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Effects of soaking period on the growth and carbohydrate content of young corn seedlings

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Abstract

The effects of 12-, 24- and 36-hour soaking periods on the growth and carbohydrate content of corn seedlings grown either in distilled water or in nutrient solution have been studied. The soaking period of the seeds was found to affect the regularity of the growth rate, the extent of root elongation, fresh and oven-dry weight and carbohydrate content of different parts of corn seedlings. A period of 24 hours soaking was most suitable to obtain regular growth of corn seedlings whether in distilled water or in nutrient solution.

INTRODUCTION

Absorption of water is the first step of seed germination, one may expect that pre-soaking the seeds in pure water should accelerate germination. Within limits, this is correct but the effect depends greatly on timing, on the soaking conditions (amount and temperature of water, density of the seeds, aeration etc.) and on the size and other properties of the seeds (Lang 1965). Excessive periods of pre-soaking frequently result in a decrease of the germination percentage and also affect later growth stages.

Although seed germination has been studied extensively (Crocker and Barton 1953, Toole et al. 1956, Koller et al. 1962) much of the work concerned changes in the whole seed, which may be obscure changes occurring in the embryo or embryonic parts.

Before studying ion stress (Hatata and Farah 1982a, b) or some other environmental effects on elongation of the root or shoot, it was necessary to find the soaking period most suitable to yield seedlings with roots which grow in a regular and reproducible manner. Rønnike (1958) found that various conditions (water content, degree of purity of culture medium) during preliminary growth exert an exceptionally strong effect on the growth of *Lupinus albus* seedlings and that the highest reliability of the results was obtained with roots having a high rate of growth. In studying the effect of the soaking period of wheat seeds in distilled water Younis and Hatata (1971a) concluded that a more regular rate of elongation was noticed with an 8-hour period than with shorter or longer periods.

The aim of this work is to evaluate the effects of soaking periods on the elongation of corn roots, fresh and oven-dry weight of different parts of the seedlings and also changes in soluble and insoluble carbohydrates content during germination. This was necessary for further studies of salt effects on the elongation of roots and on some metabolic changes in corn seedlings (Hatata 1982, Hatata and Farah 1982a, b).

MATERIAL AND METHODS

Zea mays, var. double hybrid 186 was used in this study. The grains were obtained from the Department of Corn Research, Ministry of Agriculture, Giza, Egypt.

In this study, the growth of roots, changes in fresh and oven-dry weight and also changes in soluble and insoluble carbohydrates were studied in different parts or corn seedlings raised in distilled water or in nutrient solution as follows.

Uniform grains were washed thoroughly with distilled water, then sterilized with 70% alcohol for 3 minutes. The grains were soaked in distilled water with continuous aeration for 12-, 24- and 36-hour intervals at 27°C ("0" time was the beginning of soaking). After soaking, the grains were sown in pots containing sawdust, irrigated with distilled water until the first root was well established. After that, the selected seedlings were transferred to growth jars containing distilled water or balanced nutrient solution with continuous aeration as previously described by Younis and Hatata (1971a). The solution was changed regularly every 24 hrs. throughout the experiment which was carried out in darkness at 27°C.

At 24-hour intervals 4 jars providing 48 seedlings were taken at random from every treatment, and the seedlings were photographed for measurement of root length, following the procedure described by Younis and Hatata (1971b). After photographing, the seedlings were cut into three parts: roots, grains and tops, the latter comprising the plumule with its first leaves. Every batch was weighed separately for fresh weight determination, then dried at 58°C in a forced-air stream oven to dry weight.

At selected times: 0, 72, 144 and 216 hours after soaking, the carbohydrate content (soluble and insoluble) of the different seedling parts was determined by taking a weight amount of the dried material and treating it with 70% alcohol to extract soluble carbohydrates. The alcohol extract was used for determination of soluble sugars (reducing and non-reducing), whereas, the residue was used for insoluble sugar determinations after hydrolysis and the reducing value was determined as glucose by the method described by Somogyi (1952). Simple statistical analysis was performed to determine the standard error of the mean at any given time.

RESULTS

The results presented in Fig. 1 show that the growth rates of corn roots were clearly affected by the pre-soaking period of the seeds whether in distilled water or nutrient solution. And on the average the roots obtained from seedlings pre-soaked for 24 hours and raised in distilled water were much longer than those obtained from seedlings with 12 or 36 hours pre-soaking treatment. By comparing the average lenght of roots raised in distilled water with those in nutrient solution

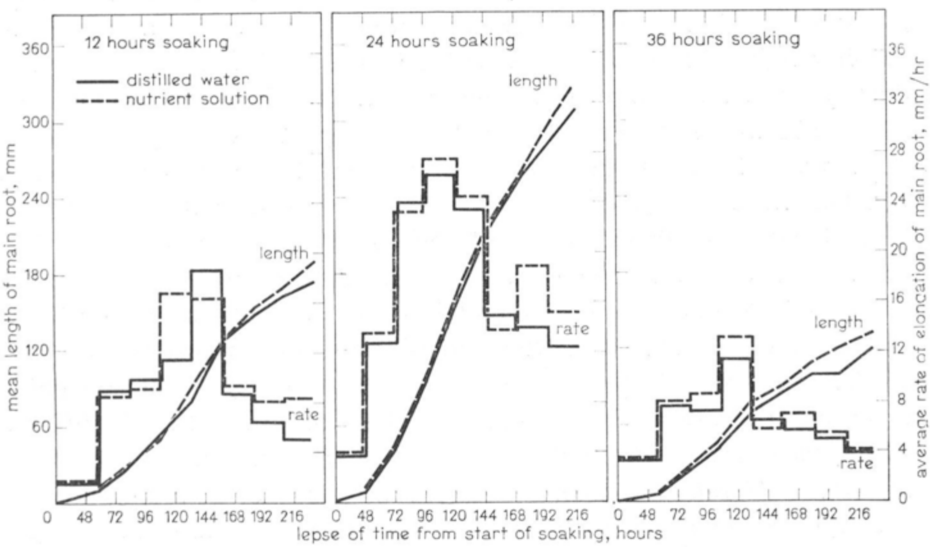

Fig. 1. Effect of soaking of corn grains in water on subsequent elongation of main root of seedlings grown in distilled water and nutrient solution

recommended by Breazeale (quoted by Bergman 1958) we found that: the average lenght of roots raised in nutrient solution was very similar to that of roots raised in distilled water till the 5-th day after soaking (120-hour-old), later, the length of roots grown in nutrient solution was greater than the corresponding lenght of roots grown in distilled water. For example, at the end of the experiment the average lengths of roots were about 174±3, 310±2.8 and 121±3.5 mm for roots grown in distilled water in comparison to 189±2.6, 331±4.0 and 133±3.0 mm in nutrient solution for 12, 24 and 36 hours soaking treatments, respectively.

FRESH WEIGHT

There was an increase in fresh weight of the whole seedlings with advance of time in all treatments tested (Fig. 2), whether in nutrient solution or in distilled water. The highest gain in fresh weight was in the seedlings soaked for 24 hours and a progressively lower gain was recorded in seedlings after 36 hours soaking. There is no significant difference between the fresh weight of seedlings raised in distilled water and those in nutrient solution. For example, in the 24-hour soaking treatment the fresh weight of seedlings in distilled water was 326.5 corresponding to 335.3 g in nutrient solution at the end of the experiment (about 2.7 per cent difference). The changes in fresh weight of the separate parts of the seedlings (Fig. 2) show a very pronounced increase in fresh weight of roots and tops with advance of time in all treatments, following the same trend of change in fresh weight of the whole seedlings. Again the fresh weight of roots and tops of seedlings soaked for 24 hours was higher than of those soaked for 12 or 36 hours, respectively. On the other hand, the grains showed a different picture; there was an increase in fresh weight of the grains in the first 4 days, then it decreased with advance of time. This increase in fresh weight of the grains is obviously the result of the high imbibitional action of the colloidal materials stored in the endosperm. After hydrolysis of these materials and their translocation into developing organs, the weight of the grains decreased. By comparing the fresh weight of different seedling parts grown in distilled water with that in basic nutrient solution, after different pre-soaking periods we also obtain a similar trend of changes as mentioned above and the 24-hour soaking period gives a higher fresh weight of roots and tops than that after 12 or 36 hours, respectively.

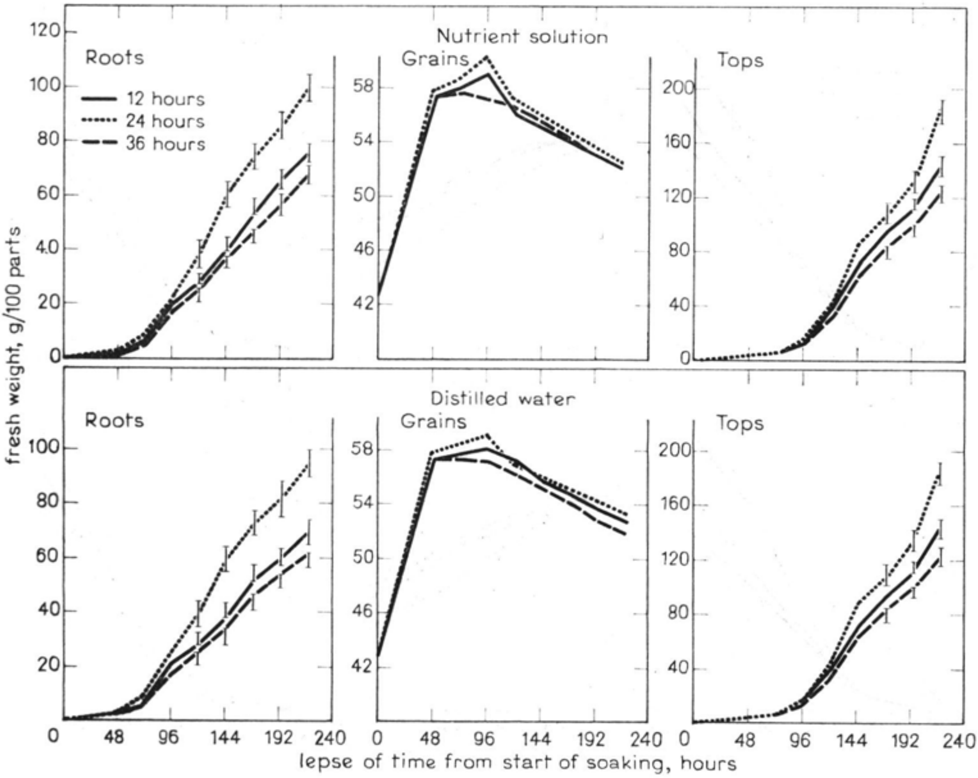

Fig. 2. Effect of soaking of corn grains in water on the fresh weight of various parts of seedlings. The bars denote ± SE

OVEN-DRY WEIGHT

As concerns the change in dry weight of various parts of the seedling, the data presented in Fig. 3, show that whereas the dry weight of the grains falls markedly during the whole experimental period, that of the roots and tops increases steadily. This trend was the same in all treatments, but the extent differed much with differences in the soaking period. In seedlings for 24 hours pre-soaked the drop in dry weight of grains was more than in those after 12 hours and this in turn was more than in those after 36 hours. Generally speaking, the decrease in dry weight of the grains was more than the increase in dry weight of the roots and tops, and hence the loss in dry weight of the whole seedling under all treatments. It is also evident that there are no significant differences between the oven-dry weights of the seedlings raised in distilled water and those in nutrient solution.

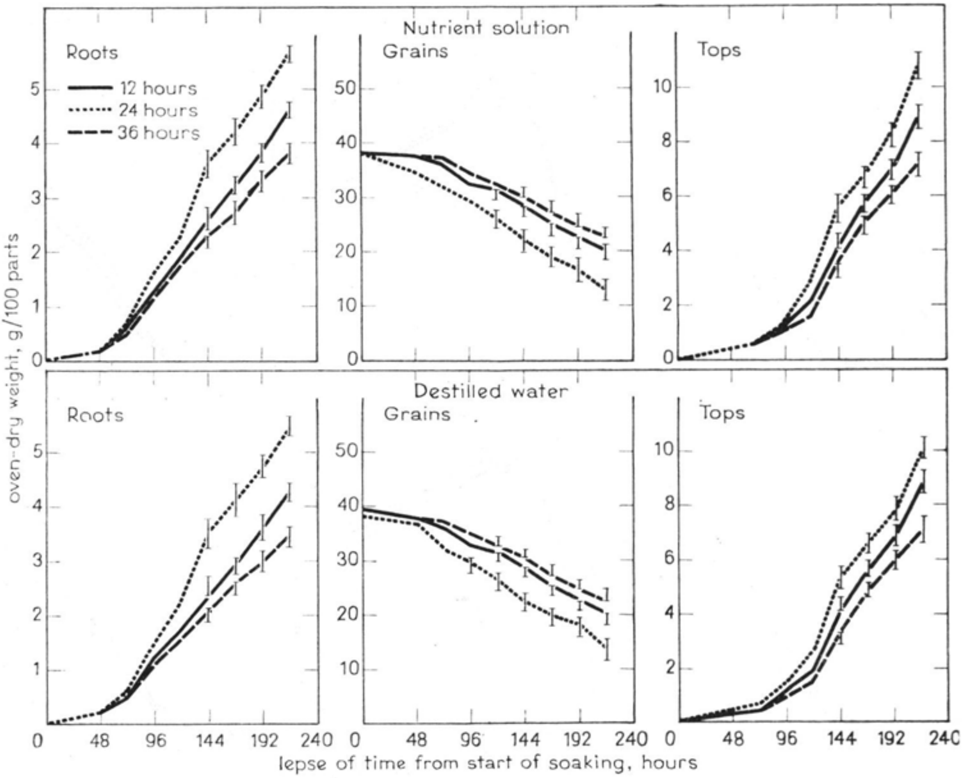

Fig. 3. Effect of soaking of corn grains in water on the oven-dry weight of various parts of seedlings. The bars denote ± SE

If we calculate the percentage of dry matter distributed among various parts of seedlings, we can also obtain the same picture as mentioned above. For example, after 9-days of growth the distribution of dry matter was as follows: in roots 12.8, 18.9 and 10.5 per cent, in grains 60.2, 46.1 and 67.8 per cent and in tops 27.0, 35.0 and 21.7 per cent after 12-, 24- and 36-hour treatments respectively. This indicates that in grains pre-soaked for 24 hours, the catabolic activities and translocation of organic material to the developing embryo were more rapid than in 12 or 36 hours soaked grains.

CARBOHYDRATES

A study of the changes in carbohydrates content of seedling parts after different soaking periods and grown in distilled water shows the following features (Fig. 4). There is an increase of carbohydrate content (soluble and insoluble) of roots and tops with advance of time. This increase was more pronounced in roots and tops obtained from grains pre-soaked for 24 hours than in those soaked for 12 and 36 hours. On the other hand, the soluble sugar content of the grains also increased with time, whereas the insoluble sugar content changed in opposite direction, i.e. it decreased with advance of time. The loss in total or insoluble sugars shown by grains soaked for 24 hours was also more than that in grains after 12 hours soaking and this in turn more than in 36 hours pre-soaked grains.

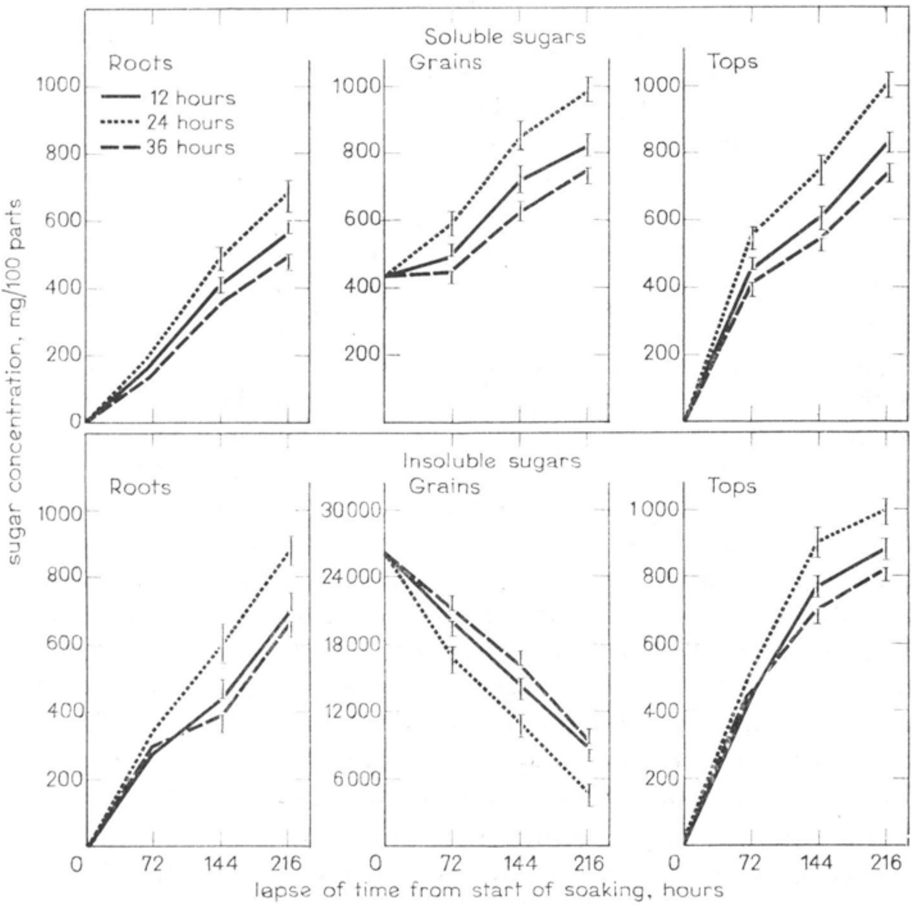

Fig. 4. Effect of soaking of corn grains in water on the distribution of soluble and insoluble sugars among various parts of seedlings. The bars denote ± SE

These results indicate a reduction in the metabolic activities in grains after 12 or 36 hours of soaking, but not in grains soaked for 24 hours. This is clear from the results recorded concerning fresh and oven-dry weights, changes of carbohydrate contents and elongation and growth of roots.

DISCUSSION

The results in this study show that corn roots do not require an external supply of mineral nutrients during the first 7 days following germination, as their growth in the nutrient solution is not better than their growth in distilled water. On the other hand, there is a pronounced difference in the growth of corn roots following soaking in distilled water and in nutrient solution for periods of 12, 24 and 36 hours. A more regular rate of root elongation was noticed with the 24-hour soaking period. While the rate of root elongation after 24 hours at soaking was higher than that of roots after shorter or longer periods of soaking. The growth rates throughout the growth periods of 12 and 36 hours soaking varied and were not so regular as was the rate in the 24-hour soaking period. This agrees with the findings of Younis (1954) that 18 hours soaking of *Vicia faba* was more suitable than shorter or longer periods.

Kidd and West (1918) also found promotive effects of short pre-soaking periods on germination and seedling growth, however, as the pre-soaking period was extended these effects gave way to a decrease in the germination percentage and the vigor of the seedlings. It was also found by Hassan and Overstreet (1952), Rønnike (1958), Eliasson (1959), Younis and Hatata (1971a), that the duration of the soaking period and pregermination conditions markedly affect the course of growth of the root. Other extensive experiments which demonstrated "injurious" effects of pre-soaking of seeds have been conducted by Toumey and Dorland (1923) with forest trees and by Barton (1950, 1952) with vegetables and cereals. All authors agree that there exist, as regards sensitivity to pre-soaking injury, wide differences between plants, injury appearing after quite different periods of soaking. There are also seeds that can withstand prolonged periods of soaking, although they do not germinate while submerged (Lang 1965).

The rate of transport of materials to the axis (root and shoot) seems to depend on the capacity of the axis as a sink for nutrients and this is closely linked with its rate of growth (Guardiola and Sutcliffe 1972). Factors which affect the growth rate also affect the rate of transport from the endosperm. It is clear from our results that soaking the seeds for 24 hours enhances growth of the axis and transport, whereas, 12- and 36-hour soaking reduces them.

In conclusion, it is clear from this study that the effects of the soaking periods tested were mainly manifested in the mobilization of metabolites in the corn seedlings. This feature was clear from the results of changes in dry weight and carbohydrate contents of different seedling parts. Since the seedlings were grown in complete darkness, there was no possibility of *de novo* synthesis of carbohydrates. The metabolic activities which are likely to take place in corn seedlings under such conditions would be hydrolysis of complex compounds into simpler ones in the grain (Ingle et al. 1964), and the mobilization of these metabolites to the developing organs where they may be recondensed into complex forms (James 1940). Again, a 24-hour soaking period proved to be more stimulative to the mobilization of the metabolites than the other periods.

It is obvious from this discussion that the data obtained from these experiments paved the way to obtain a regular growth curve which is an essential requirement for any further study of environment or stress effects on the growth of the main root of corn seedlings.

REFERENCES

Barton L. V., 1950. Contr. Boyce Thompsion Inst. 16: 55-71.

Barton L. V., 1952. Contr. Boyce Thompsion Inst. 17: 7-34.

Bergman W., 1958. Methoden zur Ermittlung mineralischer Bedurfnisse der pflanzen. In: Encycl. Plant Physiol. Ruhland W. (ed.), vol. 4, pp. 37-89.

Crocker W., Barton L. V., 1953. Physiology of seeds. Chronica Botanica Co. Waltham, Mass. p. 267.

Eliasson L., 1959. Kungl. Landburk. Ann. 25: 285-293.

Guardiola J. L., Sutcliffe J. F., 1972. J. Exp. Bot. 23: 322-337.

Hassan M. N., Overstreet R., 1952. Alex. J. Agric. Res. 2: 20-27.

Hatata M. A., 1982. Acta Soc. Bot. Pol. 51: 263-273.

Hatata M. A., Farah M., 1982a. Acta Soc. Bot. Pol. 51: 71-80.

Hatata M. A., Farah M., 1982b. Acta Soc. Bot. Pol. 51: 81-90.

Ingle J., Beevers L., Hageman R. H., 1964. Plant Physiol. 39: 735-740.

James A. L., 1940. New Phytologist 39: 133-144.

Kidd F., West C., 1918. Ann. Applied Biol. 5: 1-10.

Koller D., Mayer A. M., Poljakoff-Mayber A., Klein S., 1962. Ann. Rev. Plant Physiol. 13: 437-464.

Lang A., 1965. Encyclop. Plant Physiol. Ruhland W. (ed.). vol. 15, pp. 848-893.

Rønnike F., 1958. Physiol. Plant. 11: 421-440.

Somogyi M., 1952. J. Biol. Chem. 195: 19-25.

Toole E. H., Hendricks S. B., Borthwick H. A., Toole V. K., 1956. Ann. Rev. Plant Physiol. 7: 299-324.

Toumey J. W., Dorland W. D., 1923. J. Forestry 21: 269-375.

Younis A. F., 1954. J. Exp. Bot. 5: 357-372.

Younis A. F., Hatata M. A., 1971a. Plant and Soil 34: 49-56.

Younis A. F., Hatata M. A., 1971b. Plant and Soil 34: 293-308.

Wpływ czasu moczenia ziaren kukurydzy na wzrost i zawartość węglowodanów w młodych siewkach

Streszczenie

Badano wpływ 12-, 24- i 36-godzinnego moczenia ziaren kukurydzy na wzrost i zawartość węglowodanów w młodych siewkach, rosnących albo w wodzie destylowanej albo w pożywce płynnej. Okazało się, że czas moczenia wpływa na regularność wzrostu, intensywność wydłużania się korzenia, oraz na świeżą i suchą masę i zawartość węglowodanów w różnych częściach siewek. Optymalne było moczenie przez 24 godziny, powodujące regularny wzrost siewek kukurydzy rosnących zarówno w wodzie destylowanej jak i w pożywce.