SOIL & CROP SCIENCES | RESEARCH ARTICLE

Effect of nylon mulch and some plant growth regulators on water use efficiency and some quantitative traits in onion (Allium cepa cv.) under water deficit stress

Mohammad Hasan Shirzadi¹, Mohammad Javad Arvin²*, Abdolhosayn Abootalebi³ and Mohammad Reza Hasandokht⁴

Abstract: In order to investigate the effects of plant growth regulators (PGRs) and mulch on some traits of onion under water deficit stress, a split-factorial experiment based on Randomized Complete Block Design with three replications was conducted in Iran in 2016 and 2017. The main plot consisted of water deficit stress treatment at three levels (100%, 80% and 60% of water requirement), and sub-plots consisted of a dark nylon mulch application and an unmulched control, and PGRs six levels (zero, salicylic acid 0.5 mM, methyl jasmonate 5 and 7.5 mM, and 24-epibrassinolide 0.5 and 1 mM, respectively). Final yield under water deficit stress (60% water requirement) decreased by 30% compared to control (100% water requirement). On the other hand, the use of plastic mulch increased the yield by 29%. Interaction of water deficit stress and PGRs on leaf number, fresh and dry weight of plant, plant height, bulb length and diameter, early yield and final bulb yield were significant and the effect of regulators was mainly effective in severe water deficit conditions. The highest crop yield of 52.55 ton per hectare was obtained from 1 micromolar brassinolide treatment under non-stress conditions which had a 9% increase

ABOUT THE AUTHOR

Mohammad Hasan Shirzadi born in Iran, I am and graduated from Tehran University of Science and Research with a degree in Horticulture and also a member of the Department of Horticulture in Islamic Azad University Jahrom branch. So far I have published more than 20 scientific articles in Iranian and international journals ISI and ISC. Most of his research has been in the field of horticulture and vegetable science.

PUBLIC INTEREST STATEMENT

Water is the lifeblood and the main driving force behind agricultural activities, and 70% of the world’s water consumed is devoted to irrigation of crops. Many countries, especially those in arid and semi-arid regions, require water to produce crops, and more than 90% of Iran’s agricultural production is due to irrigated crops and is in fact a water-based agricultural development. In the future, the agricultural sector will have to produce more water while consuming less water, so with the proper management of water resources and the use of new knowledge and technologies, it should improve the efficiency of water resources, increase water use efficiency (WUE), increase irrigation efficiency and increase yield. The surface unit took basic steps. To achieve optimal performance in arid and semi-arid regions, one of the new options is to identify and apply new irrigation methods, because the application of new technologies will effectively increase WUE.
compared to control under non-stress conditions and 28% increase compared to control under severe water deficit stress.

Subjects: Agriculture & Environmental Sciences; Horticulture; Agriculture and Food

Keywords: drought stress; bulb yield; early ripening yield; plant growth regulators

1. Introduction
To achieve optimal performance in arid and semi-arid regions, one of the new options is to identify and apply new irrigation methods, since the application of new technologies will effectively increase water use efficiency and prevent solute accumulation in the root growth area, which will result in better. Agricultural professionals must adopt new technologies to address the quantitative and qualitative decline of water and soil resources, by opting for strategies such as the use of mulch. The use of a variety of mulch in agriculture, horticulture, soil conservation and sand stabilization and green space development has increased in recent years. The use of plastic mulch to increase yield and precocity (Caruso et al., 2013, 2019; Sekara et al., 2019) and increase water use efficiency is increasing. In a study relevant to the effects of three types of blue, black and transparent plastic mulch on cabbage pepper, the highest weed population in the transparent mulch was the least reported in the dark mulch (Ashraf et al., 2010). Many studies have been done on the benefits of mulch, including the findings in tomato. It has also been reported that the use of plastic mulch to maintain soil moisture is effective in raising the growth and yield (Bajguz & Hayat, 2009) and also for increasing the water use efficiency (Steinmetz et al., 2016). Salicylic acid is a phenolic compound that is naturally produced in plants. Numerous studies have confirmed the role of salicylic acid as an important messenger molecule in plant responses to numerous biological and non-biological stresses (El-tayeb, 2005; Malamy et al., 1990). It is possible to tolerate stresses in plants by treatment with salicylic acid and its derivatives in agriculture, horticulture and forestry (Senaranta et al., 2002). There are many reports of the positive effects of salicylic acid on plant tolerance against live and abiotic stresses, including increased growth parameters such as fresh and dry weights of roots and shoots, leaf area, etc., in maize under salinity stress (Khodray, 2004); Increase of resistance of maize (Khodray, 2004) and Arabidopsis (Borsanio et al., 2001) to salinity; Increase of tomato tolerance to salinity stress (Stevens & Senaranta, 2006); Increase of resistance to heat stress, cold and dry matter in bean and tomato plants (Senaratna et al., 2002); jasmonic acid, methyl jasmonate and other jasmonates activate many physiological activities in plants (Koda, 1992). Jasmonates are compounds that are activated during plant stress and are also important regulators of plant growth and development and simultaneously they increase cell division and cell proliferation (Takahashi et al., 1995). Methyl jasmonate plays an important role in cellular regulation in the developmental process, such as seed germination, root growth, fertility, maturation and aging (Creelman & Mullet, 1997; Wasternack & Hause, 2002). Evaluation of methyl jasmonate levels in tomato roots under salinity stress has shown that with increasing internal jasmonate, genes are expressed that cause resistance to stress (Abdala et al., 2003). In one experiment, salicylic acid and methyl jasmonate significantly increased the growth rate and effect of capsicum in suspended pepper cell environment (Sudha & Ravishankar, 2003). Other roles of jasmonates include accelerating fruit ripening, producing healthy pollen, growing roots, increasing plant resistance to stress and attacking insects and pathogens (Creelman & Mullet, 1997). In another experiment, using methyl jasmonate under water deficit stress in strawberries reduced evapotranspiration, reduced water loss and reduced MDA in leaves, as well as reduced the rate of loss of membrane lipids, glycolipids, and phospholipids and unsaturated fats (Bajguz & Hayat, 2009). brassinosteroids are steroid hormones that regulate plant growth. brassinosteroids (brs) increase plant adaptation to adverse environmental conditions (Ashraf et al., 2010). Studies show that brassinosteroids can induce a wide variety of cellular responses such as stem elongation, pollen roll growth, root formation, induction of ethylene biosynthesis, proton pump activation, and gene expression regulation (Kagale et al., 2007). Application of a type of brassinosteroid increased the relative water content, nitrate reductase activity, chlorophyll content, and photosynthesis. In
this study, plants that were treated with brassinosteroids had beneficial effects in the form of traits such as higher leaf area, higher biomass production, grain yield and yield components were observable (Sairam, 1994). The best treatment for increasing water use efficiency in onion, determining the best treatment for improving overall yield and other quantitative and qualitative traits of onion, determining the best treatment for early onion yield and determining the best treatment for increasing drought resistance on onion was carried out in Jiroft city.

2. Materials and methods
The experiment was conducted in Iran, on the outskirts of Jiroft city, at latitude, longitude and sea level, e.g., 28°33′N, 57°95′E and 625 MAMSL above sea level 35 km from the city center in a 2500 square meter land area in 2015. The soil texture was light and sandy loam, with no limitations on salinity. Soil pH of the test site was 7.5. The results of the physicochemical analysis of soil and water used in Table 1 are presented.

The experiment was conducted as a factorial split-plot based on randomized complete block design with three replications. The seedlings were planted in three planting lines per row and the distance between the seedling was 8 and between the rows was 35 cm. Water stress treatments were placed in the main plats and the combinations between mulch and growth plant regulator application in the sub-plots. Six-week-old transplants of Primavera were cultivated in the field after soil sampling and disk and leveler operations in a fully mechanized, four-row arrangement on a stack. Each experimental plot consisted of three 8 meter planting lines. At the beginning of planting, according to the soil fertilizer test results, fertilizers were added to the soil and other nutrient requirements of the plant were provided either through foliar application or through the irrigation system during the growing season. Irrigation of the field was done by drip and strip type. The mulch treatment was applied before planting. After full transplantation, seedlings were first sprayed at four to five leaf stage (and repeated 3 weeks later) and irrigated stress at 45 days after transplanting. Water intake was monitored through tanks of a specified volume and through adjustable valves and embedded meters at the outlet of each tank at the beginning of each plot. During the growing season, vegetative parameters were accurately measured. During experiment traits, leaf number, plant height, bulb length, bulb diameter, plant fresh weight, plant dry weight, bulb fresh weight, bulb dry weight, preterm yield (marketable tubers before final harvest), total yield was measured (with Digital Scale). In addition, the water use efficiency index in this experiment was obtained by dividing the yield of product (kg) and the amount of irrigation water to produce the product. Finally, SAS software was used for statistical analysis. Through the analysis of variance and means were compared with Duncan's test at 0.05 probability level.

3. Results
According to the results of analysis of variance, there was a significant interaction between water stress and mulch as well as water stress and PGRs on all studied traits. However, there was no significant interaction between the three factors studied (Table 2). Therefore, despite the significance of the individual effects of the three factors, the effects of significant interactions are discussed below.

| Soil | Soil depth(cm) | pH | EC mmoh | Soil Texture | K(ppm) | P (ppm) | N % |
|------|---------------|----|---------|--------------|--------|---------|-----|
| 0–30 | 7.5           | 2.14 | Sandy loam | 165 | 9 | 0.03 |
| Water | pH | EC (µs/cm) | Ca³⁺ | HCO₃⁻ | CL⁻ | SO₄²⁻ | Ca²⁺ | Mg²⁺ | Na⁺ |
| 7.3 | 1613 | 0 | 2.34 | 9.4 | 3.8 | 4.56 | 2.45 | 10.2 |
Table 2. Analysis of variance of traits measured in onions under water stress, mulch and growth regulators

| Sources | DF | Block | Drought (D) | Error a | Mulch (M) | D*M | Plant Growth Regulator (PGR) | D*D PGR | M* PGR | D*M* PGR | Test error | CV% |
|---------|----|-------|------------|---------|-----------|-----|-------------------------------|---------|--------|-----------|------------|-----|
|         |    | 2     | 10.12 ns   | 27.81 ns | 8.53 ns   | 6.00 ns | 7.75 ns                       | 8.11 ns | 28.88 ns | 10.62 ns   | 14.43 ns   | 6.16 |
|         |    | 2     | 208.06 **  | 10183.16 ** | 1836.75 ** | 101.83 ** | 28.49 ns                       | 37.22 ns | 497.31 ns | 802.05 **  | 4122.11 ns | 4.86 |
|         |    | 4     | 0.04       | 11.73    | 8.03      | 0.84    | 0.25                          | 0.11     | 10.51    | 11.14      | 7.99        | 6.84 |
|         |    | 1     | 88.60 **   | 4766.06 ** | 850.08 ** | 33.69 ** | 6.08 **                       | 12.61 ** | 396.18 ** | 678.10 **  | 1960.57 ** | 6.85 |
|         |    | 2     | 4.01 **    | 158.57 ** | 46.08 **  | 3.15 ** | 0.86 **                       | 0.16 **  | 36.29 ** | 48.04 **   | 145.56 **  | 9.45 |
|         |    | 5     | 3.04 ns    | 160.10 ** | 21.15 *   | 1.21 ** | 0.66 **                       | 0.59 *   | 12.16 ** | 17.00 **   | 90.00 **    | 11.09 |
|         |    | 10    | 17.51 **   | 80.99 **  | 49.15 **  | 0.25 ** | 0.38 **                       | 1.09 **  | 4.81 **  | 11.71 **   | 71.12 **    | 10.21 |
|         |    | 5     | 10.43 ns   | 18.67 ns  | 8.48 ns   | 0.09 mn | 0.05 mn                       | 0.02 mn  | 3.25 mn  | 1.22 mn    | 16.70 ns    | 6.85 |
|         |    | 10    | 10.63 ns   | 18.64 ns  | 15.28 ns  | 0.11 mn | 0.08 mn                       | 0.05 mn  | 2.50 mn  | 2.87 mn    | 13.56 ns    | 9.45 |
|         |    | 66    | 0.02       | 10.93     | 4.39      | 0.60    | 0.25                          | 0.11     | 10.94    | 8.10       |            |     |
|         |    |       |            |           |           |        |                               |          |          |            |             |     |
4. **Plant height and number of leaves**

The interaction of dehydration with PGRs on plant height and number of leaves per plant was significant, so that under non-stress and mild conditions (100% and 80% water requirement), the regulators showed no effect on increasing plant height and number of leaves, but under severe dehydration (60% water requirement), the regulators had an effective influence on increasing plant height and number of leaves and in comparison with the results the percentages of plant height and the number of leaves were increased up to 10% and 12% by the regulators (Table 3, Figure 1A and 1D). Also, the results presented in Table 4 show that plastic mulch under water non-stress condition did not affect plant height and leaf number but under severe water deficit stress (60% water requirement), plastic mulch, plant height and the number of leaves increased by 9% and 18%, respectively (Table 4, Figure 2A and 2D).

5. **Plant fresh weight**

Interaction of dehydration stress with PGRs on plant fresh weight was significant, so that under non-stress conditions and mild stress (180% of water requirement), the regulators had no effect on plant fresh weight gain but under severe stress dehydration conditions (60% of water requirement), the regulators were effective on increasing the fresh weight of the plant and, compared to the results, the regulators increased about 10% of the fresh weight of the plant (Table 3, Figure 1B). Besides, the results presented in Table 4 show that plastic mulch under non-stress conditions did not affect plant fresh weight but under severe water deficit stress (60% water requirement), using plastic mulch will increase wet weight by up to 17% in comparison with the results (Table 4, Figure 2B).

6. **Plant dry weight**

The interaction of water deficit stress with PGRs on plant dry weight was meaningful, so that under non-stress and mild stress conditions (180% of water requirement), the regulators had no effect on plant dry weight gain but under Severe dehydration stress conditions (60% of water requirement), the regulators had an effective influence on increasing the dry weight of the plant and compared to the results, the plant dry weight was increased from 2% to 20% by the regulators (Table 3, Figure 1C). Also, the results presented in Table 4 show that plastic mulch under non-stress conditions did not affect plant dry weight, but under severe water deficit stress (60% water requirement), use of plastic mulch will increase plant dry weight by up to 18% compared to the corresponding control (Table 4, Figure 2C).

7. **Length and diameter of bulb**

The interaction of dehydration stress with PGRs on bulb length and diameter was considerable, so that under non-stress conditions and mild stress (180% of water requirement), the regulators had no effect on bulb length and diameter but under severe drought stress conditions (60% water requirement), the regulators had an effect on increasing the length and diameter of the bulb and, compared to the results, the regulators increased the bulb length and diameter by 8% to 10% and 5%, respectively (Table 3, Figures 1F and 1E). Moreover, the results presented in Table 4 show that plastic mulch under non-stress conditions did not increase bulb length and diameter but under severe water deficit stress (60% water requirement), use of plastic mulch will raise the length and diameter up to 10% compared to the corresponding control (Table 4, Figure 2C).

8. **Early yield and final bulb yield**

The interaction of dehydration stress with PGRs was significant on early yield and final yield of the crop, so that under non-stress and mild stress (180% of water requirement), the regulators had no effect on crop growth but under Severe dehydration stress conditions (60% of water requirement), regulators had an effect on increasing preterm yield and final yield, and compared to related results, preterm yield and final yield were increased between 22 and 28% and 12% to 14% by regulators, respectively (Table 3, Figures 1H and 1G). Also, the results presented in Table 4 show that plastic mulch under non-stress conditions did not increase yield and final yield, but under severe dehydration (60% water requirement), use of plastic mulch will raise the preterm yield and final yield by 43% and 29%, respectively (Table 4, Figures 2H and 2G).
Table 3. Comparison of interaction of water deficit stress and PGRs on studied traits

| Traits WR% × PGR | Plant height (cm) | Plant fresh weight (g) | Plant dry weight (g) | Leaf number | Bulb length (cm) | Bulb diameter (cm) | Final yield (ton/ha) | Early performance (yield) (ton/ha) |
|------------------|-------------------|------------------------|---------------------|-------------|-----------------|-------------------|-------------------|---------------------------------|
| **60**           |                   |                        |                     |             |                 |                   |                   |                                 |
| Control          | 62.51             | 110.17h                | 22.50g              | 9.01e       | 6.73d           | 5.67d             | 41.50c            | 24.73e                         |
| SA 0.5 mM        | 66.17h            | 116.62fg               | 24.00fg             | 10.11cde    | 7.28d           | 5.97d             | 47.50abc          | 30.17d                         |
| MJ 5.0 µM        | 67.50g            | 113.00gh               | 22.65g              | 9.23e       | 7.02d           | 5.78d             | 46.50bc            | 30.84d                         |
| MJ 7.5 µM        | 68.00f            | 119.00f                | 23.00g              | 9.38e       | 7.28d           | 5.95d             | 47.00abc           | 31.08d                         |
| BE 0.5 µM        | 66.89h            | 116.67fg               | 25.01efg            | 9.67e       | 7.02d           | 6.03cd            | 46.56bc            | 31.73cd                        |
| BE 1.0 µM        | 66.50h            | 118.50fg               | 27.06def            | 9.94de      | 7.35cd          | 5.98d             | 46.89bc            | 31.74cd                        |
| **80**           |                   |                        |                     |             |                 |                   |                   |                                 |
| Control          | 68.19f            | 129.00e                | 28.00de             | 11.12bcd    | 7.60d           | 6.61b             | 46.00bc            | 31.99bcd                        |
| SA 0.5 mM        | 68.34f            | 134.50de               | 30.01cd             | 11.37bcd    | 8.12abc         | 7.00b             | 47.49abc           | 32.73abcd                       |
| MJ 5.0 µM        | 69.01e            | 136.00d                | 33.51bc             | 11.49b      | 8.34ab          | 6.73b             | 47.01abc           | 33.56abcd                       |
| MJ 7.5 µM        | 71.11c            | 138.50d                | 37.51a              | 11.18bcd    | 8.23abc         | 6.50bc            | 47.51abc           | 34.15abcd                       |
| BE 0.5 µM        | 70.23d            | 134.50de               | 30.00cd             | 11.28bc     | 8.27abc         | 6.90b             | 48.50ab            | 33.00abcd                       |
| BE 1.0 µM        | 70.55d            | 137.00d                | 30.49cd             | 11.83ab     | 8.61a           | 6.90b             | 48.73ab            | 33.95abcd                       |
| **100**          |                   |                        |                     |             |                 |                   |                   |                                 |
| Control          | 69.45e            | 145.00c                | 36.00ab             | 12.72a      | 8.97a           | 7.67a             | 50.95abc           | 35.01abcd                       |
| SA 0.5 mM        | 70.65d            | 150.00abc              | 38.04a              | 12.87a      | 8.83a           | 8.28a             | 52.50a             | 37.41ab                         |
| MJ 5.0 µM        | 72.10b            | 146.50bc               | 37.51a              | 12.95a      | 8.94a           | 7.73a             | 52.15ab            | 36.67abc                        |
| MJ 7.5 µM        | 72.00b            | 154.00a                | 38.50a              | 12.89a      | 8.99a           | 7.71a             | 52.01ab            | 37.50ab                         |
| BE 0.5 µM        | 72.45b            | 151.00ab               | 38.51a              | 12.95a      | 8.99a           | 7.94a             | 51.58ab            | 37.00abc                        |
| BE 1.0 µM        | 73.09a            | 150.00abc              | 39.006a             | 13.16a      | 9.09a           | 8.21a             | 52.55a             | 38.08a                         |
| Shirzadi et al., Cogent Food & Agriculture (2020), 6: 1779562
https://doi.org/10.1080/23311932.2020.1779562

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9. Water use efficiency
The interaction of water deficit stress with PGRs was significant on water use efficiency, so that under non-stress and mild stress conditions (180% of water requirement), the regulators had no effect on increasing water use efficiency but under Severe dehydration stress conditions (60% of water requirement), regulators had a significant effect on increasing water use efficiency, and compared to the control results, regulators increased water use efficiency by 12% to 14% (Table 3, Figure 1I). Also, the results presented in Table 4 show that plastic mulch under water non-stress does not increase water use efficiency, but under severe water deficit conditions (60% water requirement), plastic mulch use will raise the water use efficiency by up to 26% compared to the corresponding control (Table 4, Figure 2I).

Means in each row with the same letter are not significantly different according to Duncan’s test (p < 0.05).

10. Discussion
In the present experiment, it was found that with increasing water deficit stress all vegetative traits and onion bulb yield decreased significantly. Due to drought stress, plant height, leaf number, fresh and dry weight of leaf and onion (Allium cepa L.) decreased (Samvati, 2014; Wakchaure et al., 2018). Growth parameters including leaf area index, dry matter accumulation in soybean (Glycine max L.) were also sensitive to water stress resulting from reduced irrigation (Karam et al., 2005). Which affects leaf area index through leaf fall and death at different stages of growth. The results of other studies also showed that the leaf was susceptible to moisture depletion in different plants, indicating a decrease in leaf number under these conditions.

| WR% × Mulch | 60 | 80 | 100 |
|-------------|----|----|-----|
| No mulch    | No mulch | No mulch | No mulch | No mulch | No mulch |
| Plant height (cm) | 62.85f | 67.67e | 68.17d | 70.67c | 71.00b | 72.17a |
| Plant fresh weight (g) | 106.82d | 124.50c | 128.50c | 141.33b | 144.50b | 153.83a |
| Plant dry weight (g) | 25.00d | 29.50c | 30.00c | 34.00b | 35.33b | 40.66a |
| Leaf number | 8.75c | 10.36b | 10.78b | 12.10a | 12.70a | 13.15a |
| Plant fresh weight (g) | 6.3d | 7.55cd | 7.90bc | 8.48ab | 8.90a | 9.03a |
| Plant dry weight (g) | 5.63d | 6.16c | 6.41c | 7.13b | 7.53b | 8.32a |
| Leaf number | 8.75c | 10.36b | 10.78b | 12.10a | 12.70a | 13.15a |
| Bulb length (cm) | 34.48d | 44.50c | 49.03bc | 52.44ab | 54.86a | 56.02a |
| Bulb diameter (cm) | 25.08d | 35.88c | 36.54bc | 39.91abc | 40.98ab | 43.64a |
| WUE (kg/m³) | 47.89c | 60.41a | 51.07bc | 54.62b | 45.71c | 46.68c |

ns, * and **, respectively, no significant difference, significant difference at p < 0.05 and p < 0.01.

Means in each row with the same letter are not significantly different according to Duncan’s test (p < 0.05).
Water deficit stress in the present study also significantly reduced growth parameters such as plant height, fresh and dry weight of plant organs. The observed decrease in growth parameters due to dehydration stress is probably due to reduced photosynthesis and materialization, chlorophyll degradation and lack of development and cell division. It has been reported that a concentration of 0.05 mM salicylic acid increases cell division within the root meristem of wheat seedling and thereby improves plant growth. (Shakirova et al., 2003). Other reports indicate that salicylic acid increases biomass and plant height in seed under non-stress conditions (Nemeth et al., 2002).

Methyl jasmonate also reduced the effects of water stress on onion in the present experiment. Similarly, the beneficial effects of methyl jasmonate on growth traits and tolerance to dehydration have been reported by others in various cases (Ahmad & Murali, 2015; Alam et al., 2014; Miranshahi & Sayyari, 2016; Mohamed & Latif, 2017; Sheteiwy et al., 2018). Jasmonic acid and methyl jasmonate have inhibitory or accelerating effects on the physiology and morphology of plants as well as their effect on exposure to environmental stresses such as dehydration, cold stress and salinity stress and activation mechanisms. Defenses against insects, pathogens and vegetarians have been identified (Creelman & Mullet, 1997; Lorenzo et al., 2003; Reymond, 2000).

In the present experiment, it was found that the application of mulch and PGRs increased and water deficit stress reduced all vegetative traits and yield components in onion. The highest vegetative traits and subsequently bulb yield were obtained from growth regulator treatments in the presence of 1 μM brassinosteroid in the presence of mulch treatment. This increase in vegetative traits may be due to the stimulation of plant cell proliferation by brassinosteroids, which alter the expression patterns of brassinosteroids in the presence or absence of auxin, indicating that brassinosteroids alone have this effect. Recently, it has been shown that brassinosteroids stimulate cell division independently on other growth hormones. However, brassicinoids react with endogenous auxin levels and increase the effects of each other (Arteca, 1996), thereby increasing plant height and increasing plant fresh weight.

According to the results of this study, under severe drought stress, regulators had an effect on increasing water use efficiency, and compared to the results, regulators increased water use efficiency by 12% to 14%. RWC is one of the most important indicators of water status in plants, which is related to root water uptake and leaf secretion. RWC has been shown to be an important indicator of water stress in plants that is directly related to soil water content (Mohamed & Latif, 2017). The positive effect of methyl jasmonate growth regulator on water deficit stress on RWC has been reported in different plant species (Ahmad & Murali, 2015; Alam et al., 2014; Mahmoud et al., 2012; Mohamed & Latif, 2017; Pazirandeh et al., 2015; Sheteiwy et al., 2018; Wu et al., 2012). The use of growth regulators, possibly by closing the stomata and accumulating osmolytes, improves RWC tissue and tissue content under drought conditions. In addition, it improves root hydraulic conductivity through independent and calcium-dependent ABA signaling pathways that can improve water uptake and plant water status under limited moisture (Sanchez-Ramera et al., 2014).

Based on the results of this study, the interaction of water stress and PGRs on yield components including diameter, length and final bulb yield was significant at p < 0.01 and in all cases, the highest bulk yield and final yield components were required from treatment composition. One hundred percent water requirement (non-stress) and growth regulator were obtained with 1 μM Brassinoid, while the lowest level was obtained from 60% water requirement (severe stress) and no use of growth regulators. The effect of brassinosteroids on metabolic activities and plant function, and tolerance to a variety of stresses can be stimulated by the production of other hormones (Divi et al., 2010) due to the greater expression of stress-responsive genes (Kagale et al., 2007), increased activity of antioxidant enzymes and osmotic adjustments (Divi & Krishna, 2010), higher photosynthetic efficiency (Ogweno et al., 2008), increased membrane stability (Shen et al., 1990), or protein synthesis special effects (Kulaeva et al., 1991). Generally, brassinosteroids can be useful in moderating a variety of stresses if used at the right concentration and at the appropriate growth
stage of the plant (Bajguz & Hayat, 2009), but they also increase the quality of crops and their tolerance to a variety of stresses (Bajguz & Hayat, 2009; Talaat & Shawky, 2012). The results of this study also showed that the interaction between dehydration and mulch on diameter, length and final yield of bulb was significant at p < 0.01 level and the highest bulb diameter, length and final yield were obtained from 100% water requirement and nylon mulch application. The lowest amount was obtained from 60% water requirement and no use of mulch. All the traits and yields were increased after the application of mulch in the present experiment, so that using nylon mulch under 60% water deficit and irrigation treatments increased the final crop yield to 30% and the early crop yield to 43%. Benefits from using mulch include improved soil moisture capacity, soil protection against erosion, and weed control. Nowadays, plastic mulch is used to increase yield and early crop yield, especially for thermophile varieties such as pepper, corn, tomatoes and more. Since 2006, there has been considerable research and advances on rubbish to make it easier to use, cheaper and more environmentally friendly. Over the past 5 years, these developments have led to innovations in the field, including the technology of making plastics in agriculture such as light-decomposing mulch or colored dyes (Ashrafuzzaman, et al., 2011).

In this experiment, plastic mulch was able to control weeds very well, but in black plastic, the best weed control was achieved probably because black plastic completely prevented light from reaching the root zone and thus weeds grew. Some research (Diaz Perez et al., 2004) has shown that the use of dark nylon mulch increases the temperature in the root growth zone by 2 degrees, and this factor causes faster and greater growth of onion plants in winter. This is one of the main reasons for the increased performance of onion in the present experiment. The author’s observations throughout the growing season showed that pests and diseases were significantly lower in plants treated with mulch than in the control treatment. The application of mulch accelerates the beginning of the harvest and, given the price of the crop, has a good economic justification. In a similar experiment that examined the effect of colored mulch on lettuce, red and dark mulch showed the highest positive effects on leaf length and width, transplant survival percentage, fresh lettuce weight and leaf width, among others (orange, yellow, green). The overall performance of lettuce per unit area was consistent with the

Figure 1. Changes of the studied parameters as an influence by water requirement percent and the plant growth regulators. SA: Salicylic acid; MJ: Methyl jasmonate; B: Brassinostroid.
results of this study (Franquera, 2011). Nowadays, foliar application of plant PGRs to increase the quantity and quality of agricultural products is considered as a suitable option by researchers. Brassinosteroids affect the function of the whole gland by stimulating cell division and enlargement (Arteca, 1996). In an experiment by Pipatanavang (1996), the application of brassinolide had a significant effect on yield increase at 1 μM concentration on strawberry bushes. In the present study, foliar application of 24-epi-brassinolide was performed before the plants were dried. As a result, the increase in yield was probably due to the effect on bulb weight per plant. One of the most important effects of brassinosteroids appears to be its close relationship with indole acetic acid (IAA) and the interaction between these two hormones.

11. Final conclusion
From the present research, it has arisen that water stress significantly reduced yield onion, while nylon mulch increased water use efficiency and increased onion yield. It was also found that PGRs improve the final yield and increase water use efficiency in onions while reducing the effects of water stress. Among the growth regulators, 1 μM brassinosteroid showed the most positive effect. Overall, severe dehyrdation stress (60% water requirement) reduced yield by about 20% compared to the control (100% water requirement). Although under non-stress and mild stress conditions (100% and 80% of water requirement), the regulators had little effect on crop growth, but under severe water deficit conditions (60% of water requirement), the regulators had an effective influence on growth. Regulators increased the yield by 12% to 14% compared to the control. The results also show that under severe dehydration (60% of water requirement), the use of plastic mulch increased the crop yield by 29% compared to the control.

Funding
The authors received no direct funding for this research.

Competing Interests
The author declare no competing interests.

Author details
Mohammad Hasan Shirzadi
E-mail: shirzadi.hassan@gmail.com
Mohammad Javad Arvin
E-mail: arvinsmj@gmail.com
Abdolhosayn Abootalebi
E-mail: ao94607@gmail.com
Mohammad Reza Hasandokht
E-mail: mrahassan@ut.ac.ir

1 Department of Agricultural Management, College of Agriculture and Food Industry, Agronomy and Horticulture Science, Science and Research Branch, Islamic Azad University, Tehran, Iran.
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