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Research Article

RESPONSE OF TWO NEW RELEASED WHEAT (*TRITICUM AESTIVUM*) CULTIVARS TO LEAF SPRAYING OF PHOSNOTERN AS A NATURALLY OCCURRING GROWTH BIO-STIMULATOR UNDER LATE SEASON LIMITED IRRIGATION

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ABSTRACT
There is need for a better understanding of the role that are played by the naturally occurring bio-stimulators associated with the plant in the crop field under water stress conditions. Field experiment was conducted in Ardabil, Iran, during 2012 and 2013. Studied treatments were wheat new released cultivars included *Sabalan* and *L 4057* in main plot; and factorial combinations of irrigation cutting at late growth season×Phosnotern foliar spraying as a plant growth bio-stimulator as sub plot. Wheat plants of *L 4057* in irrigation cutting×fosnotern spraying treatment had lower stem height than other treatments. Fosnotern spraying increased grain number per spike in *Sabalan* cultivar. Grain weight per spike of *Sabalan* had good response to fosnotern spraying. In late season irrigation cutting regime grain weight per spike experienced reduction of 33% as compared to normal irrigation. Fosnotern spraying only in normal irrigation regime was able to production of heavy seeds in wheat plants. Also, fosnotern spraying lead to producing of longer spikes than control. In normal irrigation regime crop seed yield increased 136 g m^{-2} compared to stressed plants. This research study revealed that the wheat farmers in semi arid regions of Iran could increase yield by leaf spraying of phosnotern as a naturally occurring growth bio-stimulator under late season limited irrigation.

***Keywords**: Fosnotern Spraying, Grain Number, Irrigation Cutting, Late Season*

INTRODUCTION
Wheat (*Triticum aestivum*) is a cereal grain, originally from the Near East and Ethiopian Highlands, but now cultivated worldwide. In 2012, world production of wheat was 651 million tons, making it the third most-produced cereal after maize (844 million tons) and rice (672 million tons). This grain is grown on more land area than any other commercial food. Globally, wheat is the leading source of vegetable protein in human food, having a higher protein content than other major cereals, maize (corn) or rice (Kijne *et al.*, 2003).
Deficit irrigation is a watering strategy that can be applied by different types of irrigation application methods. The correct application of deficit irrigation requires thorough understanding of the yield response to water (crop sensitivity to drought stress) and of the economic impact of reductions in harvest. In regions where water resources are restrictive it can be more profitable for a farmer to maximize crop water productivity instead of maximizing the harvest per unit land (Fereres and Soriano, 2007). The saved water can be used for other purposes or to irrigate extra units of land (Kipkorir *et al.*, 2001). Deficit irrigation is sometimes referred to as incomplete supplemental irrigation or regulated deficit irrigation.
Drought stress after pathogens is the main factor in yield decrease among environmental stresses (Sabagpour, 2006). Studies have shown that stress caused water deficit results in growth, leaf area, stem height, chlorophyll content and root growth decrease, and consequently results in final crop yield decrease (Levitt, 1980).
In previous investigations researchers found beneficial effects of rhizobacterium *Bacillus subtilis* on the reduction of drought and salt stresses (Boehme, 1999), and its effects against fungal and bacterial diseases are also proved (Grosch *et al.*, 1999; Krebs *et al.*, 1998; Loeffler *et al.*, 1968; Schmiedeknecht *et al.*, 1998). Organic substances with different chemical composition can be used as bio-stimulators, e.g.

humates and lactates. Also for these substances growth stimulating and stress-reducing effects could be shown IN agriculture (Boehme, 1999; Boehme *et al.*, 2000; Hoang, 2003). Recently, in modern plant production activities, apart from the already known hormones, microbiological fertilizers, different bio-stimulators and bio-regulators affecting plant development, have been used (Nelson, 2003; Poincelot, 1993). These kinds of studies describe and discuss the evidence that the presence or application of bio-stimulators also increases plant growth directly via phyto-hormone action and also influences the plant's ability to control its own hormone biosynthesis and homeostasis.

We need for a better understanding of the role(s) that are played by the naturally occurring bio-stimulators associated with the plant in the crop field. It is suggested that better understanding will allow for optimal crop yield returns, since disruptions of phyto-hormone homeostasis in plant organs and tissues can yield either beneficial or sub-optimal outcomes. Therefore, this research study was aimed to evaluation of response of two new released wheat (*Triticum aestivum*) cultivars two leaf spraying of phosnotern as a naturally occurring growth bio-stimulator under late season cutting irrigation.

MATERIALS AND METHODS

Experimental Location

Field experiment was conducted on a sandy loam soil with EC of 0.81 ds m^{-1} and pH of 7.4 the Agricultural Research Station of Ardabil, Iran, during growing seasons of 2012 and 2013. Ardabil is located in the north-west of Iran and the climate is semiarid and cold; in spite of dispersed precipitation in summer, it's arid and average annual precipitation is 320 mm. Average annual temperature; average maximum and minimum annual temperatures have been reported 12, 15 and 4 ^{0}C, respectively.

Cultivation Practices

The experimental field had been in a bean-potato-barley rotation cycle for the last two years. The experimental area was ploughed in the fall and manured with 6 t ha^{-1}. Fields were cultivated, disked, and then plotted in spring before sowing the seeds. Fertilizers used, in spring and before sowing, were 90, 30 and 150 kg ha^{-1} of ammonium phosphate, potassium sulfate and urea, respectively. The size of plots was 1.2 by 3 m. Each plot consisted of six wheat rows spaced 20 cm apart.

Experimental Procedure

Plots were arranged in a split factorial experiment based on randomized complete block design with 3 replications. Studied treatments were wheat new released cultivars included *Sabalan* and *L 4057* in main plot; and factorial combinations of irrigation cutting at late growth season × Phosnotern foliar spraying as a plant growth bio-stimulator as sub plot.

Materials Studied

Phosnotern is a natural bio-stimulator containing amino acids derived from enzymatic hydrolysis, making them more effective than chemical derived products. It is a technologically advanced product that may be used both foliar and through all irrigation systems. It is suitable for all crops and absorbed immediately, promoting plant growth, flowering, fruit-set and fruit size.

Plots were irrigated immediately after sowing to assure uniform emergence. Also all plots were hand removed for narrow leaf and broad leaf weed species in growing season. No herbicide, neither before nor after sowing, was used to control weeds. At harvesting stages, the middle four wheat rows of each plot were hand harvested.

Statistical Analysis

Measured variables were stem height, spike weight and length, grain number per spike, grain weight per spike, 250 seed weight, biological and economical yields. All data were analyzed using the MSTAT-C software. Treatment means were separated using Fischer's Protected LSD at P= 0.05 level.

RESULTS AND DISCUSSION

Variance Analysis

Analysis of variance for response of two new released wheat (*Triticum aestivum*) cultivars to leaf spraying of phosnotern as a naturally occurring growth bio-stimulator under late season limited irrigation indicated that there is significant difference between wheat cultivars with a view to stem height, 250 seed weight and spike length. All of studied variables affected by irrigation cutting except stem height and 250 seed weight. Interaction of cultivar× irrigation cutting also influenced spike weight and grain yield. Stem height, 250 seed weight and grain yield affected by bio-stimulator. Interaction of cultivar× bio-stimulator was significant for grain number and weight per spike and grain yield. Also, interaction of irrigation cutting×bio-stimulator was significant on 250 seed weight. Interaction of cultivar×irrigation cutting×bio-stimulator was also significant only on stem height and length (Table 1).

Table 1: Analysis of variance for studied variables in wheat cultivars

SOV	df	Stem height	Grain number per spike	Grain weight per spike	250 seed weight	Spike weight	Spike length	Biological yield	Grain yield
		Mean squares							
Replication	2	411.657	91.856	3.54*	0.081*	0.824	0.567	1.013	18462.96
Cultivar (a)	1	5061.09*	0.001	0.001	1.832**	0.006	38.735*	2.768	1.17
Ea	2	310.245	1.063	1.063	0.002	0.291	0.892	1.173	22546.907
Irrigation cutting (b)	1	78.048	1.944*	1.944*	0.041	0.753*	14.183**	2.235**	110419.09**
a×b	1	7.238	0.774	0.774	0.095	1.274*	0.111	0.234	40090.199
Bio-stimulator (c)	1	115.545*	0.001	0.001	1.691**	0.49	4.092*	0.284	9343.76**
a×c	1	7.304	0.948*	0.948*	0.162	0.388	1.311	0.008	11158.593
b×c	1	17.888	0.004	0.004	0.84**	0.011	2.001	0.078	9122.101
a×b×c	1	124.488*	0.485	0.485	0.029	0.179	3.643*	0.036	1274.584
Ebc	12	23.906	0.239	0.239	0.074	0.172	0.814	0.179	6233.045
CV (%)	-	5.64	23.9	23.9	6.84	19.55	9.31	11.89	23.83

**, ** mean significant difference at 5% and 1% probability levels, respectively.*

Mean Comparisons

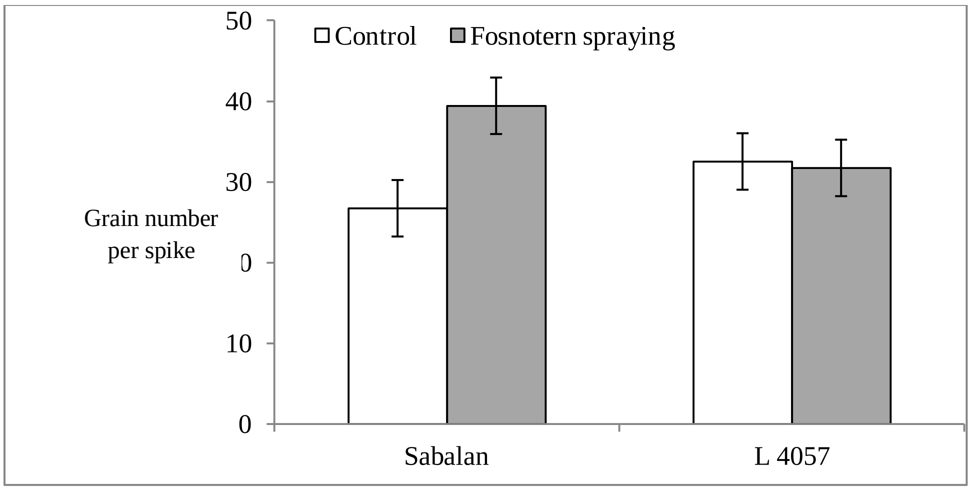
Based on data means there was significant difference between *Sabalan* and *L 4057* wheat cultivars with a view to stem height at the repining stage. In the experiment condition *Sabalan* had 29 cm greater height than *L 4057*. Stem height of crop plants in fosnotern sprayed treatments was 5% shorter than control.

Mean comparison of interaction of studied factors (Table 2) indicated that wheat plants of *L 4057* in irrigation cutting×fosnotern treatment had lower stem height than other treatments.

Table 2: Interaction of studied factors on stem height and spike length of wheat plants

Treatments			Stem height (cm)	Spike length (cm)
Sabalan	Bio-stimulator	Irrigation cutting	71.4 c	9.2 bc
		Control	77.6 c	9.1 bcd
	Control	Irrigation cutting	102.8 ab	13.1 a
		Control	102.1 ab	10.5 b
L 4057	Bio-stimulator	Irrigation cutting	69.6 c	8.0 cd
		Control	70.0 c	7.4 d
	Control	Irrigation cutting	94.1 b	10.1 b
		Control	105.8 a	10.2 b

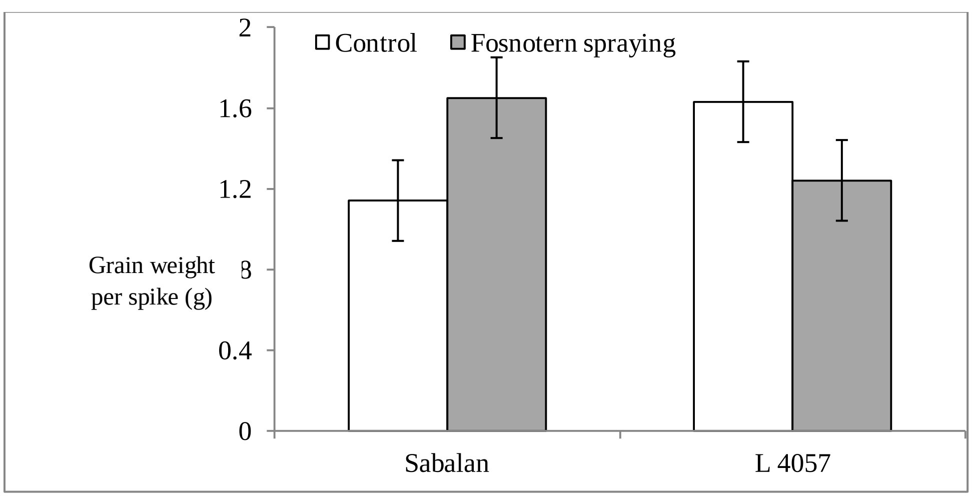
There is increasing interest in the use of naturally occurring bio-stimulators for enhancing the growth of agricultural and horticultural crops. In our experiment leaves spraying of studied growth bio-stimulator caused to 16.7% improvement of grain number per spike compared to the control. Fosnotern spraying increased grain number per spike in *Sabalan* cultivar (Figure 1). The activity of bio-stimulators to promote plant growth is often attributed to their ability to directly or indirectly provide mineral nutrients (mostly nitrogen, but also phosphorous, sulphur and other macro- and micro-nutrients) to plants. Alternatively, bio-stimulators are postulated to increase the plant's ability to assimilate these mineral nutrients, often in return for photo-assimilates (as occurs with certain bacteria and fungi associations). Although optimal growth of plants depends on the availability of adequate mineral nutrients, that growth (and also development, including reproduction) is also regulated by plant hormones (phyto-hormones), including gibberellins, auxins and cytokinins (Kurepin *et al.*, 2013).



Wheat cultivars

Figure 1: Grain number per spike of wheat cultivars as affected by fosnotern spraying

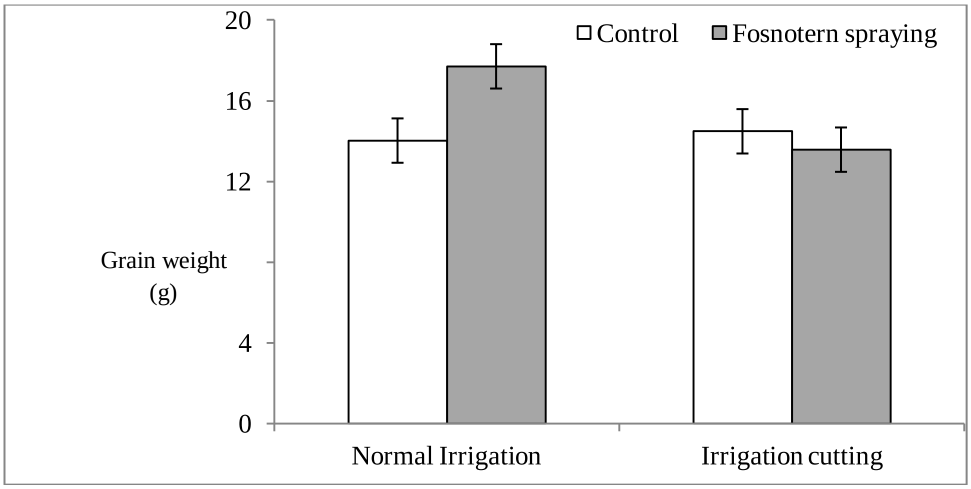
Grain weight per spike of *Sabalan* had good response to fosnotern spraying (Figure 2). In late season irrigation cutting regime grain weight per spike experienced reduction of 33% as compared to normal irrigation.



Wheat cultivars

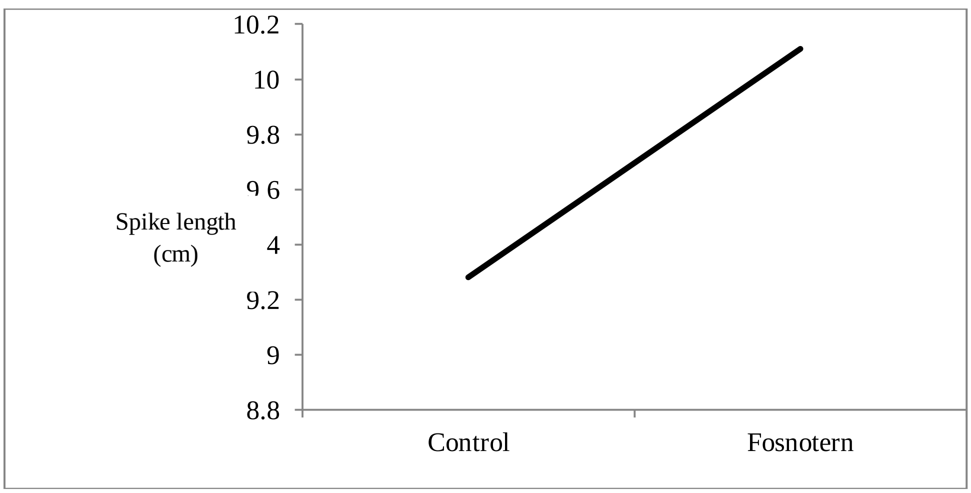
Figure 2: Grain weight per spike of wheat cultivars as affected by fosnotern spraying

In our study seed weight in *Sabalan* was heavier than *L 4057*. Also, fosnotern spraying could be effective in improvement of seed weight compared to the control. Fosnotern spraying only in normal irrigation regime was able to production of heavy seeds in wheat plants (Figure 3). Nesmith and Ritchie (1992) in an experiment conducted on corn (*Zea mays*) reported that water stress caused to reducing of 300 seed weight and yield in crop plants. It seems that drought stress occurrence in seed filling period causes to dry matter accumulation decrease in seeds as a result of effective seed growth period shortening (Nesmith and Ritchie, 1992).



Irrigation treatments

Figure 3: Interaction of fosnotern spraying×irrigation treatments on wheat grain weight



Bio-stimulator

Figure 4: Wheat spike length as affected by fosnotern spraying

Weaker spikes were observed in plants under late season irrigation cutting than control. Also, fosnotern spraying lead to producing of longer spikes than control (Figure 4). Also, biological yield of wheat plants under water stress at late season growth stage and in non bio-stimulator treated plants was lower than control. The application of humates affected positively dry matter content. The dry matter content increased after the treatment with humates in the root zone or on leaves and also in combination with the other substances. The application of all biologic substances tested stimulated the shoot development represented by a higher fresh matter of shoots and leaves in most variants. Obviously, the location of application was important for the effect of the bio-stimulators. The effect on leaf fresh matter was also a stimulating one. Based on this study, the effect of substances studied was positive stimulating if applied over the leaves (Boehme *et al*., 2006).

The application of bio-stimulators enhanced in most cases the dry matter content of shoots and leaves (Boehme *et al*., 2006). In Hoang (2003) efforts the effect on the root growth was much stronger than on the shoot growth. In this respect much more investigations are necessary and the results are only a first advice.

In normal irrigation regime crop seed yield increased 136 g m^{-2} compared to stressed plants. Lower number of secondary branches (8.2 branches) in fennel plants observed in normally irrigated treatment (70mm evaporation from pan). While, fennel plants under limited irrigation levels produced greater secondary branches (10 branches) than control. Plants under sever water deficit (irrigated when done 130mm evaporation from pan) produced lower seed yield than 100mm evaporation level. Similarly, plants under foliar spraying of the bio-stimulator produced 125 g m^{-2} greater seed yield than non-sprayed ones. All bio-substances have beneficial effects on plants in stress situations. Therefore, a combination of these substances should be investigated to stabilize the growing conditions. Bio-stimulators affect better seed germination (Jelačić *et al*., 2006; Yildirim *et al*., 2002), and represent stimulators of plant biological activity, having simultaneous effects on the plant yield.

The bio-stimulators can be applied in the root zone or on the leaves. Substances with biological origin have been used to avoid or counteract abiotic or biotic stress in agricultural and horticultural plants. Applications of bio-stimulators are reported to reduce abiotic stress in plants. In an experiment conducted by Boehme *et al*., (2006), in absent of the bio-stimulating complex cucumber yield dropped to 0.73. Several plant parameters such as plant shoot length, shoot weight, leaf weight, leaf area, root weight and root length were influenced by treatments tested. The temperature stress reduced the growth of the plants much more if no bio-stimulator was applied. Results showed that there is strong correlation between green biomass of treated cucumber plants and their root mass. It can be assumed that the effect of stress reduction by use of this bio-stimulator complex is based mainly on enhancing the root growth.

Conclusion

This research study revealed that the wheat farmers in semi arid regions of Iran could increase yield by leaf spraying of phosnotern as a naturally occurring growth bio-stimulator under late season limited irrigation.

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