vernalization does have an effect in decreasing heat damage as well as effecting seed viability in a strain of peas which is non-vernalizable so far as flowering is concerned. 2) In a strain which is vernalizable, high temperature devernalizes with respect to flowering. However, vernalization markedly increases the heat resistance of this strain.

Literature Cited

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