J. Phytol. Res. 10 (1-2): 47-50, 1997

FLUORIDE INDUCED ALTERATION IN GROWTH AND METABOLIC ACTIVITIES IN MAIZE SEEDLINGS

S. NAGOOR
Department of Botany, University School of Sciences, Gujarat University, Ahmedabad 380 009, India.

Fluoride induced alteration in maize (*Zea mays* L. var. Ganga Safed 2) seedlings is reported. Root and shoot elongations were inhibited by NaF, inhibition was more in root. Fresh weight and dry weight of growing axis were lowered, reverse was true to endosperm. NaF stimulated the α-amylase, β-amylase and protease activities in growing axis but lowered in endosperm. The trend was reversed for invertase. In embryo of NaF grown seedlings, protein, amino acids and reducing sugars were less, but total sugar was more in comparison to that in control seedlings. In endosperm, starch, protein and amino acid contents were higher in NaF grown seedlings.

Keywords: Fluoride; Growth; Maize seedlings; Metabolic activities.

Introduction

Soil normally contains between 20 to 500 μg/ g^{-1} fluoride[1]. Several workers have reported adverse effects of fluoride on height, root and stem dry weight of different plants[2,3]. It also alters the metabolic activities in plants[4]. In Gujarat, the soil of Amreli district i reported to be high in fluoride content. Maize being food and fodder crop, its cultivations is very common. Seed germination and seedling growth determine the further growth and finally yield of the plants. Looking to this, it was planned to study the growth and metabolic activities in maize seedlings grown in presence of sodium flouride.

Material and Methods

Graded seeds of maize (*Zea mays* L. var. Ganga Safed 2) were germinated in sterilized petridishes (9 cm D) lined with filter paper in distilled water (DW) and 200 ppm of sodium fluoride (NaF) under laboratory conditions. On completion of six days, control and treated seedlings, twenty each, were analysed for number of roots, elongation of root, shoot and leaf. Mean was calculated and presented as cm/seedlings. The embryo axis of these seedlings was separated from endosperm and fresh weight, dry weight and percent moisture of embryc and endosperm were noted. α-, β-amylases, starch, invertase, reducing and total sugars, protein, protease, amino acids and phenols were estimated from embryo and endosperm[5-12]. The calculation of enzyme activities are based on mg protein, while metabolites are calculated on mg. fr. wt.

Results and Discussion

Table-1 represents the seedling growth of maize under DW and 200 ppm NaF. Number and elongation of root, shoot and leaf is greatly inhibited by sodium fluoride. Data support the findings of Chang[3] and Davis and Barnes[2]. The most severe inhibition is found in root elongation. The fresh weight, dry weight and percent moisture of embryo are lowered, while reverse in true for endosperm. NaF may reduce the water uptake thus seedling growth may be poor. In the present investigation, elongation of embryo axis is inhibited, which may be correlated with percent moisture in growing axis.

The presence of NaF in the media may be considered as stress for germination and seedling growth of maize. The most significant effect of stress on plant is inhibition in cell elongation[13]. In the present study, the inhibition in root, shoot and leaf elongation

Table 1. Effects of NaF (200 ppm) on growth of six days old Maize seedlings (var. Ganga safed-2).

Parameter	Control (DW)		NaF (200 ppm)	
Root number (no/plant)	12.50 ± 0.17		6.55 ± 0.11	
Root length (cm/seedling)	10.66 ± 0.10		1.71 ± 0.05	
Shoot length (cm/seedling)	3.03 ± 0.05		1.74 ± 0.05	
Leaf length (cm/seedling)	2.21 ± 0.04		1.04 ± 0.02	
Total seedling length (cm/seedling)	15.88 ± 0.15		4.49 ± 0.11	
	Embryo	Endosperm	Embryo	Endosperm
Fresh weight (mg/seedling)	580	360	240	440
Dry weight (mg/seedling)	141	173	102	215
Percent moisture (Percent)	75.69	51.94	57.50	51.14

mean ± SE

confirms that 200 ppm NaF is working as a stress inducing agent. Endosperm supplies nutrients for the growth of growing axis. Higher fresh weight and dry weight of endosperm in NaF grown seedlings indicate less utilization of reserves. Thus seedling growth may be poor. The reduction in number of root indicates that NaF may adversely affect the differentiation in root. Thus study on root may be considered as a good and simple parameter for evaluating the effects of NaF on seedling growth. Data also suggest differential sensitivity of organ for NaF.

Table-2 represents the data on metabolic activities in embryo and endosperm of control (DW) and NaF growr seedlings. Starch is absent in the embry(axis of DW and NaF grown seedlings. NaF grown endosperm contains more starch than that in DW grown seedling. Higher starch in NaF grown seedling indicates its less utilization, which may cause retardation in seedling growth. α-amylase activity is less than β-amylase activity in embryo and endosperm, which indicates that α-amylase being a *de novo* enzyme, its activity may be less in the initial period of seedling growth. NaF stimulates the α and β amylases activity in the embryo axis. Generally hydrolysing enzymes are stimulated by stress[13]. Stimulation in hydrolizing enzyme may provide more soluble compounds, which may be used by growing axis. Decrease in α-amylase activity may be correlated with more starch in endosperm. Increase in β-amylase activity may provide more sugars to maintain the growth.

NaF decreases the invertase activity in embryo axis, but promotes it in endosperm. Decrease in invertase activity in embryo axis may suggest the less amount of reducing sugar. Total sugars are more in the embryo axis but less in endosperm, when seedlings are grown in NaF. Higher amounts of sugar may maintain the osmoregulation in seedlings under adverse conditions. The lower total sugar content in endosperm indicates its less mobilization from endosperm to embryo axis. NaF decrease the reducing sugar in embryo and endosperm. Data may be correlated with invertase activity. Less sugar in the seedling may be related with decrease in seedling growth.

Protein content is lowered in embryo

Table-2. Effects of NaF on Enzyme Activities and Metabolic Contents in six days old Maize seedlings.

S. No.	Parameter	Control Embryoaxis	Endosperm	NaF (200 ppm) Embryoaxis	Endosperm
1.	Starch (µg/mg fr wt)	- -	50.07±0.04	- -	75.00±0.14
2.	α-amylase* activity	1.02±0.05	53.43±0.64	5.44±0.09	16.70±0.57
3.	β-amylase* activity	16.01±0.12	56.05±0.27	104.11±2.44	83.48±1.37
4.	Invertase** activity	12.10±0.09	23.63±0.34	6.03±0.14	37.25±0.69
5.	Reducing sugar (µg/mg fr wt)	50.22±0.62	116.41±2.37	22.82±0.38	65.50±1.31
6.	Total sugars (µg/mg fr wt)	61.83±0.80	157.97±3.00	109.93±1.70	81.93±1.18
7.	Protein (µg/mg fr wt)	55.14±0.47	25.87±0.85	43.96±1.06	59.19±0.22
8.	Protease@ activity	8.59±0.35	9.66±0.20	12.25±0.27	27.82±0.95
9.	Aminoacids (µg/mg fr wt)	173.61±3.36	96.98±1.19	154.39±3.42	139.11±1.65
10.	Phenol content (µg/mg fr wt)	4.27±0.16	5.25±0.05	4.39±0.18	5.16±0.07

Mean ± SE
* : µg starch hydrolized/10 min/mg protein; ** : µg glucose lib/h/mg protein; @ : µg tyrosine lib/h/mg protein

axis but higher in endosperm. Data indicate less hydrolysis and mobilization of protein, which may cause adverse effect on seedling growth. Protease activity is more in embryo and endosperm of NaF grown seedlings.

Amino acids are lowered in embryo but more in endosperm of NaF grown seedlings, when it is compared with that in control. Amino acid data are correlated with protease activity in endosperm which indicate that protein metabolism is changed by NaF. Ballantyne and Glover[4] reported higher protein and RNA in fluoride treated pea shoots. Chang[14] reported higher ribonuclease activity in fluoride treated corn roots. Phenol is considered as a secondary metabolite and it is, generally, accumulated in plants under stress. In the present work, phenol content is more in embryo axis under NaF, while reverse is true in endosperm. High phenol indicates it's accumulation due to NaF, which may influence and thus growth is retarded.

Chang[15] reported the biochemical mechanism of growth retardation due to fluoride and ozone. From the above study, it seems that hydrolysis of protein and starch

are reduced, moreover the translocation of soluble compounds like sugar and aminoacids may be less and thus the seedling remains stunted. Under such conditions, still seedlings are able to grow by maintaining osmotic balance with the help of total sugars.

Acknowledgement

Thanks are due to Dr. A.V. Vyas for encouragement and the Head, Department of Botany for providing necessary laboratory facilities.

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