CHANGES IN MINERAL CONTENT OF COTYLEDON AND EMBRYO OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) SEEDS DURING GERMINATION

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ABSTRACT

The contents of all the elements under investigation, (i.e. nitrogen, phosphorus, potassium, calcium, magnesium, sodium, manganese, iron and zinc) decrease in the cotyledon of sunflower and increase in the embryo as the seed passes from 0 to 120 hr of germination.

INTRODUCTION

Inspired by the great promise of sunflower in agriculture and industry in India and the limited work done in the field of its germination, the present work was undertaken to understand the order in which metabolic reactions are initiated during the early stages of germination. This paper presents qualitative and quantitative changes occurring in different parts of germinating sunfower seeds with respect to major and trace elements. The changes were recorded at different periods of germinating process and in different seed parts, namely, the cotyledon and embryo. No work has been done on this aspect on sunflower.

The elements, nitrogen and phosphorus, are two most significant among the major elements in cell reaction and play important roles in the metabolic changes occurring during germination[1–8]. It has been established that calcium, megnesium, sodium and potassium are biologically very important. Selected micronutrients are physiologically necessary for seedling establishment of a mature plant[9].

MATERIALS AND METHODS

'Peredovik' (EC 68415), the easily available variety, was used as the material for this investigation and obtained from the seed farm of Bidhan Chandra Krishi Viswa Vidyalaya. Immediately after harvest, the seeds which dried in the sun were found to be most viable after a month or two of their harvest. Accordingly, this experiment was carried out during this period.

The healthy seeds were soaked in sterile glass-distilled water for 6 hr and allowed to germinate on the surface of wet Whatman No.1 filter paper spread on a petri dish of 6″ diameter. About 30 to 35 seeds were taken in each petri dish and allowed to germinate in a B.O.D. incubator in the dark at 30°C. The seeds were removed from incubation at intervals of 24, 48, 72, 96 and 120 hr of germination and the decoated seeds were dissected into the cotyledon and the embryo parts. The dissected parts were then wiped out of any adhering water and dried in an oven at 45 to 50°C. The dried materials were then ground in a sieve grinder at 40 mesh. These ground materials, packed in sealed polythene packets, were stored in disiccator at 4 to 5°C. When required, the dry powdered materials were used for analysis.

Nitrogen was determined by the Kjeldahl method. Phosphorus was estimated by molybdovanadate yellow method[10]. Magnesium, calcium, zinc and manganese were determined by the use of atomic absorption spectrophotometry[11]. Sodium and potassium were determined by flame photometry[12] and iron by the 0-phenanthroline method (AOAC)[13].

RESULTS

The amounts of the elements, under investigation, present in the cotyledon and embryonic parts of the seed of *Helianthus annuus* L. at different stages of germination are presented in tables 1 and 2.

The contents of all the elements decrease in the cotyledon with a concomitant increase in the embryonic part as the seed passes through the initial to the final stages of germination. In the case of cotyledon, the degree of decrease is greatest for sodium and manganese (about 80%) and least for potassium (about 30%). The percentages of decrease for magnesium, calcium, iron and zinc are found to be between these values (about 60%). This was also the case for nitrogen and phosphorus (about 50%). On the other hand, in the case of embryo, the degree of increase is highest for manganese (8 times) and lowest for nitrogen and potassium (1.5 times). Magnesium, iron, sodium and zinc showed, on average, an increase of about 4

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Table 1 *Elemental analysis of cotyledon of germinating Helianthus annuus L. seed*[a]

Germination (hr)	Mg	Ca	Fe	Zn	Mn	Na	K	P	N
0	45	200	3.0	4.5	0.8	30.5	254	1.30	8.85
24	38	170	2.8	4.0	0.6	28.7	230	1.01	8.21
48	32	150	2.2	3.6	0.4	22.8	216	0.82	7.92
72	28	135	1.7	2.7	0.3	20.5	210	0.68	6.56
96	22	122	1.2	2.0	0.3	18.6	190	0.56	5.32
120	15	80	0.9	1.3	0.1	5.4	180	0.55	4.02

[a]Data are expressed in ppm except nitrogen which is expressed in percentage (g/100 g). Each determination represents a mean of four separate experiments.

Table 2 *Elemental analysis of embryo of germinating Helianthus annuus L. seed*[a]

Germination (hr)	Mg	Ca	Fe	Zn	Mn	Na	K	P	N
0	10	85	0.6	1.2	0.10	8.0	150	1.26	5.92
24	16	112	1.2	2.0	0.25	10.8	170	1.50	6.01
48	22	132	1.9	2.5	0.50	17.1	180	2.01	6.52
72	27	145	2.4	3.2	0.60	19.8	195	2.42	6.92
96	36	170	2.8	4.1	0.70	21.0	210	2.61	7.62
120	45	203	3.0	5.2	0.80	33.6	221	2.72	7.82

[a]Same as in table 1.

to 5 times, while calcium showed an increase of 2.5 times and phosphorus about 2 times.

In most cases, the contents of the elements in cotyledon and embryonic part equal each other, on average, at 72 hr of germination except manganese and phosphorus. In the case of manganese, it occurs even before 48 hr. In the case of phosphorus, cotyledon and the embryo possess almost the same concentration initially which decreases in cotyledon and increases in embryo as the seeds gradually pass from the initial to the final stage of germination. The content of sodium, both in cotyledon and embryo, is found to change abruptly after 96 hr of germination which is not common in other elements.

DISCUSSION

The rationale behind the studies of the mineral contents in the embryo and cotyledon at different germination periods is based on their relation to the enzyme systems as part of chemical constituents or as activators.

All the elements included in this investigation are present in considerably higher amounts in cotyledons at the initial stages of germination. But as the time of germination progresses, the mineral percentage of the cotyledon gradually decreases. On the other hand, all the elements are present in comparatively lower concentrations in embryo at the beginning of germination and gradually increase with increase of germination time. This decrease in the percentage of minerals in cotyledons with their concomitant rise in the embryo with increase of germination hours is due to a steady translocation of the elements from the cotyledon to the embryo. During the five days of the experiment, the cotyledons exported about 50% of their nitrogen, phosphorus and potassium, 70% of their magnesium sium, calcium, iron and zinc, and more than 80% of their manganese and sodium. After the inhibition period, as the embryo starts growing and developing, brisk metabolic activities begin. The elements, either as structural elements or as activators of various enzymes, need to be present in the embryo. The elements, originally taken up from the soil during seed maturation and kept as reserve in the cotyledons, are now exported to the embryo. Plants shed their cotyledons at an early stage; so rapid export of the minerals from cotyledon to embryo is also very important because these seed minerals are physiologically necessary for the early establishment and growth of the seedling.

In this context, it may also be mentioned that to ensure adequate supplies of phosphorus and nitrogen for the synthesis of metabolites and of functional and structural constituents, particularly ATP, coenzymes, enzymes, proteins and nucleic acids, for the early growth of seedlings prior to efficient root absorption, complex and bigger molecules containing these two elements are broken down in cotyledons and translocated to the embryonic site where these metabolites are needed in adequate amounts. Detailed account of compositional changes in different phosphorus and nitrogen compounds during germination of a number of seeds has been reported where it is clearly shown that the increase of various nitrogen and phosphorus compounds in early seedlings is at the expense of the cotyledon reserves[2,5].

As regards the other elements, many of these elements act as activators of the enzymes which become active during the germination process; for example, magnesium activates acid phosphatase, iron activates catalase and cytochrome oxidase; manganese activates peptidases and kinases and zinc activates alkaline phosphatase and carbonic anhydrase. Magnesium is also involved in protein synthesis and is a chemical component of the chlorophyll molecule, both of which are essentially synthesized during the early growth of the seedling. Since calcium ion plays a role in protein synthesis, possibly in the reduction of nitrate, its importance at the early stages of germination can easily be visualized. In addition, calcium is also essential in meristematic growth. The more rapid growth associated with the epicotyl, hypocotyl, radicle etc may require increased calcium. However, as there are reports of the above enzymes operating during germination of other seeds, possible correlation may be suggested between the rush of the minerals from the cotyledon to embryo with increased rates of enzyme activities[9,14].

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ANNOUNCEMENT

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The Seventh National Symposium on Tobacco will be held during January, 1988 at Anand, Gujarat for two days, after the A. I. C. R. P. (Tobacco) Workshop. Actual dates will be announced later.

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