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ANATOMY OF ROOT AND STEM OF SESAME UNDER WATER LOGGING

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ABSTRACT

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Water logging is an environmental factor that limits plant growth, reduces gas exchange between plant tissues and damages root and stem structures. A pot experiment was conducted with seven sesame genotypes *viz.* RajshahiKhoyeri, KistotilChapai, KathtilChapai, Gopalgonj MV-40, Gopalgong Black, KalotilGopalgong and LaltilGopalgonj at BINA farm, Mymensingh during March to June 2017. Four water logging treatments *viz.* Control, 24, 48 and 72 hours were imposed at flowering stage of the sesame genotypes. Tissue of root and shoot of sesame genotypes under water logging had a great damage compared to control. Root and stem anatomy of all the sesame genotypes were severely affected by 72 hours water logging, the epidermis, hypodermis and vascular bundle were damaged and prominent hallow was found in stem due to damaged tissue. However, RajshahiKhoyeri was less affected, water logging at 72 hours partially damaged its epidermis, hypodermis and vascular bundle and adventitious roots were formed to help storage and exchange of gases within stressed plants to maintain a hypoxia tolerance pathway for survival.

Key words: *root anatomy, stem anatomy, sesame, water logging*

INTRODUCTION

Water logging reduces gas exchange between plant tissues and the atmosphere, resulting in an imbalance between slow diffusion and rapid consumption of oxygen in the rhizosphere that drastically reduces the oxygen supply and induces anoxia in plants (Kozlowski 1984 and Sachs *et al*. 1980). Short-term water logging often firstly causes oxygen deficiency (hypoxiaor anoxia) in plants and leads to root damage (Grassini *et al*. 2007; Maltby *et al*. 1991; Meyer *et al*. 1987). Water logging causes a shortfall in oxygen availability to plants which is felt directly by the root system, and indirectly by the shoots (Capon *et al*. 2009). In tissue suffering hypoxia (and specially anoxia), oxygen-depending processes are suppressed, both carbon assimilation and photosynthate utilization are inhibited, and functional relationships (especially the internal transport of oxygen) between roots and shoots are disrupted (Chugh *et al*. 2012; Irfan *et al*. 2010; Vartapetian and Jackson, 1997). The response of a plant to hypoxia can be conceptually divided into three stages. Initially, the plant rapidly induces a set of signal transduction components, which then activates the second stage, a metabolic adaptation involving fermentation pathways. Finally, the third stage involves morphological changes such as the formation of gas filled air spaces (aerenchima) and/or adventitious root, depending on the tolerance of the plant (Jackson and Colmer, 2005; Evans 2003; Justin and Armstrong, 1987).

Sesame (*Sesamum indicum*), a crop with high oil content, has the potential capacity to combat nutritional deficiencies in developing regions and countries. Most current cultivars contain 50–60% oil and 18–24% protein in their seeds (Mondal *et al*. 2010 and Ram *et al*. 1990). In particular, greater than 80% of its oil is in the form of unsaturated fatty acids, which are more beneficial for human health than are saturated fatty acids. In addition, the antioxidant properties of sesame lignans, primarily sesamin and sesamolin, are used for therapeutic and cosmetic applications (Nakano *et al*. 2006 and Miyahara *et al*. 2000). Sesame is typically considered drought-tolerant but susceptible to water logging, a property that can be ascribed to its suspected origin in Africa or India and its subsequent dispersal to tropical or semitropical regions (Ram *et al*. 1990 and Bedigian 2004). According to the Food and Agricultural Organization, the average sesame yield was alarmingly low at only 617 kg ha^{-1} worldwide in 2011 and ranked second to last among 22 oil crops between 2007 and 2011. This low yield may be attributed to several reasons, but water logging is a primary factor.

To understand the effects of abiotic stress in an effort to maintain a stable food supply, a number of studies have investigated the responses of model plants and crops to stresses (Rasmussen *et al*. 2013 and Nakashima *et al*. 2009). These studies have revealed that plant responses to different stresses are coordinated by complex and often interconnected signaling pathways that regulate numerous metabolic networks (Nakashima *et al*. 2009 and Miro and Ismail, 2013). At the protein level, low oxygen selectively induces the synthesis of anaerobic proteins, especially enzymes involved in sugar metabolism, glycolysis and fermentation (Huang *et al.* 2005; and Komatsu *et al*. 2009). The vast majority of these proteins have been investigated in water logging-susceptible or tolerant strains of Arabidopsis or rice (Nakashima *et al*. 2009; Bahmanyar 2007 and Atkinson *et al*. 2013). Sesame mutants/varieties/land races show some tolerance to water logging (Islam and Khatoon, 2018 and Islam *et al*. 2017, 2006). In this study, anatomical features of root and stem of sesame land races under water logging were investigated to observe the damage of root and shoot structures to identify tolerant genotype.

MATERIALS AND METHODS

A pot experiment was conducted with seven sesame genotypes *viz*. RajshahiKhoyeri, KistotilChapai, KathtilChapai, Gopalgonj MV-40, Gopalgong Black, KalotilGopalgong and LaltilGopalgonj at BINA farm, Mymensingh during March to June 2017. The sesame land races were collected from different agro-ecological zones of Bangladesh. The objective of the study was to find out the water logging tolerant genotypes. Four water logging treatments *viz.* control and water logging periods of 24, 48 and 72 hours were imposed at flowering stage of the sesame genotypes. Each pot contained 8 kg soil collected from BINA farm. Urea, TSP, MP and Gypsum were applied 125, 150, 50 and 110 kg ha^{-1}, respectively. Half of urea and all other fertilizers were mixed with pot soils and remaining urea was applied at 30 days after sowing. After seedling establishment one seedling was allowed to grow in each pot. The experiment was laid out in completely randomized design with three replications. Anatomical features of both root and stem of all the sesame genotypes under water logging and controlled condition were efficiently observed by sectioning and finally by using Stereo Microscope having fixed slide. In water logging and controlled condition, anatomy of root and stem of a relatively tolerant cultivar RajshahiKhoyeri was shown and described in details.

RESULTS AND DISCUSSION

Tissue of root and shoot of sesame genotypes under water logging had a great damage compared to control (Fig. 1-4). In control both root and stem, the orientation of epidermis, hypodermis and vascular bundle looks normal (Fig. 1 & 3). Root and stem anatomy of all the sesame genotypes were severely affected by 72 hours water logging, the epidermis, hypodermis and vascular bundle were damaged and prominent hallow was found in stem due to damaged tissue. However, RajshahiKhoyeri was less affected, water logging at 72 hours partially damaged its epidermis, hypodermis and vascular bundle and adventitious roots were formed to help storage and exchange of gases within stressed plants to maintain a hypoxia tolerance pathway for survival. (Fig. 2 & 4). The results are in conformity of Wei *et al.* (2013) who found less damaged tissue, adventitious root and aerenchyma in tolerant type of sesame. Water uptake, nutrient and oxygen supply hamper due to damage of vascular bundle and plants show wilting and may die. In oxygen-deprived condition the plant rapidly induces a set of signal transduction components, activates a metabolic adaptation involving fermentation pathways and involves morphological changes such as the formation of gas filled air spaces (aerenchyma) and/or adventitious root, depending on the tolerance of the plant (Jackson and Colmer, 2005; Evans 2003; Justin and Armstrong, 1987).

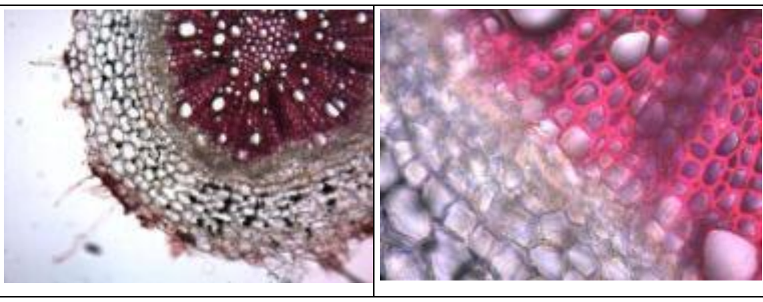

Fig. 1. Anatomy of root of a sesame cultivar, RajshahiKhoyeri (Control)

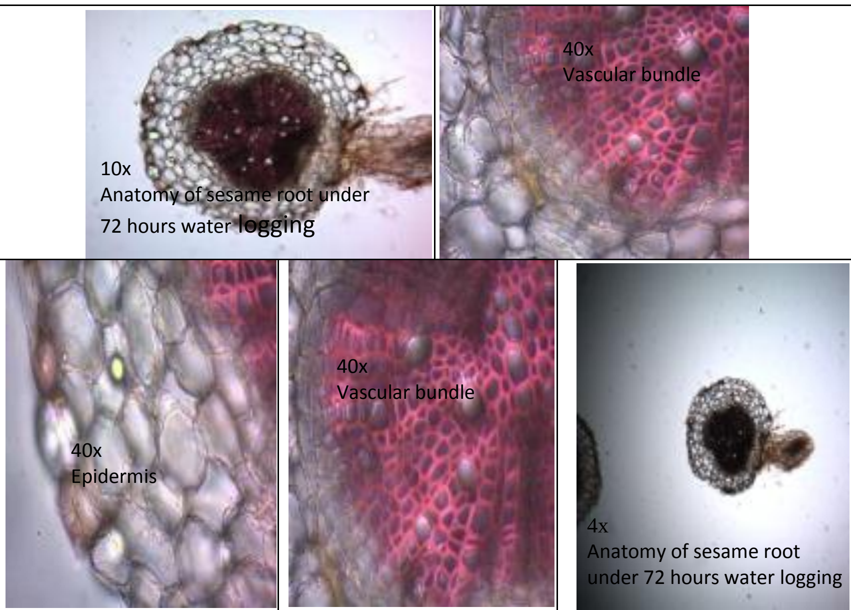

Fig. 2. Anatomy of root of a sesame cultivar, Rajshahi Khoyeri under 72 hours water logging

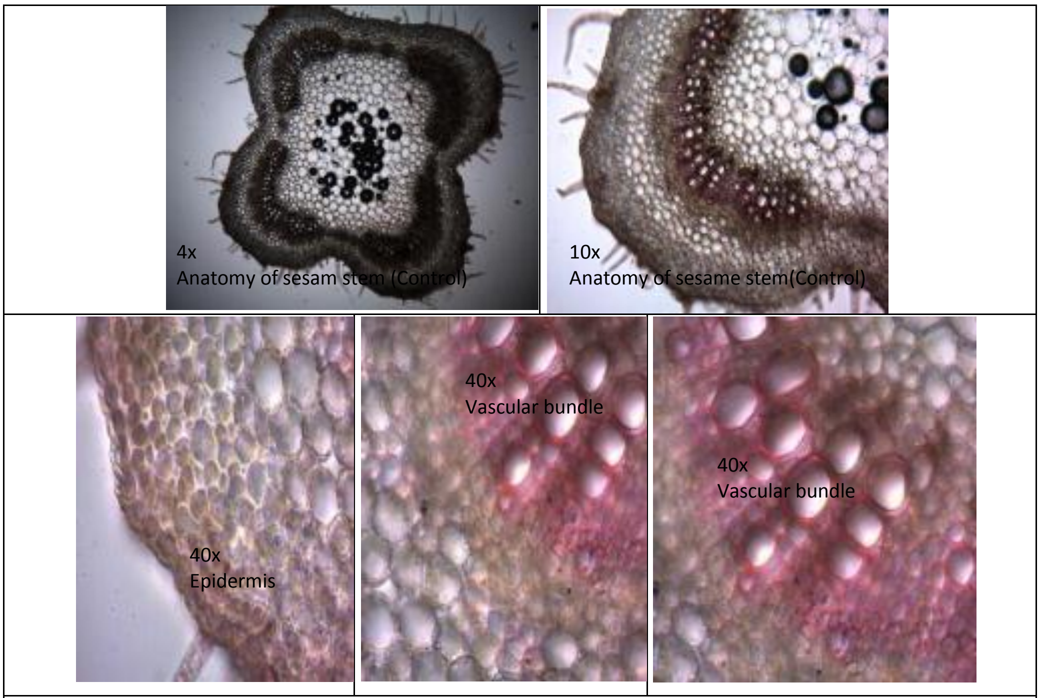

Fig. 3. Anatomy of stem of a sesame cultivar, Rajshahi Khoyeri (Control)

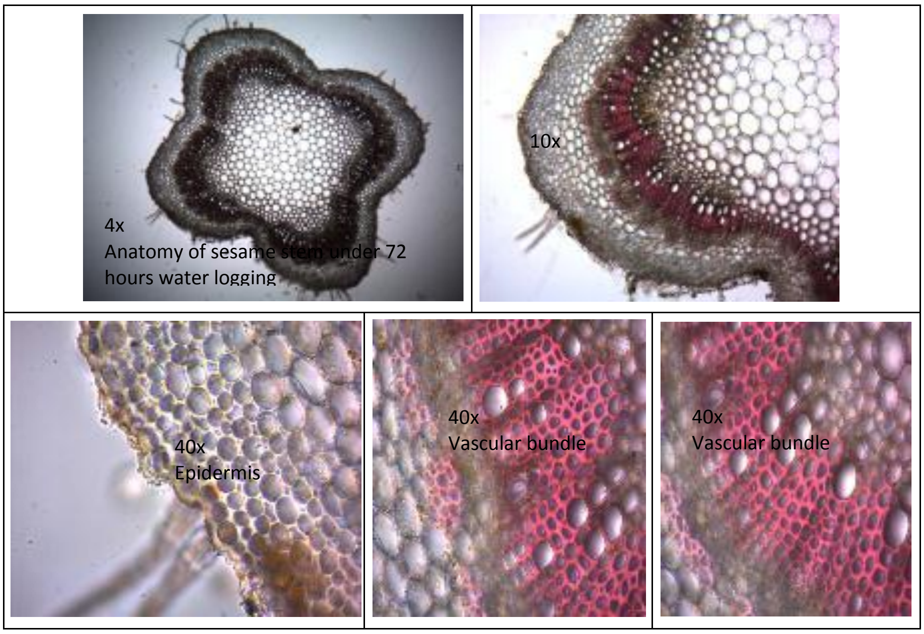

Fig. 4. Anatomy of stem of a sesame cultivar, Rajshahi Khoyeri under 72 hours water logging

CONCLUSION

Root and stem anatomy of all the sesame genotypes were severely affected by 72 hours water logging. RajshahiKhoyeri was less affected by 72 hours water logging, however, its epidermis, hypodermis and vascular bundle were partially damaged and showed some tolerance.

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