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Original article

The investigation of Pseudomonas bacteria on some morpho-physiological traits of two cultivars of potatoes (*Solanum tuberosum* L.) with different irrigation intervals

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Extended abstract

Introduction

The use of biological fertilizers can be effective and beneficial in abiotic environmental stresses specially in drought stress, arid and semi-arid regions of the world.

Materials and methods

An experiment was conducted to investigate the effect of deficit irrigation stress and Pseudomonas bacteria on some morpho-physiological traits of two potato cultivars at the research farm of Shahroud University of Technology located in Bastam region in 2010. Treatments included irrigation cycles as the main factor at three levels (7, 10, and 14-days), Pseudomonas bacteria (inoculation and non-inoculation) and cultivar at two levels (Savalan and Agria) as the sub-factor with three replications.

Results and discussion

The results showed that the highest dry matter accumulation in the aerial part was observed in the 7-day irrigation cycle and inoculation with Pseudomonas bacteria. The number of tubers was increased about 12.66% because of inoculation with Pseudomonas fluorescens per square meter. Savalan cultivar interaction and 7-day irrigation cycle also obtained the highest number of tubers with an average of 166.39 per square meter. The application of inoculation with Pseudomonas fluorescens increased chlorophyll A by 9.3%. It compared with non-bacterial inoculation. Chlorophyll B had the highest chlorophyll content in the main treatments of the 7-day irrigation cycle and Agria cultivar. The highest amount of potassium content was obtained at the rate of 2.06% at the highest irrigation cycle (14-day). The application of inoculation and non-inoculation with Pseudomonas caused the highest amount of proline at 14-day irrigation cycle. Inoculation with Pseudomonas bacteria increased the final tuber yield about 22.85%. Furthermore, Savalan cultivar increased the final tuber yield about 110.09% in the 7-day irrigation cycle compared to the 14-day. Finally, the 7-day irrigation cycle was the best irrigation cycle to increase the morpho-physiological traits, chlorophyll, number of tubers, and the final tuber yield. Inoculation with Pseudomonas bacteria increased the effectiveness of these traits. Also, the production of compatible osmolytes (proline and potassium) improved drought stress tolerance in 14-day irrigation cycle. Growth-promoting bacteria improves seed germination, root propagation, shoot and root weight,

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leaf area, chlorophyll content, hydraulic conductivity, protein, nutrient absorption and plant yield (Batool et al., 2020). Growth-promoting bacteria of polysaccharides increases biomass production under drought stress conditions (Daffonchio et al., 2015). Potassium is one of the most important osmolytes under drought stress conditions and adverse conditions (Anschütz et al. 2014). Cellular and physiological responses are carried out through organic salts as proline to reduce cellular damage during drought stress. It is an osmotic regulator (Merwad et al., 2018)

Conclusion

The 7-day irrigation cycle was the best irrigation cycle to increase the morpho-physiological traits, chlorophyll, number of tubers, and the final tuber yield. Inoculation with Pseudomonas bacteria increased the effectiveness of these traits. Also, the production of compatible osmolytes (proline and potassium) improved drought stress tolerance in 14-day irrigation cycle.

***Keywords*:** Biological fertilizers, Irrigation cycle, Potato, Tuber yield

Table 1. Physical and chemical results of soil test (0 to 60 cm)

K	P	N	Soil texture	Sand	Silt	loam	Organic carbon	pH	EC
%		ppm		----------%----------					$dS.m^{-1}$
143	14	0.057	Silt- loam	32	44	22	0.79	7.89	0.26

Table 2. Investigating in some characteristics of Agria and Savalan cultivars

cultivar	Group Reaching	Tuber shape	Brain color	Flower color	Sensitivity, tolerance and resistance index to dehydration stress
Agria	Medium late	Drawn egg	dark yellow	White	Sensitive
Savalan	Medium late	Round	yellow	Purple	Half tolerant

Table 3. Variance analysis of measured traits under the irrigation cycle, Pseudomonas and cultivar in 115 days after planting

S.O.V	df	Dry weight leaf of	Dry weight of stem	Number of tubers	Tubers yield
Repetition	2	73.92	22205.27	121.21	20.39
Irrigation cycle (Ic)	2	94240.33**	14778.70**	9241.19**	534.01**
The first error	4	766.11	1528.54	289.93	36.6
Pseudomonas bacteria (Pb)	1	2580.30	444.85	2052.09**	189.70**
Cultivar (C)	1	5817.11*	438.41	2391.21**	6.13
Ic×Pb	2	4099.07*	3312.11*	67.16	2.45
Ic×C	2	1434.94	1883.06	213.99**	42.35**
Pb×C	1	5403.23*	322.98	12.79	0.38
Ic×Pb×C	2	353.35	89.06	49.31	11.79
The second error	18	966.40	824.35	37.47	5.20
CV (%)		*11.77*	*16.17*	*14.94*	*10.20*

Table 3. Continued

S.O.V	df	Proline	K	Chlorophyll a	Chlorophyll b	Total chlorophyll
Repetition	2	0.13	0.02	5.28	0.83	12.52
Irrigation cycle (Ic)	2	191.67**	0.35*	22.48	27.25*	216.93**
The first error	4	6.16	0.04	4.65	3.63	5.21
Pseudomonas bacteria (Pb)	1	7.79*	0.19	19.13*	5.48	32.53
Cultivar (C)	1	0.05	0.06	5.89	55.25**	93.81*
Ic×Pb	2	8.72*	0.11	3.34	4.49	9.41
Ic×C	2	0.83	0.01	0.63	4.69	41.39
Pb×C	1	1.08	0.05	2.07	0.30	30.95
Ic×Pb×C	2	0.92	0.02	4.23	23.34	22.36
The second error	18	1.68	0.05	2.88	5.35	12.31
CV (%)		*13.26*	*11.93*	*10.40*	*16.52*	*11.61*

* and ** significant at 0.05and 0.01 probability levels, respectively

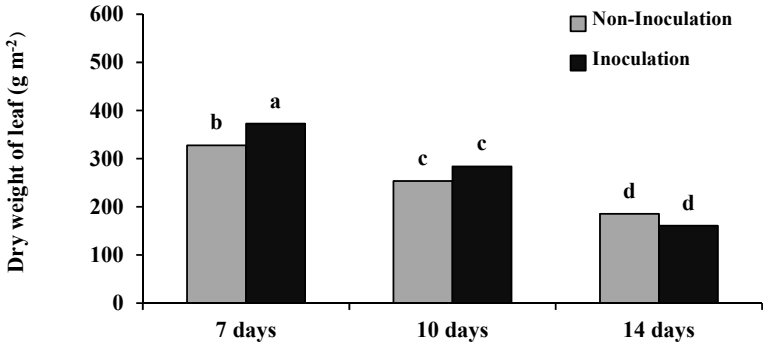

Fig. 1. The interaction of irrigation cycle and Pseudomonas bacteria on the traits of leaf dry weight. Non-identical letters indicate a significant difference in the probability level of LSDα = 5%

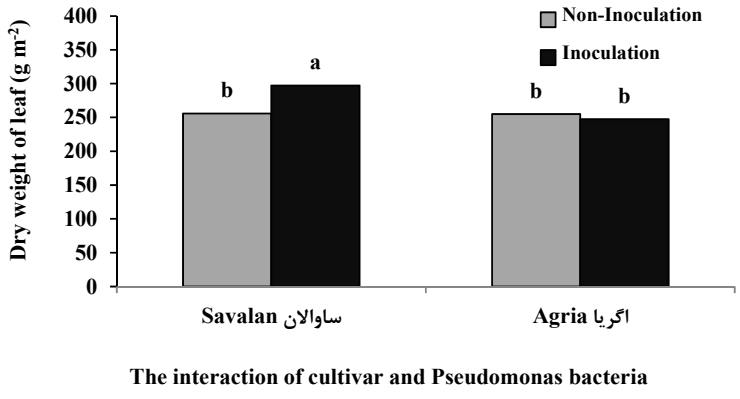

Fig. 2. The interaction of cultivar and Pseudomonas bacteria on the traits of leaf dry weight. Non-identical letters indicate a significant difference in the probability level of LSDα = 5%

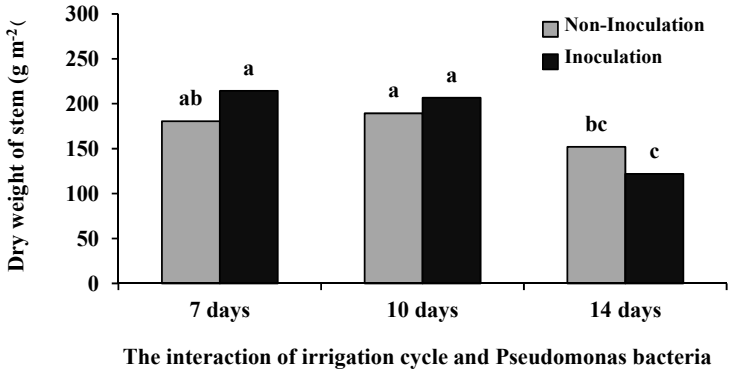

Fig. 3. The interaction irrigation cycle and Pseudomonas bacteria on the traits of stem dry weight. Non-identical letters indicate a significant difference in the probability level of LSDα = 5%

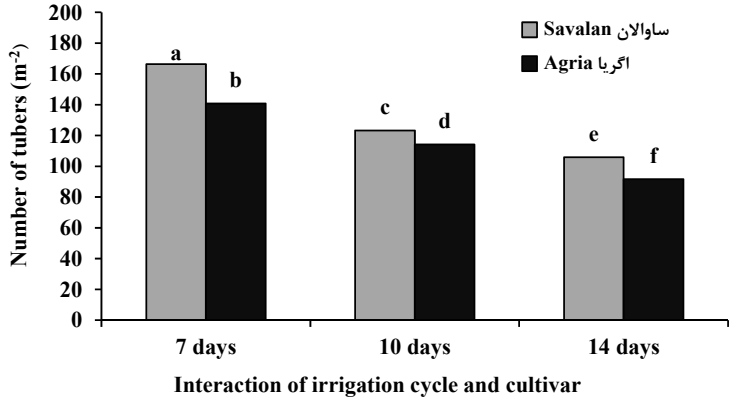

Fig. 4. The interaction irrigation cycle and cultivar on the traits of tuber number. Non-identical letters indicate a significant difference in the probability level of LSDα = 5%

Table 4. Table 4. The main effect of Pseudomonas bacteria, irrigation cycle and variety on the number and yield of tuber and chlorophyll a, b and total and percentage of potassium

Treatments		Number of tubers	Tuber yield	Chlorophyll a
		no. m^{-2}	$t.ha^{-1}$	$\mu g.g^{-1}$ fw
Pseudomonas bacteria (Pb)	Non-Inoculation	116.5b	20.08b	15.59b
	Inoculation	131.25a	24.67a	17.05a

		Chlorophyll b	Total Chlorophyll	K
		---------- $\mu g.g^{-1}$ fw ----------		(%)
Irrigation cycle	7 days	15.99a	35.04a	1.71c
	10 days	12.66b	28.54b	1.9b
	14 days	13.34b	27.05b	2.06a
Cultivar	Savalan	12.76b	28.6b	
	Agria	15.23a	31.83a	

Non-identical letters indicate a significant difference in the probability level of LSDα = 5%

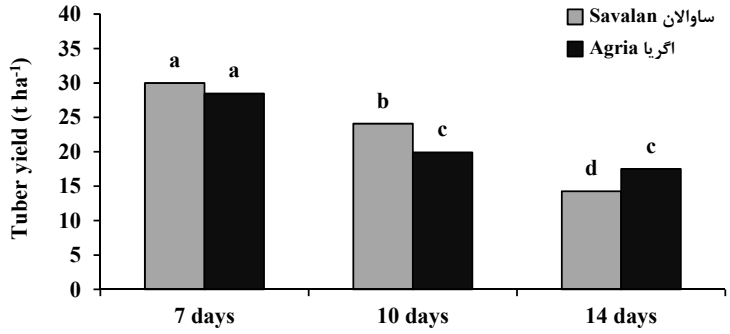

Fig. 5. The interaction irrigation cycle and cultivar on the tuber yield traits. Non-identical letters indicate a significant difference in the probability level of LSDα = 5%.

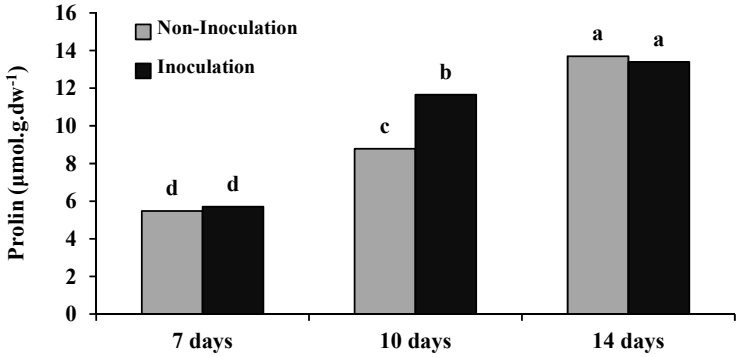

Fig. 6. The interaction irrigation cycle and Pseudomonas bacteria on the traits of prolin. Non-identical letters indicate a significant difference in the probability level of LSDα = 5%