Journal of the Saudi Society of Agricultural Sciences (2016) **xxx**, xxx–xxx

King Saud University

Journal of the Saudi Society of Agricultural Sciences

www.ksu.edu.sa
www.sciencedirect.com

FULL LENGTH ARTICLE

Improvement of wheat yield grown under drought stress by boron foliar application at different growth stages

F.M.F. Abdel-Motagally [a], **Manal El-Zohri** [b,*]

[a] *Department of Agronomy, Faculty of Agriculture, Assiut University, Assiut 71526, Egypt*
[b] *Department of Botany and Microbiology, Faculty of Science, Assiut University, Assiut 71516, Egypt* [1]

Received 8 December 2015; accepted 27 March 2016

KEYWORDS

Wheat;
Growth stages;
Boron application time;
Water stress

Abstract Two field experiments were conducted to determine the effect of boron foliar application and water stress on yield of wheat plant grown in calcareous soil during 2013/2014 and 2014/2015 seasons. The highest mean values obtained against boron application time were potential contributor to total grains mass by improving the plant height (99.42 and 98.32 cm), spike length (11.86 and 11.72 cm), number of spikelets m^{-2} (332.65 and 324.35), grain yield $plant^{-1}$ (21.56 and 20.26 g), 1000-grain weight (35.2 and 37.4 g) and grain yield (1.87 and 1.85 ton $fed.^{-1}$), which were recorded at normal irrigation level (100% from the amount of water consumption for wheat) with boron spraying at booting stage (B_1) in the first and second seasons, respectively. Furthermore, boron application significantly enhanced all studied growth traits under water stress levels (50% from the amount of water consumption for wheat) compared to B-untreated plants. Boron spraying at booting stage enhances also plant pigment contents recording its highest mean values under normal water level (100% from the amount of water consumption for wheat). The reduction in stress markers (proline and H_2O_2) and the enhancement of plant pigment content under water stress levels (50% from the amount of water consumption for wheat) by B spraying suggest an alleviating effect of boron foliar application to water stress in the test plant. This alleviating effect was more pronounced when B applied at booting stage. Therefore, booting stage was found to be the best time for boron application to get higher grains production and consequently, better economic returns of wheat.

* Corresponding author at: Department of Biological Sciences, Faculty of Science, King Abdulaziz University, Jeddah 21551, Saudi Arabia.
E-mail addresses: mnzohri@yahoo.com.au, melzohri@kau.edu.sa, mnzohri@aun.edu.eg (M. El-Zohri).
[1] Permanent address.

Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.jssas.2016.03.005
1658-077X

1. Introduction

In Egypt, wheat is one of the oldest and most important cereal crops. Although wheat production per unit area in Egypt has significantly increased during the past years, it still does not supply enough amount for annual domestic demand. During 2011–2012, wheat was shown on an area of 3 million fedan (1.26 million ha^{-1}) in Egypt. The total production of wheat was 8.82 million tons with an average yield of 7 tons ha^{-1} (Anonymous, 2012). Most importantly, Egypt is still one of the largest countries that import wheat. Therefore, increasing wheat productivity occupies a central position in forming agricultural policies. The lacking ability of Egypt to produce sufficient wheat for domestic consumption is attributed to many factors, since poor fertility status of the soil and improper crop management practices are of primary significance. Production of wheat can be increased either by bringing more area under cultivation or by increasing its yield per unit area. In the current situation, it is hard to increase its area under cultivation due to restriction of irrigation water supply and competition with other crops on the cultivated lands. Hence, the most practical approach for increasing wheat production in the country is to obtain higher yield per unit area.

Many environmental stresses are responsible for low grain yield of wheat including drought, high temperature, salinity and insufficient nutrients availability (Subedi et al., 2000). Soils of Egypt are generally alkaline and calcareous soils that usually have some problems associated with poor water retention and low contents of available essential nutrients. It is well known that newly reclaimed soil is often very poor in macro- and micronutrient elements. Micronutrients deficiency is one of the most important biotic stresses in plants grown on calcareous soils (Xudan, 1986).

Boron is known to play different roles in plant vital activities such as cell division, elongation in meristimatic tissues, membrane integrity, cell wall formation, leaf expansion, water relations, ion absorption, IAA and carbohydrates metabolism in addition to translocation of sugars and its deficiency may affect all these processes (Marschner, 1995; Gupta and Solanki, 2013; Da Rocha Pinho et al., 2015). Indeed, the key role of boron in plants includes floral organs and flower male fertility, pollen tube growth and utilization of carbohydrates (Blevins and Lukaszewski, 1998). Therefore, the unavailability of boron during grain setting period results in poor anther and pollen development (Cheng and Rerkasem, 1993) and the grain thus formed is often without starch (Dell and Huang, 1997). In the field, sexual reproduction is often more affected by low boron and significant grain yield reductions may occur without visual symptoms expressed during vegetative growth.

According to Dell and Huang (1997) vegetative development of wheat is relatively insensitive to B deficiency. However, lack of B during reproductive development can cause devastating yield loss through sterility (Rawson, 1996; Subedi et al., 1997a, 1997b). The mechanism by which B deficiency induces sterility of wheat includes the poor development of anthers and pollen as well as pollen germination failure (Cheng and Rerkasem, 1993; Rerkasem et al., 1993). It is believed that B deficiency affects pollen development during the pollen mother cell stage which coincides with the booting stage (Growth stage (GS) 45 (Rerkasem et al., 1993). Although it is known that B supply in the stigma and style is important to pollen germination in maize little is available for wheat even though reports of B deficiency in wheat, especially in warmer areas, are becoming more common (Mann and Perkasem, 1992).

The sterility induced by inadequate boron supply in wheat is of major concern in boron deficient soils (Shorrocks, 1997). Therefore, the problem can be handled by ensuring the continuous exogenous boron supply during reproductive development. However, calcareous soil has a serious problem concerning the rapid fixation of applied nutrients, including boron, when added to the soil (Majidi et al., 2010). Keeping this in view, the present study was therefore, designed to determine the effect of foliar application of boron at different growth stages in wheat. Consequently, foliar B application could be suggested as one cost effective solution to the problem of severe yield loss due to boron deficiency in commercially grown wheat crops when grown in water stressed under calcareous soils.

2. Materials and methods

2.1. Experimental design

Two field experiments were carried out in the Agricultural Experiment Station Farm of Assiut University (El-Wady El-Assiuty Agric. Farm), Assiut, Egypt, in 2013/2014 and 2014/2015 seasons to investigate the response of wheat (*Triticum aestivum* L.) to foliar application of boron in two growth stages under different water levels. The physical and chemical properties of experimental site are shown in Table 1.

The randomized complete block design using strip-plot arrangement with three replicates was adopted. Three irrigation levels (I_1 = 50%, I_2 = 75% and I_3 = 100% from the amount of water consumption for wheat) were arranged in main strip, while foliar application of boron (50 ppm) in two growth stages was laid in subplot. Boron foliar applications were sprayed at booting growth stage (B_1) or at anthesis stage (B_2), while (B_0) includes wheat plants sprayed with distilled water that was used as control. The difference among the wheat growth stages was made by using Feeks scale (Hanft and Wych, 1982).

Phosphorous fertilizer was applied in the form of calcium superphosphate (15.5% P_2O_5) at the rate of 31 kg P_2O_5 $fed.^{-1}$ during soil preparation. Nitrogen in the form of ammonium nitrate (33.5% N) at the rate of 100 kg N $fed.^{-1}$ was added in two equal doses after one month and two months later. Potassium fertilizer in the form of potassium sulfate (48% K_2O) at the rate of 24 kg K_2O $fed.^{-1}$ was added in two equal doses. The preceding crop was sorghum in both seasons. The area of each subplot was 10.5 m^2 (3.5 m length × 3 m width). Sowing was carried out on the 2nd and 4th of December in the first and second seasons, respectively. Sprinkler irrigation system used underground water followed by 60 mints of I_1 = 50%, 90 mints of I_2 = 75% and 120 mints of I_3 = 100% every 3 days. The amount of water consumption for wheat at Assiut government used I_1 = 2000, I_2 = 1500 and I_3 = 1000 m^3 $fed.^{-1}$ according to Abdel-Mawgoud et al. (2007), El-Koliey et al. (2001) and Mohamed (2007).

Please cite this article in press as: Abdel-Motagally, F.M.F., El-Zohri, M. Improvement of wheat yield grown under drought stress by boron foliar application at different growth stages. Journal of the Saudi Society of Agricultural Sciences (2016), http://dx.doi.org/10.1016/j.jssas.2016.03.005