Cauliflower qualities in two irrigation levels with the using of hydrophilic agent

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Abstract

Koudela M., Hnilička F., Svozilová L., Martinková J., 2011. **Cauliflower qualities in two irrigation levels with the using of hydrophilic agent**. Hort. Sci. (Prague), *38*: 81–85.

The aim of this work was to evaluate the influence of a hydrophilic agent (Agrisorb), added to a substrate for seedling cultivation (3 g Agrisorb/l of substrate), on the weight of roots, weight, and height of the aboveground part, the number of leaves and root collar diameter of precultivated cauliflower seedlings (cultivar Chambord F1). Seedlings were planted under two different irrigation levels: optimal with available water capacity 80%, and reduced with 50%. The influence of Agrisorb on the following characteristics of cauliflower edible parts was evaluated after harvest: weight, diameter, percentage representation of marketable parts, market yield, content of ascorbic acid, nitrates and dry matter, and total antioxidative capacity value. The addition of Agrisorb significantly increased the weight of the aboveground parts by 17.3%, the root weight by 28.1%, and the number of leaves by 7.9%. After harvest, it was noted that Agrisorb significantly increased marketable yield (by 17.5%) and decreased total antioxidative capacity (by 19.9%) in the treatment with a reduced irrigation level.

Keywords: water stress, seedlings, market yield, chemical composition

Drought (water deficiency) is a limiting stressor for plants; it lowers enzymes activity and decelerates growth. Frequent causes of water deficiency are climatic conditions and weather characteristics. Water uptake of a plant is dependent on the nutrients and salts in the soil, as well as on the soil pH value. Water stress is often affected by salination of soil (Bláha et al. 2003).

In recent years, extreme high temperatures and the absence of rainfall are among important stress factors. Vegetables grown in the Czech Republic include species with high requirements of soil water. Intensive vegetable growing is therefore associated with additional irrigation, but its effectiveness could be insufficient in extreme temperatures (over 35°C) combined with long drought periods; this could also become an important stress factor.

Agrisorb (Evonik Stockhausen Gmbh, Krefeld, Germany) is a hydrophilic polymer compound, which is capable to efficiently absorb water into its structure and transfer it to the roots during the vegetative period. Kumaran et al. (2010) indicates that hydrophilic polymers are able to absorb 100 to 300 times their weight in water. Dubrovskii et al. (2001) describes

Supported by the Ministry of Agriculture of the Czech Republic, Project No. QH81110 and the Ministry of Education, Youth and Sports of the Czech Republic, Project No. MSM 6046070901.

Table 1. Trial treatments

Irrigation levels (EWC)	80% (FO – optimal)	50% (FS – stressed)
Without Agrisorb (0 g/l) A0	FO/A0	FS/A0
With Agrisorb (3 g/l) A3	FO/A3	FS/A3

EWC – efficient water capacity; FO – the variant with optimal levels of irrigation; FS – the variant with reduced levels of irrigation; A0 – the substrate for seedling cultivation was unadjusted; A3 – the substrate was supplemented with a hydrophilic polymer (agent Agrisorb) in the quantity of 3 g of Agrisorb/l of substrate; each trial treatment was done in 4 replications

that polymer chains are prepared by copolymerizing polyethylene oxide methacrylate bis-macromonomers with small ionogenic monomers such as 2-acrylamido-2methyl-1-propansulfonic acid, its potassium salt, and methacrylate of potasium. Hydrophilic polymer networks are capable of retaining huge volumes of water by swelling; the so-called superabsorbent hydrogels are of great interest in view of their practical uses (Dubrovskii et al. 1990). Kazanskii and Dubrovskii (1992) mentioned that the superabsorbent ability of hydrophilic polymers is appropriate for practical usage, especially for the improvement of soil water retention. Paschold and Kleber (1995) present the possibility of using hydrophilic polymer material for the cultivation of vegetable seedlings for hydroponic culture. A positive influence of hydrophilic polymer material on the growth of plants in impaired soil conditions was noted by El-Hady et al. (1990), El-Sayed et al. (1991), Szmidt and Graham (1991), Borowski and Michalek (1998). Agrisorb is recommended for the production of adjuvants for hydrogel preparation, which is used in doping naked-rooted forest and fruit tree seedlings. For the enrichment of substrate, 2–3 g/l of substrate is recommended. Hydrophilic polymer Agrisorb is not normally used in vegetable seedling production. Therefore, the aim of this study was to examine how the addition of hydrophilic polymer to the substrate for the pre-cultivation of seedlings influences not only seedling characteristics, but also the consumable part after the cauliflower harvest.

MATERIAL AND METHODS

Field trials were established in 2009 and 2010. Seedlings were grown in greenhouses of the Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Czech Republic in culticells T 160 in the peat-bark substrate RKS I (Agro, Czech Republic). The cultivar Chambord F1 for year-round culture was used (Rijk Zwaan, The Netherlands). Prior to sowing, the substrate for seedling cultivation was unadjusted (A0), and was supplemented with a hydrophilic polymer (agent Agrisorb) in the quantity of 3 g of Agrisorb/l of substrate (A3). Field trials were carried out on land belonging to the Demonstration and Research Station of Czech University of Life Sciences Prague-Troja, which is situated 195 m a.s.l., in a mild warm and dry area on soil classified as modal fluvisol with a pH of 6.6–6.9. Average temperatures during the cauliflower vegetation period were 14.8°C in 2009 and 13.3°C in 2010. Seedlings were planted on a site covered with a plastic sheet in order to eliminate the effects of precipitation, which would make it impossible to maintain required soil levels. The planting space was 0.50 × 0.60 m. Irrigation was carried out by microspraying, and was based on current values of efficient water capacity (EWC); the critical value of the EWC was 80% for optimally irrigated fields, and 50% for variants with reduced levels of irrigation. A Virib sensor (AMET, Velké Bílovice, Czech Republic) was used for measuring soil moisture. When the current value drops below the minimum set limit, the soil moisture controller opens the solenoid valve of irrigation system and irrigates the experiment in the form of the microspray with an amount 10 to 20 mm (to the development of the vegetation – according to rooting depth). The total amount of irrigation water during vegetation is as follows: the variant with optimal levels of irrigation (FO) had 322 mm in 2009 and 306 mm in 2010; for the variant with reduced levels of irrigation (FS) it was 157 mm in 2009 and 129 mm in 2010. The cauliflower was cultivated in accordance with techniques recommended by Petříková et al. (2006). Standard fertilizer applications (following soil sample tests) and weed control practices were used.

Trial variants and agrotechnical terms of cauliflower are shown in Tables 1 and 2.

Prior to planting in the field, seedling samples were taken for the evaluation of root collar diameter, height and weight of the aboveground parts, root weight, and number of leaves. Weight, diameter, representation percentage, and the yield of marketable edible por-

Table 2. Agrotechnical terms of cauliflower growing in 2009–2010

Year	Sowing	Planting	Harvest	Irrigation quantity (mm)
2009	11. 2. 2009	6. 4. 2009	25. 6.–30. 6. 2009	FO (322 mm) FS (157 mm)
2010	11. 2. 2010	30. 3. 2010	24. 6.–2. 7. 2010	FO (306 mm) FS (129 mm)

Spacing in both years was 0.50 × 0.60 m

tions were evaluated after harvest. The contents of ascorbic acids, nitrates, dry matter, and values of total antioxidative capacity (TAC) were also evaluated. The reflectometric method was used for ascorbic acid and nitrate content determination. Dry matter contents were set by the gravimetric method (Javorský 1987), and the values of TAC by the spectrophotometric modified method of Fasseas et al. (2007). Mixed samples from three plants from each repetition (each trial variant was grown in 4 replicates) were prepared for analysis. The measured values were statistically analyzed using the STATISTICA 9.0 software system (Stat Soft CR s.r.o., Czech Republic) for data analysis.

RESULTS AND DISCUSSION

Average values of the seedling parameters in 2009 and 2010 are given in Table 3. With respect to cauliflower seedlings, the application of Agrisorb to the substrate for seedling precultivation significantly increased the weight of the aboveground parts by 17.3%, the root weight by 28.1%, and the leaf number by 7.9%. In contrast, the addition of Agrisorb significantly influenced neither the diameter of the root collar nor the height of the aboveground part of the cauliflower seedling.

The results of this experiment correspond to the information of Kant et al. (2008), which states that the addition of a hydrophilic substance to a substrate has a meliorative effect, which, among others, reduces electro conductivity of potting compost. Also, Miceli et al. (2003) indicated a reduction in weight and number of leaves of plants in soil conditions with a higher salt content.

Average values of weights, diameters, market yield, and percentage of marketable curds in 2009 and 2010 are shown in Table 4.

A significant influence of Agrisorb on the marketable yield was noted (22.2% increase) in conditions with reduced irrigation levels (FS); its influence on other evaluated parameters was not significant in this treatment. However, there are noticeable increases in values after the application of Agrisorb: weight (8% increase), diameter (3.6% increase), and percentage of edible parts of the cauliflower (8.6% increase). These results correspond with data of El-Hady et al. (1990), El-Sayed et al. (1991), Szmidt and Graham (1991), who brought attention to the positive influence of hydrophilic substances on plant growth, and hence their yield, in impaired environmental conditions.

The effect of Agrisorb on weight, diameter, marketable yield, and percentage representation of marketable edible parts was not significant in optimal irrigation conditions (FO). Heavier edible parts were noted in the variant with Agrisorb (FO/A3) (6.2% increase); yet, representation of marketable edible parts was lower in this variant (5.4% decrease). Thiss also negatively influenced the market yield by 3% compared with the non-Agrisorb treatment (FO/A0) which provided a lower yield. This effect may be due to the formation of inappropriate (excessive) moisture conditions, which, according to Bartoš et al. (2000), act as a negative pre-harvest factor.

Average levels of ascorbic acid, nitrates, dry matter, and TAC in 2009 and 2010 are shown in Table 5.

Although no significant differences are among the ascorbic acid contents between treatments, a lower ascorbic acid content with Agrisorb (A3) can be observed when compared with the non-Agrisorb (A0)

Table 3. Qualities of seedlings grown in substrate with and without Agrisorb in 2009–2010

Treatments	Diameter of root collar (mm)	Aboveground part		Weight of roots (g)	Number of leaves (pcs)
		height (mm)	weight (g)		
A0	1.682 ± 0.063[a*]	84.96 ± 4.33[a]	1.016 ± 0.055[a]	0.2100 ± 0.0221[a]	4.06 ± 0.16[a]
A3	1.644 ± 0.067[a]	91.78 ± 6.81[a]	1.192 ± 0.078[b]	0.2703 ± 0.0369[b]	4.38 ± 0.14[b]

*The significant differences ($P < 0.05$) between average values (± SD) are indicated in the column by various letters (LSD test); note: see Table 1

Table 4. Weight, diameter, market yield, and representation of marketable edible parts of cauliflower in 2009–2010

Treatments	Weight of edible part (g)	Diameter of edible part (cm)	Marketable yield (kg/100 m^2)	Percentage of marketable edible parts (%)
FO/A3	1,509 ± 94[b*]	19.83 ± 0.58[a]	373.3 ± 22.5[b]	75.86 ± 14.23[a]
FO/A0	1,421 ± 75[ab]	19.74 ± 0.53[a]	384.4 ± 22.4[b]	81.23 ± 10.91[a]
FS/A3	1,495 ± 99[ab]	20.05 ± 0.59[a]	388.3 ± 30.2[b]	82.24 ± 12.57[a]
FS/A0	1,384 ± 76[a]	19.35 ± 0.45[a]	317.8 ± 23.3[a]	73.64 ± 12.71[a]

*The significant differences ($P < 0.05$) between average values (± SD) are indicated in the column by various letters (LSD test); note: see Table 1

treatment (about 9.7% decrease) in conditions with lower levels of irrigation (FS). Contrarily, Agrisorb (A3) increased the ascorbic acid content (by approximately 9.2%) at optimal levels of irrigation (FO).

The increase in ascorbic acid content in the FS/A0 variant is most likely associated with plant responses to abiotic drought stress, which leads to the creation of more antioxidants, including ascorbic acid; this antioxidant helps the plant eliminate the negative effects of drought stress. The increase of ascorbic acid and other antioxidant compounds in plants due to abiotic stresses is reported by Babu and Devaraj (2008) in experiments with *Phaseolus vulgaris* L. and Nair et al. (2008) in experiments with *Vigna unguiculata* L.

The increase in ascorbic acid content in conditions of optimal irrigation with Agrisorb is interesting. This result is similar to the conclusions of Borowski and Michaek (1998), who reported an increased content of ascorbic acid in lettuce after the addition of hydrophilic substances to peat potting compost. This effect may occur when the optimal level of irrigation in combination with Agrisorb create inappropriate (excessive) moisture conditions, which act as excess water stressors. A similar trend of changes in ascorbic acid content can be seen in TAC, which increases significantly in variant FS/A0 (by 19.9%) when compared with variant FS/A3. However, it is clear that the TAC value is created not only by ascorbic acid, but also through a combination of many other antioxidants, which can react to changing moisture conditions differently than ascorbic acid. The effect of oxidative stress (due to abiotic and biotic agents) on the increase of antioxidant components in plants is also mentioned by Hernandez et al. (2009). However, Hernandez et al. (2009) consider the results in this area to be insufficiently verified.

Average levels of nitrates were insignificant due the high rate of variability. However, an opposite trend was observed in nitrate levels, when compared with respect to ascorbic acid. The addition of Agrisorb caused a nitrate increase in the variant with lower levels of irrigation (of 61.1%). Similar results were presented by Kant et al. (2008), who mentioned that the addition of a hydrophilic substance to a growing medium with higher salinity (which creates conditions similar to water deficit) increases nitrate levels. In optimal conditions of irrigation, the variants with Agrisorb showed a decrease in nitrate content (by 36.7%) when compared with the non-Agrisorb variant. An optimal irrigation level in combination with Agrisorb could create waterlog in the root zone and reduce the oxygen content in the soil, which in turn could induce denitrification in some of the nitrates. Reduced levels of nitrate in the soil were subsequently evident, through a lower nitrate content in plant parts. Increased denitrification in soil waterlogging was indicated by Nelson and Terry (1996), who found that irrigation by flooding, which creates anaerobic conditions in the soil for a certain period of time, may increase soil nitrate loss up to fourfold.

Table 5. Chemical composition and total antioxidative capacity in edible parts of cauliflower in 2009–2010

Variant	Ascorbic acid (mg/kg)	Nitrates (mg/kg)	Dry matter (g/kg)	Total antioxidative capacity (mg AA/kg)
FO/A3	426.9 ± 78.5[a*]	353.8 ± 131.4[a]	64.57 ± 5.39[a]	677.8 ± 66.4[a]
FO/A0	391.1 ± 54.8[a]	483.8 ± 260.3[a]	66.90 ± 6.44[ab]	690.5 ± 73.0[a]
FS/A3	374.5 ± 55.0[a]	421.3 ± 147.9[a]	72.11 ± 4.14[ab]	646.6 ± 45.8[a]
FS/A0	410.7 ± 63.0[a]	261.5 ± 113.5[a]	74.86 ± 8.58[b]	775.5 ± 67.9[b]

*The significant differences ($P < 0.05$) between average values (± SD) are indicated in the column by various letters (LSD test); AA – Ascorbic acid; note: see Table 1

The dehydration of plant tissues exposed to water deficit conditions is evident through a significant increase in dry matter content of the non-Agrisorb treatment with lower levels of irrigation: this is a direct comparison to the Agrisorb-added variant with optimal levels of irrigation, which had a much lower dry matter content.

In conclusion, the results indicate that Agrisorb seems to be an appropriate addition to the substrate, which positively affects the precultivated seedlings of cauliflower by forming a more massive root system and aboveground plant part, as well as a higher leaf number. In field conditions after outplanting, the effect of Agrisorb was not as strong as it had been during the precultivation of seedlings. In field conditions, utilizing Agrisorb is a way to limit the negative impact of drought on yield and quality during periods of water deficit. Yet, it is necessary to be somewhat critical and point out that the use of Agrisorb can be counterproductive in optimal conditions of irrigation.

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Received for publication December 6, 2010
Accepted after corrections February 18, 2011

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