Scientia Horticulturae 202 (2016) 125–132

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Review

Effects of synthetic brassinolide on the yield of onion grown at two irrigation levels

J. Doležalová*, M. Koudela, J. Sus, V. Ptáček

Department of Horticulture, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Prague, Czech Republic

ARTICLE INFO

Article history:
Received 14 September 2015
Received in revised form 5 February 2016
Accepted 14 February 2016
Available online 2 March 2016

Keywords:
Allium cepa L.
Bulb
Brassinosteroids
Growth
Water deficit

ABSTRACT

Field experiments were conducted in two seasons to investigate the influence of a synthetic brassinolide on the growth and yield of onion grown at two irrigation levels. The onion plants were treated with a synthetic brassinolide analogue (2α, 3α, 17β-trihydroxy-5α-androstan-6-one) at concentrations of 100 nM, 1 nM and 0.01 nM. These were sprayed to foliage of two long-day cultivars (cv. Lusy and cv. Alice). The height of the part aboveground and the diameter of the neck were measured in the plants. After harvesting, the marketable yield, parameters of the individual bulbs and the amount of dry matter and ascorbic acid were assessed. Under conditions with optimal irrigation the influence of the treatments with 1 nM and 0.01 nM synthetic brassinolide in the cultivar Alice was proven on the mass of the individual bulbs and yield in 2013. In the case of reduced irrigation, the treatment with a concentration of 1 nM had a statistically significant positive influence on the mass of the individual bulbs (2013) and yield (2012) in the cultivar Alice. With the cultivar Lusy, the treatments with a concentration of 1 nM and 0.01 nM significantly increased the marketable yield relative to the control variant in 2012.

The results confirm that it was possible to reduce the negative impact of the water deficit in the cultivation of onions with synthetic brassinolide. It is, however, necessary to bear in mind which parameter of the plants should be affected and last but not least also the varying sensitivity of the cultivars to the treatment.

Contents

* Corresponding author at: Czech University of Life Sciences Prague, Faculty of Agrobiology, Food and Natural Resources, Department of Horticulture, Kamýcká 129, Praha 6-Suchdol, 165 21, Czech Republic.

E-mail address: dolezalovajitka@af.czu.cz (J. Doležalová).

http://dx.doi.org/10.1016/j.scienta.2016.02.023
0304-4238/

1. Introduction

Water deficit is considered to be among the most severe environmental stresses and the major constraint on plant productivity; losses in crop yield due to water stress probably exceed the loss from all other causes combined (Kramer 1980). This deficit has an evident effect on plant growth that depends on both severity and duration of the stress (Araus et al., 2002; Bartels and Souer 2004). The sensitivity of plants to drought differs among species, populations and varieties and also depends upon the physiological stage of the plant (Liu et al., 2011). Water shortage considerably reduces plant dry matter production and thus final yield (Wu et al., 2008). Drought stress and UV irradiation are the most adverse factors for plant growth and productivity (Rajabbeigi et al., 2013). In this context, it is necessary to look for ways to reduce the negative impact of water deficit for growing practices.

Brassinosteroids (BRs) were first discovered in oilseed rape pollen in 1979 (Grove et al., 1979) and nowadays they are considered to function as a separate class of phytohormones (Bishop and Yokota 2001; Zullo and Adam, 2002). The growth induced by BRs has been related to increases in RNA and DNA amount, polymerase activity and protein synthesis (Kalinich et al., 1985). It has been well documented in the literature that these hormones act mainly in the meristem regions, causing cell lengthening and division (Mandava 1988).

BRs seem to be involved in the expression of critical development periods, from germination to the transition from plant vegetative to reproductive development (Suge 1986). BRs stimulated callus proliferation in *Arabidopsis thaliana*, regeneration in cauliflower and embryogenesis in conifers, rice and coconuts (Hu et al., 2000; Sasaki 2002; Azpeitia et al., 2003; Pullman et al., 2003). Growth promotion due to BRs application was reported earlier in increased growth of the geranium plant (Swamy and Rao 2008), *Coleus* plant (Swamy and Rao 2011), *Vicia faba* plants (Piñol and Simon 2009) and maize (Holá et al., 2010). In addition to promoting growth (Müssig 2005), the application of BRs increased the yield of important field crops—wheat, potatoes, rice and mustard (Ramraj et al., 1997; Khripach et al., 2000; Zullo and Adam 2002; Janeczko et al., 2010). BRs have also the potential to increase yields of horticultural crops (Cutler 1994; Fariduddin et al., 2008; Kang and Guo 2011). Their positive effect is also reflected by higher quality of the yield. The application of BRs improved quality of groundnut (Vardhini and Rao 1998), head lettuce (Koudela et al., 2012), increased total antioxidant activity of endive (Serna et al., 2013) and soluble solids contents (Gomes et al., 2006).

These phytohormones also reduce the effects of environmental stress on plant physiology, e.g. in relation to temperature (Ogweno et al., 2008), pesticides (Xia et al., 2006), herbicides (Pinol and Simon 2011), salinity stresses (Núñez et al., 2003; Shahid et al., 2011) and water deficiency (Upreti and Murti 2004; Jager et al., 2008; Behnamnia et al., 2009; Mousavi et al., 2009). Futhermore, BRs are type of environmentally-friendly (Kang and Guo 2011) and non-toxic (Esposito et al., 2011) hormone.

The application of BRs could be one way to reduce the negative impact of water deficit in vegetable production. Therefore, the aim of this two-year study was to examine how treatment with synthetic brassinolide influences plant characteristics, including yields and parameters of consumable part after the harvest, for onions grown at different irrigation levels.

2. Material and methods

2.1. Field experimental design

The investigations were conducted in 2012 and 2013 at the Demonstration and Research Station in Troja district of Prague (50°7′21.198′N, 14°23′56.359′E). The field experiment was set up in a randomized block design in four replications. The experimental factors were different levels of irrigation, concentration of synthetic brassinolide and the cultivar. Irrigation was based on current values of efficient water capacity (EWC); the critical value of the EWC was 70% for optimally irrigated variants, and 50% for variants with reduced levels of irrigation.

For the determination of EWC, the method following Brežný (1970) and Benetin (1979) was used, which arises from the relationship between the soil hydrolimits and the mechanical-physical features of the soil. The current values of EWC in the known grain size composition of the soil were monitored by measuring the soil moisture—using the sensor Virrib (AMET, Velké Bílovice, Czech Republic). When the values of the soil moisture fell below the selected level, watering was begun.

The total quantities of irrigation water during the trial: optimally irrigated variants in 2012—225 mm; 2013—390 mm; reduced irrigation in 2012—190 mm; 2013—345 mm.

A synthetic analogue of the natural brassinosteroid – substance 2α, 3α, 17β-trihydroxy-5α-androstan-6-one – was used for testing (patent pending No. 252605 Industrial Property Office, Czech Republic). Plants were sprayed with 100 nM (B100), 1 nM (B1) or 0.01 nM (B0.01) solutions of synthetic analogue or with tap water (B0—control, 0 concentration).

Two long-day cultivars of *Allium cepa* L.—cv. Lusy and cv. Alice were assessed (Semo a.s., Czech Republic). These cultivars slightly differ in the length of their vegetation period ('Lusy' is 3 days earlier from 'Alice'). Both cultivars have medium round bulbs with yellow peels. The cv. Alice is one of the most widely cultivated in the Czech Republic. The cv. Lusy is newer and should gradually replace the cv. Alice in the growers assortment. These cultivars are intended primarily for direct sowing in spring and they are characterized by good storage stability.

Seeds were sown in double rows (the distance between double rows 30 cm, the distance between seeds in rows 5 cm), 80 plants per m^2. Experiments were arranged in a split split-plot design with four replicates (main plot = irrigation level, subplots = cultivars, sub-subplots = synthetic brassinosteroide treatments). Each sub-subplot consisted of 2 double rows with 20 seeds per row (80 seeds), the layout of each type of plot in the field was random. Cultivation took place between April and August of 2012 and 2013.

The plants were cultivated in accordance with techniques recommended by Petříková et al. (2012). Standard methods of fertilizer application (following a soil sample test) and strategies of weed management were used.

2.2. Climate and soil conditions

The experimental filed was located on a gentle slope with western exposure at an altitude of 196 m. The area has a moderately warm climate and the district is slightly warm and dry, with mostly mild winters. The characteristics of the precipitation, radiation and thermal conditions during onion vegetation are presented in Figs. 1 and 2.

The vegetative season of 2012 was subpar in terms of moisture (minus 124 mm relative to the long period of 1961–1990), with an average temperature 2.47 °C higher than the average. The average temperature during growth season 2012 was 16.9 °C and 15 °C in 2013.

Excessive precipitation amounts were noted in June 2013, but overall the vegetative season of 2013 was normal in terms of moisture and temperature.

A pedological survey detected modal fluvisol soil on non-calcareous alluvial with gravel subsoil terraces. At depths of 0–0.34 m the soil is humic sandy loam containing quartz pebbles up to 50 mm. This soil is deeply cultivated, and significantly enriched