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Study of Effect of Waterlogging on Root Anatomy of Ragi and Rice

S.S. Kulkarni and P.D. Chavan
Department of Botany, Shivaji University, Kolhapur MS, India

Corresponding Author: S.S. Kulkarni, Department of Botany, Shivaji University, Kolhapur MS, India

ABSTRACT

In present study, effect of waterlogging (4, 8 and 12 days) on root anatomy of ragi and rice was studied. It was noticed that the formation of aerenchyma tissue in the ragi roots was induced due to increasing waterlogging treatment. On the other hand, rice roots grown under normal conditions had well developed aerenchyma tissue and treatment of waterlogging did not cause any noticeable change in root anatomy. Thus development of aerenchyma in response to waterlogging in ragi roots would certainly help to supply O_2 to the root metabolism. Activity of acid phosphatase was declined in both the species during waterlogging, indicating that its involvement in aerenchyma formation was no any significance. There was decline in calcium content in ragi roots due to waterlogging whereas in rice root an increase was noticeable. Thus a decreased calcium level in ragi roots may limit the availability of calcium for the formation of new cell wall material.

Key words: Aerenchyma, ragi, rice, waterlogging

INTRODUCTION

During the waterlogging, hypoxic and anoxic conditions are developed in soil which causes poor supply of oxygen to the root system. According to Vartapetian (1990), many physiological, biochemical and anatomical changes are taking place in root system during hypoxia and anoxia. Aerenchyma are soft tissues made up of large intercellular spaces which provide low resistance internal pathway for the exchange of gases between aerobic shoot to the anaerobic root (Jackson and Armstrong, 1999). Aerenchyma tissue is not only restricted to root but also observed in the leaf sheath after submergence, forming an interconnecting system of shoot-root ventilation (Fabbri *et al*., 2005). In present investigation, we studied factors which can induce formation of aerenchyma and observed in ragi and rice root sections (waterlogged and control) for aerenchyma.

MATERIALS AND METHODS

Authentic seeds of ragi variety GPU 28 were procured through courtesy of Dr. Karade, Agricultural Research Station Agriculture College, Kolhapur (MS). After positive confirmation about viability of these seeds, these were employed for further studies. The vigours healthy seedlings in each pot were thinned to 15 after 20 days. The pots were supplied with equal amount of tap water and every care was taken to ensure proper growth of the plants and control of weeds. When the plants were 1 month old waterlogging treatments were commenced. Treatment of waterlogging was given in such an interval that, at the end of treatment it was possible to obtain plants receiving differ waterlogging treatments (4, 8 and 12 days) at the same time for further experiments. Control plants received normal water supply. The experiment was performed in triplicate.

Anatomical studies were performed by observing hand cut sections of roots of both ragi and rice plants subjected to different waterlogging treatments. The sections were observed under compound microscope and the photographs of selected representative sections were taken on Leica DM 2000 sec fluorescence microscope under 4 and 10 X. Activity of enzyme acid phosphatase was measured by method of McLachlan (1980). Soluble proteins in the enzyme extract were determined according to the method of Lowry *et al.* (1951). The enzyme activity was expressed as µmol p-nitrophenol h^{-1} mg^{-1} protein. The extraction of inorganic constituents was done according to method of Toth *et al.* (1948). Extracted solution was diluted, from this solution, the amount of calcium was estimated by using atomic absorption spectrophotometer (PERKIN ELMER 3030).

RESULTS AND DISCUSSION

From Fig. 1 and 2 it is revealed that there is progressive formation of aerenchymatous tissue in root of ragi during increasing duration of waterlogging. Control roots of rice have well developed

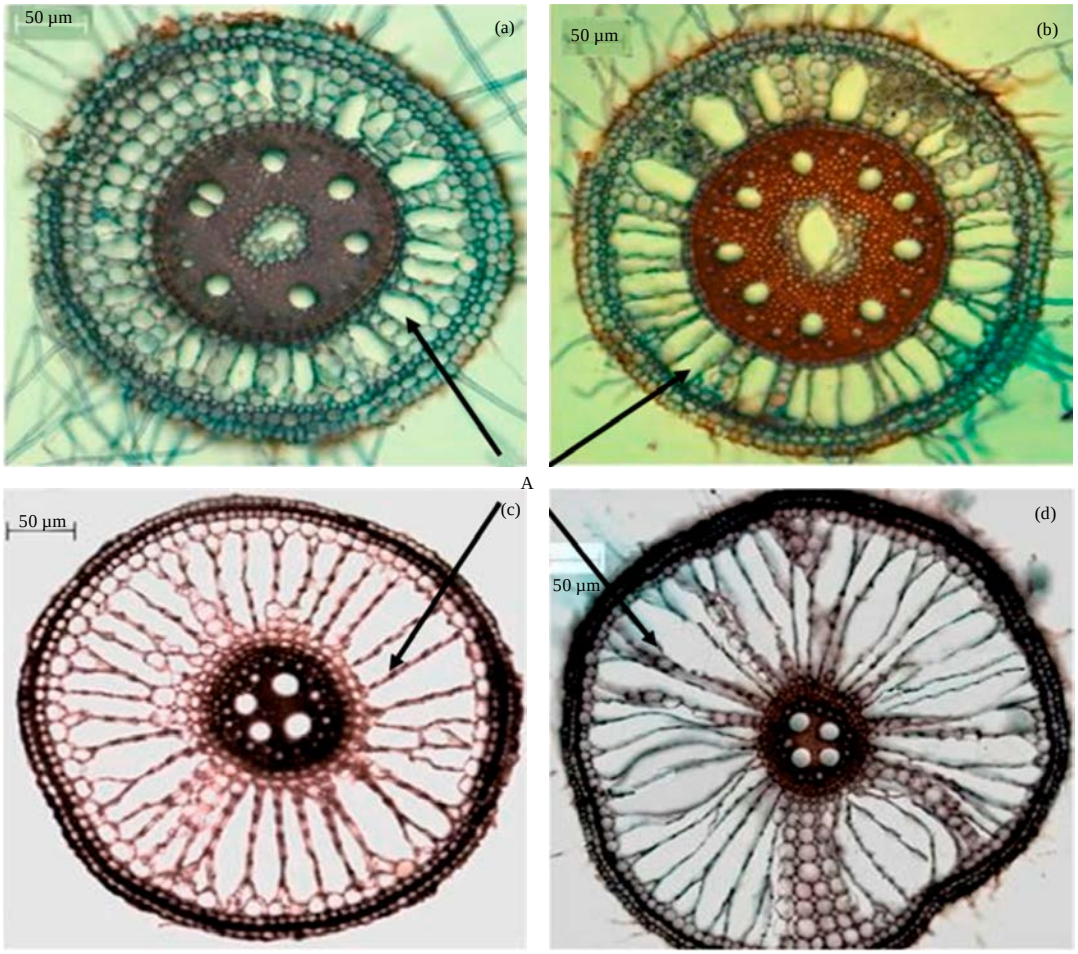

Fig. 1(a-d): Effect of waterlogging (4 days) on anatomy of ragi and rice roots (a) EC, (b) E4, (c) OC and (d) O4. E: Ragi (*Eleusine coracana*) O: Rice (*Oryza sativa*), C: Control, 4: Days waterlogging treatment and A: Aerenchyma

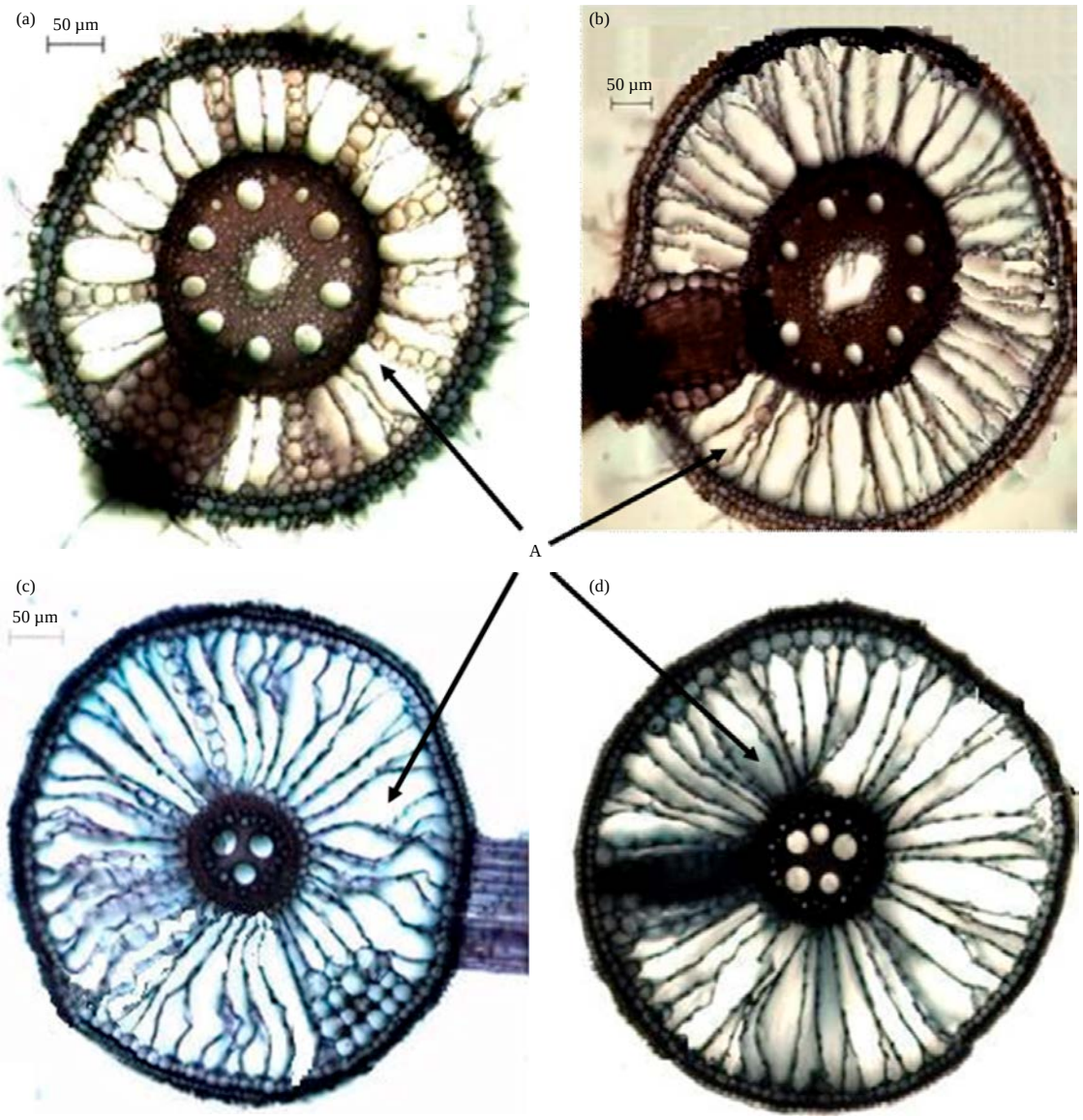

Fig. 2(a-d): Effect of waterlogging (8 and 12 days) on anatomy of ragi and rice roots (a) E8, (b) E12, (c) O8 and (d) O12. E: Ragi (*Eleusine coracana*), O: Rice (*Oryza sativa*), 8-Days, 12-Days waterlogging treatment and A: Aerenchyma

aerenchyma tissue. In rice this aerenchymatous tissue remained intact and stable during waterlogging. Anatomical and morphological changes in plant in response to environmental conditions i.e., phenotypic plasticity are often adaptive which made plants to survive under that environment (Sultan, 2000). De Souza *et al.* (2010) reported that in maize (1-18 cycles) flooding caused increase in porosity of roots through formation of aerenchyma. At last cycle of flooding there was prominent aerenchyma in roots. Similar trend is noticed in present investigation in case of ragi. Ragi roots also showed progressive formation of aerenchyma along with increase in waterlogging period.

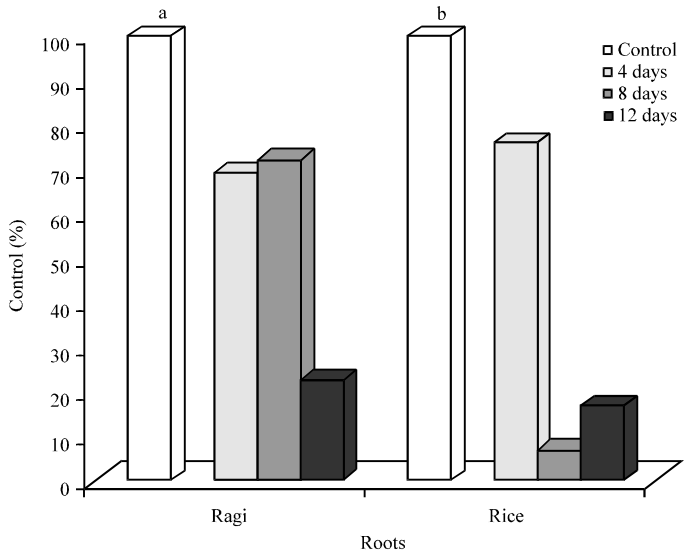

Fig. 3: Effect of waterlogging on activity of enzyme acid phosphatase in ragi and rice roots a: Control ragi roots 248.69 μmol Pnitrophenol h^{-1} mg^{-1} protein and b: Control rice roots 33.31 μmol Pnitrophenol h^{-1} mg^{-1} protein

Effect of waterlogging on activity of acid phosphatase in roots of ragi and rice is shown in Fig. 3. But in both the species there is marked reduction in root acid phosphatase activity under waterlogged condition. Jiang *et al.* (2010) determined the characteristics of cortical cell death in wheat roots during Programmed Cell Death (PCD) and the relationship between PCD and acid phosphatases. For this study, they observed roots of wheat which are exposed to waterlogged condition for 120 h. They noticed that activity of acid phosphatases gradually increased during waterlogging and was present during entire process of cell death. They concluded that acid phosphatases play an important role in PCD induced by waterlogging, being responsible for the hydrolysis of cell component at later stages of PCD. In the present investigation, we noticed progressive aerenchyma formation in ragi root while from earlier stage, rice roots have aerenchyma tissue. But there is marked decrease in activity of acid phosphatase in roots of both these species during waterlogging treatment. That means in this context there is no any role of acid phosphatase in aerenchyma formation. It is probable that acid phosphatase is released from the roots of these crops in the soil under waterlogged conditions so as to help root system in acquisition of more Pi from the soil.

Effect of waterlogging on calcium content of root of both ragi and rice is shown in the Fig. 4. In roots of ragi there is decline in calcium content while in rice roots there is accumulation of calcium. Root hairs are main site of uptake of minerals from the soil bulk. Ca^{2+} directly enters into the root hair. On dry matter basis plant requires more than 0.1-1% calcium for healthy growth (White, 2001). Wang *et al.* (2002) found an accumulation of calcium during waterlogging in the roots of sesame genotypes. On the other hand, a flooding induced decline in Ca content uptake, has been recorded in wheat, rapeseed, *Trifolium subterraneum* and *Aerschynomene americana* (Devitt and Francis, 1972; Tobisa *et al.*, 1997). Calcium is an important component of cell wall pectate, required for cell wall formation. Decline in calcium content in ragi roots may cause poor cell wall formation leading to induction of aerenchyma tissue.

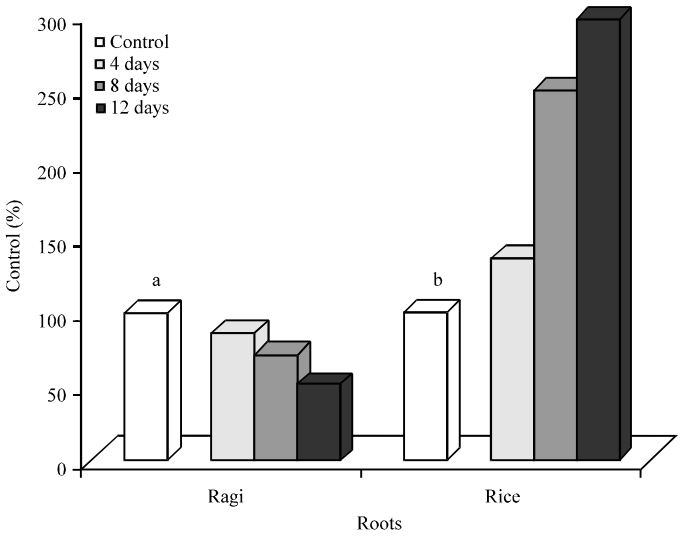

Fig. 4: Effect of waterlogging on calcium contents of roots of ragi and rice a: Control ragi roots 682 mg g^{-1} dry wt. and b: Control rice roots 104.2 mg g^{-1} dry wt.

It is evident from the forgoing account that induction of aerenchyma in waterlogged ragi roots will definitely helpful to cope up with anoxic condition.

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