THE ARTIFICIAL GERMINATION OF MAIZE POLLEN

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While the pollen of many kinds of plants germinate very well in water or even in moist air, others require the presence of certain substances in solution. A sugar solution offers such a medium in quite a number of species while in other cases this must be either replaced or else combined with some other substance, sometimes organic, sometimes inorganic, in nature. In some instances a decoction of the stigmatic parts has been found to be essential in inducing germination of the pollen.

Although certain authors have claimed to have successfully germinated maize pollen, attempts to repeat their work have resulted only in failure for us, altho we have tried repeatedly with a considerable number of different substances used as substrata.

Immersed in water, the pollen grains rapidly absorb moisture until they suddenly burst. The same is true in the case of many solutions, although this action is more or less retarded. With other solutions, instead of this sudden rupture, the pollen cells were seen in the course of a few minutes to eject long streams or sprouts of protoplasm, often curling and twisting in all directions, and with such force as to throw the pollen grain backward in recoil. These filamentous ap-

*The data for this report were collected by the junior author in connection with a thesis entitled "The Physiology of the Pollen of Zea Mays with Special Regard to Vitality."

TABLE I.

Germination Experiments in Single Solutions

Solution	Concentration 5%	10%	15%	20%	25%	30%
Sucrose	Burst	Burst 20%	Burst 10%	Burst 10%	Burst 4%	Turgid
Lactose	Burst	Burst 60%	Burst 60%	Burst 60%	Burst 50%	Burst 20%
Maltose	Burst	Burst 60%	Burst 60%	Burst 60%	Burst 60%	Burst 20%
Dextrose	Burst	Burst 80%	Burst 80%	Burst 60%	Burst 60%	Burst 20%
Levulose	Burst	Burst	Burst 80%	Burst 80%	Burst 70%	Burst 60%
Arabinose	Burst	Burst 90%	Burst 90%	Burst 80%	Burst 60%	Burst 40%
Glycerine	Burst 20%	Burst 20%	Burst	Burst	Burst	Burst
Gelatin	Burst	Pseudo-germi'tion	Turgid Pseudo-germi'tion	Turgid Pseudo-germi'tion	Turgid Pseudo-germi'tion	Turgid Pseudo-germi'tion
Gum Arabic	Burst 40%	Pseudo-germi'tion	Pseudo-germi'tion	Pseudo-germi'tion	Pseudo-germi'tion	Pseudo-germi'tion

pendages varied in length, being sometimes from 25 to 30 times as long as the diameter of the pollen grain itself. Some were very slender and threadlike, others were proportionately thicker. To this phenomenon we have applied the name "pseudo-germination" Altho at first sight this protoplasm expansion might be mistaken for germination tubes, closer examination easily reveals the distinction, for they lack most of the essential characteristics. In the first place the expansion is far too rapid to represent actual growth. Then there is no enveloping membrane surrounding the protoplasmic substance as in the true germination tube. The resemblance is close enough,

however, to suggest the possibility of this phenomenon having been mistaken for real germination in some of the previously reported work referred to above.

It is interesting to note that only fresh pollen is able to send out these protoplasmic sprouts, old pollen remaining turgid and inactive.

METHODS

For this investigation fresh pollen was used, the tassels being collected and brought into the laboratory early in the day of the experiments. The observations were made by means of the hanging drop cultures. The special precaution against the use of impure water in making up the solutions was taken by redistilling the water from glass vessels.

RESULTS

We first tried a series of simple solutions taken in varying strength from 5 to 30 per cent, and table I gives the results.

TABLE II.

Germination Experiments in Mixed Solutions

Solution	Concentration	Behavior
Sucrose Lactose	10% 10%	In 20 minutes 50 % burst
Sucrose Lactose	15% 15%	In 20 minutes 20% burst
Sucrose Dextrose	10% 10%	In 20 minutes 20% burst
Sucrose Dextrose	15% 15%	In 20 minutes 20% bust
Sucrose Lactose Maltose Dextrose	5% 5% 5% 5%	In 20 minutes 50% burst
Sucrose Malic Acid	20% 0.01%	Bursting 4%; 44% pseudo-germination, protoplasmic expansion 20 times diameter of pollen.
Sucrose Malic Acid	5% 0.01%	Burst
Sucrose Malic Acid	20% 0.05%	Turgid
Sucrose Citric Acid	5% 0.02%	Burst 50%. Some pseudo-germination.
Sucrose Citric Acid	10% 0.02%	Burst 10%. Pseudo-germination, 20%.
Sucrose Citric Acid	20% 0.05%	Turgid.

Solution	Concentration	Behavior
Sucrose Asparagin	15% 0.1%	In 10 minutes 85% burst
Sucrose Asparagin	15% 0.5%	In 10 minutes 60% burst
Sucrose Lipase	15% 5%	Some bursting, some pseudo-germination
Sucrose Lecithin	15% 5%	Some bursting, some pseudo-germination.
Sucrose Saltpeter	20% 0.5%	Turgid
Sucrose Gum arabic	5% 5%	In 5 minutes 90% burst
Sucrose Gum arabic	2.5% 7.5%	In 5 minutes many bursting, some pseudo germination
Sucrose Gum arabic	1% 9%	Burst 30%; many pseudo-germinations
Sucrose Gum arabic	7.5% 2.5%	In 10 minutes 50% burst; some pseudo germination.
Sucrose Gum arabic	9% 1%	Bursting
Sucrose Gum arabic	15% 15%	In 10 minutes 80% burst
Sucrose Gelatin	5% 5%	Burst 30%
Sucrose Gelatin	2.5% 7.5%	Burst 20%; pseudo-germination 10%
Sucrose Gelatin	1% 9%	Burst 20%; some pseudo-germination
Sucrose Gelatin	7.5% 2.5%	Burst
Sucrose Gelatin	9% 1%	Burst
Sucrose Gelatin	15% 15%	Pseudo-germination with very thin and long protoplasmic extension Burst 2%
Lactose Gelatin	15% 15%	In 10 minutes 60% pseudo-germination
Dextrose Gelatin	15% 15%	In 10 minutes 40% pseudo-germination
Sucrose Dextrose Lactose Maltose Gelatin	5% 5% 5% 5% 25%	Pseudo-germination 80%, with thin and long protoplasm extension
Gelatin Malic acid	5% .01%	Some pseudo-germination; Burst 30%
Gelatin Citric acid	5% .01%	Pseudo-germination 50%; burst 30%
Gelatin Sucrose Citric acid	5% 4% 0.01%	In 30 minutes pseudo-germination 94%
Gelatin Citric acid	5% 0.5%	Burst 6%. Turgid
Gelatin Lipase	10% 1%	Burst 80%; very few pseudo-germinations.
Gelatin Saltpeter	10% 0.05%	Turgid

Solution	Concentration	Behavior
Gelatin Sucrose Saltpeter	10% 5% 0.05%	Turgid
Gelatine Asparagin	19% 0.1%	Pseudo-germination 90%
Gelatin Arabinose	10% 2%	Pseudo-germination 70%
Gelatin Lecithin	10% 2%	Pseudo-germination 60%, with heavy protoplasm extension
Gum arabic Glycerine	20% 50%	Pseudo-germination 95%, very thin and long protoplasm extension
Gum arabic Sucrose Citric acid	10% 5% 0.02%	Turgid
Gum arabic Arabinose	10% 2%	Pseudo-germination 90%
Gum arabic Arabinose Citric acid	10% 2% 0.01%	Pseudo-germination 40%
Levulose Lecithin	15% 1%	Bursting; very few pseudo-germinations
Gum arabic Asparagin	10% 0.1%	Pseudo-germination 40%
Arabinose Lecithin	10% 1%	Burst 80%; very few pseudo-germination
Arabinose Malic acid	15% 0.01%	Turgid
Arabinose Citric acid	15% 0.01%	Turgid

In no case does germination appear. In general we see that the sudden bursting becomes less prevalent as the concentration increases.

For example, in cane sugar, in the weak solution all the pollen grains burst, but as the concentration increases, fewer and fewer rupture until at 30 per cent this is entirely prevented. The other sugars behave in the same general manner as sucrose, but with less efficiency in preventing rupture. With gelatin and gum arabic this sudden bursting ceases with concentrations at 10 per cent and above, and then pseudo-germination appears.

The next trials were made with a series of combinations or mixed solutions and the results of these tests are set forth in table II.

TABLE III.

Germination Experiments in Solutions of Sucrose and Agar

Solution	Concentration	Germination
Sucrose Agar	5% 0.15%	Burst 10%; Turgid
Sucrose Agar	10% 0.15%	Turgid; Burst 6%; Germination 5%
Sucrose Agar	15% 0.15%	Burst 5%; Germination 5%; Turgid
Sucrose Agar	20% 0.15%	Burst 2%; Germination 10%; Turgid
Sucrose Agar	25% 0.15%	Germination 10%; Turgid
Sucrose Agar	30% 0.15%	Burst 2%; Germination 16%; Turgid
Sucrose Agar	15% 0.02%	Burst 90%; no germination.
Sucrose Agar	15% 0.03%	Burst 40%; Germination 6%; Turgid
Sucrose Agar	15% 0.04%	Burst 40%; Germination 6%; Turgid
Sucrose Agar	15% 0.05%	Burst 12%; Germination 18%; Turgid
Sucrose Agar	15% 0.06%	Burst 6%; Germination 25%; Turgid
Sucrose Agar	15% 0.08%	Burst 2%; Germination 15%; Turgid
Sucrose Agar	15% 0.10%	Burst 2%; Germination 16%; Turgid
Sucrose Agar	5% 0.70%	In 10 minutes germinated 4%; burst 8%; after one hour germinated 70%; burst 10%
Sucrose Agar	10% 0.70%	In 10 minutes germinated 4%; after one hour, 75%; tube long 3-5 times diameter of pollen.
Sucrose Agar	15% 0.70%	Burst 20%; Germination 20%; Turgid
Sucrose Agar	20% 0.70%	No germination; Turgid
Sucrose Agar	25% 0.70%	Turgid

In none of the fifty combinations tried were we able to observe any sign of real germination. It was not until a combination of sucrose and agar was used that germination took place.

Table III shows the series of varying concentrations and proportions of the sucrose-agar mixture tried and it is interesting as bringing out the fact that it is necessary to have not only the proper substances in order to induce germination, but they must be present in the proper proportion and concentrations.

While more or less germination takes place in most of the various concentrations tried, it appears that after a certain concentration of sucrose with agar is reached, (20 per cent), germination ceases altogether. The optimum conditions for germination were furnished by a solution of 10 per cent sucrose with 0.7 per cent agar.