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SHORT COMMUNICATION

Screening of maize varieties for waterlogging resistance by determining leaf porosity

NK SINHA*[1] and AK SRIVASTAVA[2]

Department of Botany and Plant Physiology, Rajendra Agricultural University, Pusa, Samastipur-848 125 (Bihar), India

*Email of corresponding author: nksinha.cazri@gmail.com

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Water above the critical limit in maize (300 mm) causes various physiological disorders. Waterlogged condition in the field after a heavy rainfall with few days of sunny weather combining with wind, induces temporary wilting in plants (Lie, 1984). The effect of waterlogging in maize grown in *kharif* appears to be more sever in seedling stage than the adult plants (Patil *et al.*, 1969). The flooding of soils during early stages of germination normally results in production of abnormal seedling due to arrest of normal metabolism under anoxic condition. The seedling grown under aerobic condition develop the potential to minimize the degradation of mitochondria and other organelles of coleoptiles cells even if they are exposed to anoxic condition for different duration (Vertapetian *et al.*, 1978). Relative flood tolerance appears to be correlated with the specific physiological adaptation namely, accelerated anaerobic respiration. Physico-chemical characteristics of waterlogged soils, which can limit plant growth, lack of oxygen is primary, but not necessarily the most important problem. This is because of the fact that many wet land species appears to be able to avoid anoxic condition in their root cell by transporting oxygen from shoot to root such as British bog plant (Armstrong, 1964), *Spartina alterniflora* (Teal and Kanwisher, 1966), *Nyssa sylvatia* (Hook *et al.*, 1971). The mechanism of air transport in short term anoxic condition in maize showed similar to rice as cellular changes (aerenchyma) become permanent in rice (John, 1977) and induced in maize (Fitter and Hay, 1981).

Maize variety 'Ganga Safed-2', a *kharif* season is embedded with various problems. Being hybrid, the seeds are to be changed every season which costs much and if sown late is prone to the waterlogging problem. Therefore, there is urgent need to evaluate new varieties which suits well against various agro-climate, soil and physio-morphological management. On the contrast, recently evolved composite, especially variety 'Suwan' has been found to give yield comparable to Ganga Safed-2. The present investigation was undertaken with the objective to develop parameters for screening the varieties relatively better suited to the waterlogged situations.

The experiment was conducted in the seed physiology laboratory during 1994 and 1995 at Rajendra Agricultural University, Pusa, Samastipur (Bihar). Caryopses of *Zea mays* L. biotype 'Suwan' and 'Ganga Safed-2' were surface sterilized with 2 per cent sodium hypochloride for 30 minutes, followed by washing with 0.01 N HCl to avoid its any harmful effects. After proper washing with distilled water, seeds were germinated on filter paper moistened with 10 ml distilled water. The experiments were carried out in completely randomized design. By the end of 120 hrs of germination, the germinated seeds with good vigor were transferred to the plastic pot containing soils with full strength of nutrient.

The plastic pots of 220 ml capacity having out side surface painted with black color to cut light for proper root growth. The pots were filled with nutrient solution up to marked levels. Germinated seeds were carefully placed in the soils with root placing down in soils. The depth of water in water logging treatment was maintained to 2 cm above soil surface. The seedlings were kept in growth chamber maintained at 30/24°C ± 1°C temperature day/night and 70-80% relative humidity under fluorescent and incandescent light having luminous intensity 15000 Lux.

Simultaneously, field experiments were carried out during the *kharif* season of 1993 and 1994 in randomized block design with three replications. The seeds of maize varieties 'Suwan' and 'Ganga Safed-2' were sown in the last week of the May using all recommended package of practices in both the years. Seven treatments were employed at two stages of crop growth i.e., 28 days (seedling stage), 63 days (silking stage) with 5 cm water depth and their combinations (Table 1).

Present address: [1]Senior Scientist, Central Arid Zone Research Institute, Regional Research Station, Post Box No 63, Jaisalmer-345 001 (Rajasthan); [2]Director General, Amity Institute of Biotechnology, Amity University, Noida-201 303 (Uttar Pradesh)

Determination of leaf porosity

Fresh flag leaves were weighed to obtain the fresh weight and there after submerged fully in distilled water for 24 hrs. The leaves were removed and keeping them between the blotting sheets and pressing gently. Leaves were reweighed to obtain the saturated weight. Leaves were dried in oven at 70°C for 48 hrs and the dry weight of leaves was recorded. Leaf porosity was calculated in per cent as given below:

$$\phi_l = \frac{A - B}{C} \times 100$$

Where, f_r = leaf porosity, A = fresh weight – dry weight, B = saturated weight - fresh weight; C = saturated weight - dry weight.

In 16 days old seedling under laboratory condition, Ganga Safed-2 had relatively lower leaf porosity in all the waterlogging treatments compared to Suwan. Maximum reduction in leaf porosity was observed in Ganga Safed-2 which was 75.57 per cent, whereas in Suwan the reduction was by 65.81 per cent both in 4 days of waterlogging treatment over their respective controls. After 2-days recovery of water logging treatments, it was observed that 2.66, 38.49, 16.31 per cent and 4.86, 43.50, 22.77 per cent increase in Ganga Safed-2 and Suwan, respectively to their respective waterlogging treatments. Same trend was observed in the maize plant treated with 4, 5 and 6 days of waterlogging and followed by two days recovery of their respective treatments in 28 and 63 days old seedling in the field experiment in both the varieties. However, plants try to adapt to the water logging situations by bringing in morpho-physiological adaptation. Leaf porosity is the important morpho-physiological character which facilitate plants growing under waterlogged situations for keeping the flow of oxygen at relatively optimum rate,. Leaf porosity contributes in the maintenance of an oxygen concentration sufficient to activate inhibited cytochrome. The observation showed that the leaf porosity decreased with increase in waterlogging duration and intensity in both the varieties of maize, but more in Ganga Safed-2 than Suwan (Table 2). During recovery period of two days there was little improvement in the leaf porosity, relatively higher rate in variety Suwan than in Ganga Safed-2. Crawford (1993) reported a close relationship between soil-water content and air space in the plant system. Many monocotyledonous plants have a well-developed aerenchyma which allow them to facilitate

Table 1. Treatments for different durations of water logging in maize crop at laboratory and field conditions

Laboratory condition		Field condition	
Treatment name	Treatment details	Treatment name	Treatment details
16CA/	Control	28CA/; 63CA	Control
14CA +2/WL	Two days waterlogging	24CA+4/WL; 59CA+4/WL	Four days waterlogging
13CA/+3/WL	Three days waterlogging	23CA+5/WL; 58CA+5/WL	Five days waterlogging
12CA/+ 4/WL	Four days waterlogging	22CA+6/WL; 57CA+6/WL	Six days waterlogging
11CA/+3/WL+2/R	Three days waterlogging followed by two days recovery	22CA+4/WL+2/R; 57CA+4/WL+2/R	Four days waterlogging followed by two days recovery
10CA/+4/WL+2/R	Four days waterlogging followed by two days recovery	21CA+5/WL+2/R; 56CA+5/WL+2/R	Five days waterlogging followed by two days recovery
9CA/+5/WL+2/R	Five days waterlogging followed by two days recovery	20CA+6/WL+2/R; 55CA+6/WL+2/R	Six days waterlogging followed by two days recovery

CA = Crop age; WL= Waterlogging; R = Recovery

Table 2. Effects of different durations of waterlogging on leaf porosity of maize at different stages of crop growth

Laboratory condition					Field condition									
Treatment	Suwan	% change over control	Ganga Safed-2	% change over control	Treatment	Suwan	% change over control	Ganga Safed-2	% change over control	Treatment	Suwan	% change over control	Ganga Safed-2	% change over control
16CA/ (Control)	94.80		77.80		28CA/ (Control)	89.23		81.93		63CA/ (Control)	90.37		88.07	
14CA+2/WL	89.80	-5.27	66.43	-14.61	24CA+4/ WL	83.87	-6.23	73.53	-10.25	59CA+4/WL	88.03	+2.59	85.77	+2.61
13CA+3/WL	35.93	-62.09	25.90	-66.70	23CA+5/ WL	79.50	-12.23	54.03	-34.05	58CA+5/WL	83.63	+7.46	81.00	+8.02
12CA+4/WL	32.93	-65.81	19.00	-75.57	22CA+6/ WL	63.03	-41.56	42.27	-48.40	57CA+6/WL	71.90	+20.44	59.17	+32.81
12CA +2/ WL+2/R	94.17	+4.86	68.20	+2.66	22CA+4/ WL+2/R	88.60	+5.51	75.60	+4.05	57CA+4/ WL+2/R	89.17	-1.29	85.98	-0.24
11CA +3/ WL+2/R	51.56	+43.50	35.87	+38.49	21CA+5/ WL+2/R	84.93	+6.83	56.80	+5.12	56CA+5/ WL+2/R	86.57	-3.51	83.00	-2.46
10CA +4/ WL+2/R	40.43	+22.77	22.10	+16.31	20CA+6/ WL+2/R	75.37	+19.57	48.90	+15.68	55CA+6/ WL+2/R	80.43	-11.86	64.90	-9.68
SEm±	0.759		0.663		SEm±	0.367		3.328		SEm±	0.225		0.552	
LSD (0.05)	2.303		2.030		LSD (0.05)	1.130		10.225		LSD (0.05)	0.694		1.609	

CA = Crop age; WL = Waterlogging; R = Recovery, e.g. 12 CA +2/ WL+2/R represents 12 days of crop followed by two days waterlogging followed by two days of recovery oxygen diffusion that is provided by large air spaces (Armstrong, 1979). These large air spaces in the cortex (aerenchyma) in maize and rice showed close vicinity as it may become permanent in rice (John, 1977) and induced in maize (Fitter and Hay, 1981). Ethylene, a gaseous growth hormone has been clearly linked with the stimulation of the production of aerenchyma in maize (Sinha and Srivastava, 1998). In the present investigation, it was evident that there exist a close relationship with the status of ethylene evolution and the leaf porosity. Relatively higher tissue porosity in waterlogged resistant plant was also reported by Armstrong and Beckett (1987).

It is pertinent to note that waterlogging situations create anaerobic environment, which makes maize difficult to survive. However, there are certain biochemical adjustments in plants which get triggered under high moisture stress conditions and keep the plants healthy to respond to the recovery period. The porosity of leaf followed decreasing trend with the increase in duration of waterlogging. However, 2 days of recovery period had improved leaf porosity following an increasing trend over their respective treatment of waterlogging in both the varieties, Suwan and Ganga Safed-2.

Leaf porosity followed a decreasing trend with the increase in waterlogging duration. Two days of recovery period had improved leaf porosity following an increasing trend over their respective treatments of waterlogging in the varieties, Suwan and Ganga Safed-2. Higher leaf porosity was observed in Suwan than Ganga Safed-2. Similarly, Two days recovery after waterlogging treatments observed comparatively higher values of leaf porosity in Suwan than Ganga safed-2. Thus, it may be concluded that maize variety Suwan showed more waterlogging resistant than Ganga Safed-2.

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SUMMARY

In the present laboratory and field investigations we sought to ascertain the effect of waterlogging on leaf porosity of maize (*Zea mays* L.) varieties Suwan and Ganga Safed-2. Eleven days old maize seedlings was treated with 2, 3 and 4 days of waterlogging followed by 2 days recovery in laboratory wherein the field condition, treatment of 4, 5 and 6 days of waterlogging followed by 2 days recovery was treated in 28 and 63 days of maize plant under the both laboratory and field situations. Porosity of root followed a decreasing trend with the increase in duration of waterlogging. However, 2 days of recovery period improved leaf porosity over their respective treatments of waterlogging in both the varieties. The improvement was however, more in Suwan than Ganga Safed-2.

REFERENCES

Armstrong W, 1964. Oxygen diffusion from the roots of some British Bog species. Nature 204: 801-802.

Armstrong W, 1979. Aeration in higher plants. Advances in Botanical Research, H.W.W. Wool house, ed. Academic press, London, pp. 226-332.

Armstrong W and Beckett PM, 1987. Internal aeration and the development of stellar anoxia in submerged roots. New Phytologist 105: 221-245.

Crawford RMM, 1993. Plant survival without oxygen. Biologist 40: 110-114. Ed. Gupta US, pp. 97-131.

Fitter AH and Hay RKM, 1981. Environmental physiology of plants. Academic Press INC, London.

John CD,1977. The structure of rice roots grown in aerobic and anaerobic environments. Plant and Soil 47: 269-274.

Hook DD, Brown CL and Kormanik PP, 1971. Inductive flood tolerance in Swamptupelo (*Nyssa sylvitica* var. *biflora* (Walt) Sarg. Journal of Experimental Botany 22: 78-89.

Lie TA, 1984. Biological nitrogen fixation. In: Crop Physiology. Ed. Gupta US, pp. 97-131.

Patil VS, Kulkarni GN, Acharya NP, Bhandrapur TG, Panchal YP, Channabasiah HSM and Dastane NG, 1969. Annual Report ICAR, Soil and Water management Scheme of major River Valley Project Areas. Agriculture Research Station Sirguppa, Karnataka.

Sinha NK and Srivastava AK, 1998. Ethylene estimation from *Zea mays* L. seedlings accumulated under waterlogged situation. Journal of Applied Biology 8: 35-37.

Teal JM and Kanwisher JW, 1966. Gas transport in the margh grass *Spartina alterniflora*. Journal of Experimental Botany 17: 355-361.

Vertapetian, Andreeva IN and Nuritdinov N, 1978. Plant cells, under oxygen stress. In: Plant life in anaerobic environment. Eds. Hook and Crawford, pp. 13-88.