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Effect of the herbicide bentazone in combination with trehalose on wheat, growth, yield and associated broad weed Anagalis arvensis

K. G. El-Rokiek, S. A. Saad El-din, M. G. Dawood, M. E. El-Awadi*

Botany Department, Agriculture and Biological Institute, National Research Centre, 33 El Bohouth st P.O. 12622, Dokki, Giza, Egypt

**Corresponding author, Email address: el_awadi@yahoo.com*

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el_awadi@yahoo.com

Abstract

Two pot experiments were carried out in the greenhouse of National Research Centre, Egypt during the two winter seasons 2019/2020 and 2020/2021. In these experiments bentazone herbicide was applied single at the two doses; recommended 1L/Fed. (Rec) and ½ recommended dose ½L/Fed. (½ Rec) or in combination with trehalose 50mM (T1) and 100mM (T2) to find out their effect on the growth and yield of wheat cv. Sakha 169 plants and associated broad weed Anagalis arvensis. The results showed that the single application of herbicide bentazone at the recommended and ½ recommended doses caused great significant inhibition in broadleaved weed growth that represented by fresh and dry weight after 40 days from sowing and at the end of the season. The combined treatment of the recommended dose of the herbicide and trehalose at 50mM induced the most inhibition in weed growth. The inhibition in weed growth was accompanied with increase in wheat growth and yield. Yield and yield components that are represented by spike length, number of spiklets/spike, wheat yield / plant (g). The highest increase in these parameters was recorded by the combined treatment of the recommended dose of the herbicide and trehalose at 50mM. The results suggested using trehalose with the bentazone herbicide to avoid any negative effect of the herbicide and increasing yield production.

1. Introduction

Wheat is one of the most important food crops in the world. So, increasing wheat yield must be a national interest to minimize the gap between production and consumption. Weeds are one of the most important factors causing reduction in wheat yield. The weeds compete with wheat plants for light, water and minerals [1] and caused a significant yield reduction of wheat reached to 52% [2] as compared to weed free control. Herbicides are considered the main option to control weeds effectively in wheat fields. Bentazon related to Benzothiadiazole group, the only herbicide in this group, inhibits photosynthesis at different binding sites. It selectively controls broadleaved weeds in leguminous crops such as soybean, dry bean, pea, and peanut. It can be used postemergence in corn, sorghum, rice, and and peppermint [3]. Bentazon, 3-isopropyl-2,1,3-benzothiadiazin-4-one-2,2-dioxide control broadleaved weeds through inhibiting of photosynthesis a). Bentazon inhibited the Hill reaction in isolated chloroplasts; b) bentazon rapidly inhibited photosynthetic CO_2 fixation in susceptible *Cyperus serotinus* and other plants [4]. Regarding Bentazone effect on broad leaves weed; Vargas *et al.* [5] reported that bentazone was selective to wheat and used in controlling turnip seed and vetch. Bentazon needed to be 455 g/ha to reduce henbit (*Lamium amplexicaule*) dry weight by 90% as well as fixed weed (*Descurainia Sophia*) when was applied alone in wheat [6]. Moreover, the herbicides bentazon, is selective to wheat, cultivar Quartzo and do not affect wheat yield and efficient for wild radish control as controlled 66% of wild radish and increased grain productivity [7].

It has been found that some herbicides had counteractive effects on crop plants and these negative effects could be retarded or reduced by exogenous application of some growth agents or safeners [8-10]. The interaction resulting from the combination of herbicides with some substances resulted in products can be characterized as synergistic, i.e. resulted in product has more negative effect on the target plant However, antagonistic effect resulted in product retarded the negative effect or counteract this negative action on the target plant; additive may have no response [11]. These effects have many different advantages, one of them increasing the toxicity of the herbicide on weeds (Synergism) with or without effecting grain yield. The other effects counteract the adverse effect of the herbicide on grain yield but may reduce the herbicide efficiency on weeds. The ideal effect of the interaction is to reduce the counteraction effect on crop without affecting the selectivity of the herbicide [10, 12].

Trehalose is a nonreducing disaccharide of glucose that plays a role in the stabilization of biological structures under abiotic stress in bacteria, fungi, and invertebrates. Trehalose is not thought to accumulate to detectable levels in most plants [13]. Trehalose is very stable in comparison to sucrose because the glycosidic bond that joins the two hexose rings has low energy (1 kcal/mol), so, Trehalose is not easily broken into its two glucose molecule components, except in the presence of trehalase that can be found in cellular cytoplasm with a neutral pH or within vacuoles with a pH of 4.5 [14].

It has been proposed that trehalose in solution protects biological structures against water removal that takes place during dehydration or freezing, replacing the water molecules in the hydration layer [15]. This mechanism would help to stabilize the biomolecules and inhibit their irreversible denaturation [16].

In general, exogenous application of natural plant products could compensate certain metabolites that were eliminated by herbicide treatment [9,10]. Bentazone injury was prevented by endogenous or exogenously supplied carbohydrates [4]. Regarding this effect, so, exogenous application of trehalose with the herbicide bentazone may be of great importance. Target plant treated with herbicides may be under abiotic stress; it was found that exogenous trehaose application could alleviate the adverse effects of drought stress on quinoa plant (abiotic stress) through improving their growth and physiological attributes [17-19].

2. Materials and Methods

Two Pot experiments were conducted under the conditions of greenhouse of National Research Centre in Egypt in the two winter seasons 2019/2020 and 2020/2021to study the effect of bentazone herbicide (3-isopropyl-2,1,3-benzothiadiazin-4-one-2,2-dioxide) alone or in combination with the disaccharide trehalose on controlling the broad weed *Anagalis arvensis* associated wheat plants. Wheat seeds (*Triticum aestivum* L) cv Sakha 169 that were obtained from Agricultural Research Centre, Egypt were sown on the second week of November in pots 30 cm diameter. Weed seeds of *Anagalis arvensis* (0.01g/pot) were sown with the same time at depth 2cm. Routine fertilizers were added as super phosphate, potassium sulphate and ammonium nitrate as source of Phosphorus, Potassium and Nitrogen. The treatments were:

1. Free weed wheat plants
2. Unweeded
3. Rec (Bentazone, 1L/Fed.)
4. ½ Rec (Bentazone, ½ L/Fed)

5. T1 (Trehalose 50mM)
6. T2 (Trehalose 100mM)
7. Rec + T1 (Bentazone herbicide 1L/Fed+ Trehalose 50mM)
8. Rec + T2 (Bentazone herbicide 1L/Fed+Trehalose 100mM)
9. ½ Rec + T1 (Bentazone herbicide ½ L/Fed+ Trehalose 50mM)
10. ½ Rec + T2 (Bentazone herbicide ½ L/Fed+ Trehalose 100mM)

The herbicide at the two doses alone or in combination with Trehalose were sprayed after 30 days from sowing. The treatments were arranged at complete randomized design with six replicates in each treatment.

2.1. Weed samplings

Weed samples from three pots were taken at 40 days after sowing (DAS) and the fresh and dry weight of *Anagalis arvensis* were recorded. At the end of the season weed samples were taken from the other three pots and dry weight was determined.

2.2. Wheat data

Samples of wheat plants were taken randomly from each pot to measure plant height, number of leaves / plants, fresh and dry weight /plant DAS. At harvest, yield and yield components were determined, as spike length, no. of spikes/plant, number of spikelets/ spikes, weight of grains/spike, grain yield (g/plant) and1000 grain weight (g).

2.3. Chemical analysis in the yielded seeds

2.3.1. Determination of total phenolic content

Total phenolic content was extracted from dry finally ground seeds according to the method described by Gonzalez *et al*. [20].

2.3.2. Determination of total soluble sugars

Total soluble sugar content was extracted from dry finally ground seeds according to the method described by Homme et al. [21].

2.3.3. Determination of total carbohydrates

Total soluble sugar content was extracted from dry finally ground seeds according to the method described by Dubois et al. [22].

2.3.4. Determination of total polysaccharides

Total polysaccharides content was determined by subtracting the content of total sugar from the content of total carbohydrates.

2.4. Statistical analysis:

All data were statistically analyzed according to Snedecor and Cochran [23] the treatment means were compared by using LSD at a 5% level of probability. Means were compared by using LSD at a 5% level of probability.

3. Results

3.1. Weeds

Reduction in fresh and dry weight of *Anagalis arvensis* was realized with the application of bentazone herbicide at both doses (1L and1/2 L/Fed.). The recommended dose controlled 88% of *Anagalis arvensis* (dry weight). The lower dose caused less inhibition **(Table 1)**. In addition, the combined application of bentazone herbicide at the recommended dose and trehalose at T2 induced the most reduction in weed dry weight exceeded 90% inhibition 40 DAS and at harevest in comparison to the unweeded control. On the other hand, the unweeded control recorded the highest fresh and dry weight.

3.2. Wheat growth

Single application of trehalose at T1and T2 increased plant height as well as number of leaves/plants compared with the unweeded control. Moreover, higher increase was obtained with the combined treatments of bentazone herbicide and trehalose. Maximum significant increases in plant height and number of leaves/plants were recorded with the recommended dose of the herbicide bentazone combined with the lower concentration (T2) of trehalose **(Table 2)** at the vegetative stage as compared to the unweeded control. The greatest significant increase in fresh weight exceeded 40% over the untreated control. The increase in fresh weight was accompanied by dry matter accumulation causing corresponding result exceeded 50% over the untreated control. It is worthy to mention that wheat free plants recorded the highest results.

Table 1. Effect of the herbicide bentazone in combination with trehalose on weed growth

Treatments	Concentration	40DAS		At the end of the season
		Weed FW	Weed DW	
Weed free plants	**0**	**0.00**	**0.000**	**0.000**
Unweeded plants	**0**	**27.80**	**4.924**	**18.274**
Rec	**1L/fed.**	**3.09**	**0.572**	**1.914**
1/2Rec	**½L fed.**	**6.37**	**1.235**	**10.782**
T1	**50mM**	**15.80**	**3.101**	**12.577**
T2	**100mM**	**8.60**	**1.895**	**11.384**
Rec+T1	**1L/fed.+ 50mM**	**2.82**	**0.532**	**1.517**
Rec+T2	**1L/fed.+ 100mM**	**0.495**	**0.125**	**1.158**
½ Rec **+T1**	**½L/fed.+ 50mM**	**5.84**	**1.115**	**5.284**
½ Rec **+T2**	**½L/fed.+ 100mM**	**4.88**	**0.954**	**3.349**
LSD at 5%		**3.33**	**0.196**	**0.503**

Table 2. Effect of the herbicide bentazone in combination with trehalose on wheat growth at 40 days

Treatments	Concentration	Plant height	No. leaves	Fresh weight /plant (g)	Dry weight /plant (g)
Weed free plants	**0**	**39.66**	**5.66**	**1.61**	**0.335**
Unweeded plants	**0**	**31.11**	**4.00**	**0.750**	**0.132**
Rec	**1L/fed.**	**35.88**	**5.11**	**0.821**	**0.154**
1/2Rec	**½L fed.**	**33.66**	**5.33**	**0.93**	**0.162**
T1	**50mM**	**33.88**	**5.44**	**0.98**	**0.166**
T2	**100mM**	**35.33**	**5.55**	**1.14**	**0.195**
Rec+T1	**1L/fed.+ 50mM**	**38.33**	**5.44**	**1.37**	**0.299**

Rec+T2	1L/fed.+ 100mM	40.00	6.11	1.41	0.311
½ Rec +T1	½L/fed.+ 50mM	34.00	5.44	1.34	0.287
½ Rec +T2	½L/fed.+ 100mM	36.88	5.55	1.36	0.291
LSD at 5%		1.72	0.21	0.24	0.019

3.3. Wheat yield

Data in **Table 3** indicate significant increase in spike length, number of spikelets/spike as well as grain yield/plant (g) with trehalose at T1 and T2 and their combination with the herbicide at the two doses. The increase was superior with using the combined treatments specially the recommended dose of herbicide and trehalose at T2 in comparison to the unweeded treatment. However, the lowest results were recorded with unweeded control. The pots treated with herbicide only or in combination with trehalose exhibited significant increases in grain yield/plant (g) in comparison to the unweeded control. The increase was remarkable with combined treatment of the recommended dose of the herbicide with trehalose at T2 (Table 4). The increase in grain yield exceeded unweeded treatment by 250%.

Table 3. Effect of the herbicide bentazone in combination with trehalose on wheat yield components

Treatments	Concentration	Spike length	No. spikes/plant	No. spiklets/spike (g)	Grain yield/plant	Wt. 1000 grain (g)
Weed free plants	0	7.49	5.00	17.16	7.28	48.00
Unweeded plants	0	5.88	3.03	14.00	3.66	27.37
Rec	1L/fed.	7.22	4.25	18.88	5.95	46.5
1/2Rec	½L fed.	6.87	3.16	17.7	4.18	42.57
T1	50mM	6.50	3.75	15.5	4.53	37.94
T2	100mM	7.05	4.13	16.00	6.07	38.75
Rec+T1	1L/fed.+ 50mM	7.26	4.21	20.00	7.32	43.23
Rec+T2	1L/fed.+ 100mM	8.15	5.42	23.33	12.94	56.27
½ Rec +T1	½L/fed.+ 50mM	6.12	3.83	15.66	4.55	41.25
½ Rec +T2	½L/fed.+ 100mM	6.90	4.13	20.66	6.95	47.93
LSD at 5%		0.34	0.21	1.37	0.42	1.54

Table 4 show that phenol content in the yielded grain was significantly lower than the unweeded treatment mostly by the treahalose at the two concentrations used (50 and 100 ppm) and their combinations with bentazone at the recommended and half recommended dose. The results also reveal lower phenol content in grains by the herbicide as single application of the recommended and half recommended dose as compared to the untreated control.

Carbohydrate contents (sugar, total carbohydrates and poly saccharides) increased significantly in the grains with individual treatment of the herbicided bentazone, trehalose as well as their combinations over the unweeded treatment. Combination of trehalose at 100 ppm with the herbicide at the recommended dose measured maximum contents of all carbohydrates (sugar, total carbohydrates and poly saccharides).

Table 4. Effect of the herbicide bentazone in combination with trehalose on some chemical constituents in wheat grains

Treatments	Concentration	Phenol %	Sugar %	Total carbohydrates	Polysaccarides
Weed free plants	**0**	**3.92**	**5.985**	**79.060**	**73.075**
Unweeded plants	**0**	**5.265**	**4.00**	**56.96**	**52.96**
Rec	**1L/fed.**	**3.92**	**5.780**	**67.625**	**61.845**
1/2Rec	**½L fed.**	**3.98**	**5.180**	**61.38**	**56.2**
T1	**50mM**	**5.00**	**5.110**	**64.54**	**59.43**
T2	**100mM**	**4.115**	**5.835**	**66.72**	**60.885**
Rec+T1	**1L/fed.+ 50mM**	**3.71**	**5.985**	**75.395**	**69.41**
Rec+T2	**1L/fed.+ 100mM**	**3.03**	**6.865**	**79.015**	**72.15**
½ Rec **+T1**	**½L/fed.+ 50mM**	**3.94**	**5.225**	**63.400**	**58.175**
½ Rec **+T2**	**½L/fed.+ 100mM**	**3.565**	**5.440**	**76.55**	**71.11**
LSD at 5%		**0.227**	**0.18**	**1.52**	**1.61**

4. Discussion

Weed management is an important practice in production systems that search high productivity and quality of agricultural products. The most widely used weed management method is the chemical control because it is suitable and effective when compared to other methods.

Although controlling weed well but in some cases the target crop was damaged, however, studies have indicated that some combinations may reduce the phytotoxicity of certain herbicides as for example the combination of fenoxaprop-p-ethyl and picoxystrobin reduced the injury on wheat, leading to a higher plant development when compared to the single herbicide application [24].

So, addition of some agents to the herbicides can protect crop plants from herbicide damage without reducing activity in target weed species [12]. Various attempts were developed to reduce the negative effects of the recommended rates of herbicides. Thus, altering the phytotoxicity of the herbicide on crop plants [25].

The results obtained reveal that foliar spray with the recommended dose (L/Fed.) of the herbicide bentazone caused great significant inhibitions in the fresh and dry weight of the broadleaf weed *Anagalis arvensis* (Table 1) reaching nearly to complete death. Several workers recorded control of broadleaf weeds by bentazone herbicide in wheat [5-7].

The results in Table 2 reveal that the reduction in weed growth caused by bentazone herbicide was accompanied by increases in different growth characters of wheat plants. Thus, great significant increases in plant height, fresh and dry weight 40 days after sowing were obtained. The results also show that trehalose at T1and T2 induced increase in the growth parameters of wheat plants (Table 2) as plant height, fresh and dry weight. Additional significant increase was recorded due to dual treatments of trehalose at 100ppm and the herbicide. Many research workers proved that trehalose alleviated abiotic stress [19, 26-28].

Exogenous application of some growth agents with the herbicides in attempts to avoid the phytotoxic action of these herbicides without affecting the herbicide selectivity on weeds was reported by many workers [9, 12, 25, 29-31]. Thus, the superiority in growth and yield of wheat with combined treatments than individual one might be due to the role of trehalose in increasing growth as have been documented by several workers [18, 19, 32, 33]. The growth enhancement of wheat plants was reflected on increase in yield and yield components (Tables 3 & 4). So, recording significant increases in the grain yield (yield/plant) as well as weight of 1000 grain (g). It has been found that this disaccharide in the plant has diverse functions and plays an essential role in various stages of development, for example in the formation of the embryo and in flowering [34].

Increasing in metabolic activity in the yielded seeds may be resulted from alleviating the stress caused by the herbicide bentazone by trehalose so, soluble and total carbohydrate contents were increased. In this connection Coruzzi and Last [35] attributed the increasing in metabolic activity to the increase in carbohydrates. In addition, it was found that trehalose involved in the regulation of carbon metabolism and photosynthesis [35].

Recently, many studies have documented that exogenous application of osmoprotectants, improve crop tolerance against abiotic stress [36, 37]. Furthermore, the application of such compounds can enhance parameters such as morphology, photosynthetic capacity and consequently carbohydrate and gas exchange attributes Hussain *et al*. [38].

Conclusion

The results indicated great significant increase in wheat yield / plant due to combined treatment of the recommended dose of the herbicide and trehalose at 50 and 100ppm what may be suggested to use these combined treatments to obtain more yield production.

Disclosure statement:

Conflict of Interest: The authors declare that there are no conflicts of interest.

Compliance with Ethical Standards:

This article does not contain any studies involving human or animal subjects.

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