Growth and Productivity of Barley C.V Giza-129 cultivar as Affected by Putrescine and Spermidine under Water Stress Conditions

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Abstract: Two field experiments were carried out to study growth and productivity of barley c.v. Giza-129 as affected by putrescine and spermidine under water stress conditions in the Agriculture Experimental Station of National Research center, Nubaria Region, Behira Governorate at the winter seasons of 2011/2012 and 2012/2013 seasons. The main obtained results were: (1) Growth characters, i-e. plant height, number and dry weight of each one of tillers + sheets, blades and spikes, flag leaf blade area, and blades area /plant were significantly decreased under the water stress conditions. Moreover, results show clearly that barley plants appeared to be more sensitive to water stress during tillering stage followed by heading stage, whereas, the harmful effect caused at milk – ripe stage treatment was the lowest one. (2) Spraying barley plants with 100mg/l putrescence, as well as, 100mg/l spermidine seemed to be the most favorable treatments to increase growth characters. (3) Yield and its components, i.e. spikes dry wt. / plant. Grain, straw and biological yield / plant, as well as, grain, straw and biological yield ton/ fed were significantly affected by water stress treatments at certain developmental stages of growth. Moreover, the previous yield and its components significantly decreased by shipping one irrigation at certain developmental stages of growth. The results indicated that barley plants appeared to be more sensitive to water stress during tillering stage followed by heading stage and milk-ripe stage respectively. (4) Foliar application with 100 mg/l putrescence and / or 100mg/l spermidine produced the highest value from yield and its components. (5) The effect of interaction between skipping an irrigation at different stages of growth and putrescine as well as spermidine concentration indicated that barley plants cv. Giza-129 was More sensitive to water stress at tillering stage compared with heading and milk – ripe stage, respectively, also, putrescence and spermidine as foliar application with100 mg/l can be alleviate the harmful effect on growth characters and yield and its components caused by water stress conditions.
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1. Introduction

Barley (*Hordeum vulgare* L.) is considered to be one of the most important cereal crops in the world as well as in Egypt (FAO, 2007). In Egypt the national production of cereals is relatively lower than consumption demands. It was suggested to use barley as a complementary cereal crop to minimize this gab because of barleys ability, compared with other cereal crops to grow well under the drought conditions common to Egypt and it is mainly used to animal feeding (including both grain and straw) and bread making by bedewing people living in the desert and dry areas.

On the light of the present national water policy using barley cultivars produce high yield under suitable water regime, is greatly influenced by a number of factor especially foliar spraying with polyamine compounds under water stress conditions of drought and salinity. Thus, this work was carried out to investigate growth and productivity of barley crop cv. Giza- 129 cultivar as affected by putrescine and spermidine under water stress conditions.

2. Materials and Methods

The present investigation was carried out during the two successive seasons of 2011/2012 and 2012/2013 in the Agriculture Experimental station of National Research Center, Nubaria Region, Behira Governorate to study growth and productivity of barley cv. Giza-129 cultivar as affected by putrescine and spermidine under water stress conditions.

Each experiment was laid out in split plot design with four replication, where the main plots included the irrigation treatments, while the putrescine and spermidine treatment were distributed in the sub – plots. The experimental unit consisted of 15 rows, each of 3.5meter length and 20 cm apart between rows, where the size of each plot was 10.5 square meters, seeded at a rate of 60 Kg/fed. Sowing took place on final week of November 2011 and 2012. The normal agronomic practices of growing barley were carried out till harvest as recommended by barley Research Dept., A.R.C.

Each experiment included 28 treatments which were the combination of four irrigation treatment and seven polyamine treatments. The factors under study were:

A- The irrigation treatments:

1- Normal irrigation where barley plants irrigated with two week intervals up to ripe stage (140 days after sowing),i-e- control treatment.
2- Missing one irrigation at tillering stage (48 days after sowing).
3- Missing one irrigation at heading stage (90 days after sowing).
4- Missing one irrigation at milk- ripe stage (118 days after sowing).

B- Polyamine treatments:-

1-Tap water, i.e. control treatment.
2- 50 mg /l put.
3-75 mg/l put.
4-100 mg/l put.
5-50 mg/l Sper.
6-75 mg/l Sper.
7-100 mg/l Sper.

Putrescine (NH_2 $(CH_2)_3$ NH_2) and spermidine {NH_2 $(CH_2)_3$ $N+H_2)_4$ NH_2 } were sprayed twice after 45 and 55 days after sowing,respectively.

Samples of the guarded plants were taken at random from each plot of the four replication to measure growth characters at 105 days after sowing, where, plant height, number and dry weight of each one of tillers, sheaths, blades and spikes/plant, F/lag leaf blade area cm and blades area cm^2/plant. Flag leaf blade area and blades leaf/plant were determined according to Bremner and Taha (1966).

At harvest, a random of ten guarded pants were taken from the middle rows of each plot to determine spikes day weight g/plant, as well as grain, straw and biological yield in" g/ plant". In addition, grains, straw and biological yield in Ton/ fed were collected from the whole area of each experimental unit and then estimated into yield per feddan.

All data were subjected to statistical analysis according to procedure outlined by Snedecor and Cochran (1990). Treatments means were compared by L.S.D at 5 % level test. Combined analysis was made for the two growing seasons as results followed similar trend.

3. Results and Discussion

A- Growth characters:

A-1- Effect of water stress.

Data reported in Table (1) show clearly that skipping an irrigation at tillering,heading and or milk rip stages significantly decreased plant height, number and dry weight of each of tillers + sheaths, blades and spikes / plant, flag leaf blade area and blades area /plant at 105 days after sowing compared with control treatments. The negative significant effect in growth characters could be explained on this basis of the loss of turgidity which affects the rate of cell expansion and ultimate cell size, loss of turgidity is probably the most sensitive process to water stress. Thus, it caused a decrement in growth rate, stem elongation and leaf expansion. The depression in cell division and enlargement has been carefully discussed by Kraner and Boyer (1995). The results indicate that water stressed plants even water regulatory afterward did note recover to their normal behavior to compensate the adverse effect caused by the exposure to drought conditions. Our results are in full agreement with those detected by Sharaan *et al*. (2000), El-Hawary (2000), Abo El- Kheir et al. (2001), Kang et al. (2002) Ahmed and Badr (2004), Ahmed et al. (2004), Hussein et al. (2009) and Ahmed et al. (2013).

It is worthy that irrigation at late jointing is recommended due to the great effect in tiller survival. This impels that developmental and physiological processes at late jointing are critical in determining final grain yield and the water stress should be avoided at this growth stage. Then, the depression in growth characters by skipping an irrigation at tillering stage was more pronounced, whereas, every plant was subjected to soil moisture at tillering stage such effects might be attributed to luck of water absorbed, inadequate uptake of essential elements, inhibition of meristematic activity and or reduction in photosynthetic capacity under such unfavorable conditions (Abo El- Kheir et al., 2001, Ahmed and Badr, 2004 and Ahmed et al., 2005 and 2013). Furthermore, assimilates translocate to new developing tillers and to the spike primordial were recorded and which were not enough to mention or develop those organ.

A-2- Effect of polyamines concentration:

Data illustrated in Table (1) indicate that barley plants sprayed with 50 mg/ l put., significantly increased plant weight, number and dry weight of each of tillers+ sheaths, blades and spike/plant, flag leaf blade area, and blades area/ plant at 105 days after sowing. Increasing concentration of put to 75 and 100mg/l significantly increased growth characters studied at 105 days after sowing and the highest mean values of these growth characters were obtained by 100mg/l put compared with control, 50 and 75mg/l put.

With respect to foliar application with spermidine, data recorded in Table(1) observed that there were significant marked stimulatory effect on plant height, number and dry weight of tillers + sheaths, blades and spikes / plant,flag blade area, / plant compared with control treatment. Moreover, increasing concentration of sper., up to 100 mg/l caused a significant positive effect on the previous growth characters studied.

Table (1) Effect of water stress at certain developmental stages and polyamine concentration on growth characters of barley plant cv.Giza-129 (Average of 2011/2012 and 2012/2013 seasons

Irrigation treatment	Polyamine concentration	Plant height	Number / plant			Dry wt. / plant			Flag leaf blade area cm2	Blades area cm2 plant
			Tillers	Blades	Spikes	Tillers sheets	Blades	Spikes		
No skipping (control)		127.84	6.15	60.46	5.92	12.78	7.59	9.05	24.27	672.09
Skipping one irrigation at tillering stage		107.38	5.10	42.58	4.74	9.71	5.24	6.66	19.17	524.67
Skipping one irrigation at heading stage		110.35	5.50	45.56	5.26	8.65	6.02	6.96	21.45	553.80
Skipping one irrigation at milk-ripe stage		115.96	5.77	51.13	5.49	11.03	6.48	7.13	22.32	596.99
L.S.D at 5% level		4.42	0.27	2.32	0.29	0.57	0.62	0.02	0.53	22.01
	Tap water	106.83	4.86	43.31	4.58	9.94	5.65	6.54	19.50	546.11
	(control)	111.04	5.21	46.94	4.91	10.44	5.95	6.87	20.68	563.08
	50mg/l put	115.08	5.56	49.45	5.25	11.16	6.23	7.50	21.54	589.68
	75mg/l put	119.60	5.83	52.08	5.62	11.30	6.64	7.79	23.13	600.45
	100mg/l put	113.93	5.56	49.15	5.45	10.59	6.27	6.98	21.63	581.58
	50mg/l sper	117.31	6.02	52.63	5.67	11.20	6.62	7.71	22.48	6.00.25
	75mg/l sper	123.94	6.38	55.98	6.08	11.68	7.00	8.14	23.66	625.08
	100mg/l sper									
		3.64	0.29	2.11	0.33	0.48	0.24	0.19	0.62	18.62

The positive effect of polyamine on growth characters may be due to that polyamines are now considered as a new class of growth substances and are also well known for their anti-senescence and anti- stress effect where their acid neutralizing and antioxidant properties, as well as, to their membrane and cell wall stabilizing abilities (Velikova et al., 2000). Again, polyamines have been implicated in a large range of growth and developmental processes such as cell division, stimulation, support and development of flower buds, embryogenesis, fruit set and growth, fruit ripening, plant morphogenesis and response to environmental stress (Ozturk and Demir, 2003). In additions, Sood and Nagar (2003) reported that peroxidase and cellulose activities were reported by polyamine treatment and accelerated by polyamine biosynthetic inhibitors. Also, polyamines inhibit senescence in plants (Sood and Nagar 2003), thus, the filling period duration, effective filling period and filling rate increased and these processes caused an increase in growth characters.

A-3- Effect of interaction between water stress and polyamine concentrations:

The interaction between missing an irrigation at the assigned different stages of growth and polyamine concentration caused significant effect on plant height, number and dry weight of tillers; blades and spiked / plant, flag leaf blade area and blades area/plant (Table2). Moreover, data observed that foliar application with 100mg/1put.and 100mg/1sper. Under no skipping an irrigation treatment produced the highest significant values from growth attributes, meanwhile, foliar spraying with 50mg/1put. and /or 50 mg/1sper. with skipping an irrigation at tillering stag produced wheat plants characterized by its lowest significant values of the previous growth characters studied, Generally, foliar application with100mg/1put. and/or 100mg/1sper. can alleviate the depression in growth characters resulted by water stress conditions followed by 75 and 50mg/1put. and /or sper. respectively In addition, wheat plants were more sensitive to water stress at tillering stage compared with heading and milk-ripe stage, respectively.

B- Yield and its components:

B-1- Effect of water stress:

Table (3) indicate that skipping an irrigation at tillering, heading and /or milk-ripe stage caused significant negative effect on spikes dry weight/plant, grain; straw and biological yield per plant and/or fed.

The depression in these pervious yield components appeared to be greatest values when the water stress caused at tillering stage followed by heading stage and missing irrigation in milk-ripe stage in the end of the list order, respectively. Results obtained by Sharaan *et al.* (2000), El-Hawary (2000), Abo El-Kheir *et al.* (2001), Kang *et al.* (2002) Ahmed and Badr(2004), Ahmed *et al* (2004) and Hussein *et al.* (2009) are in full agreement with our finding.

The negative effect on yield and its components caused by skipping an irrigation could be explained on the basis of the loss of turgidity which affects the rates of the cell expansion and ultimate cell size. Less of turgidity is probably the most sensitive process to water stress, thus, decrement growth rate, stem elongation and leaf expansion. Thus, effect of water stress on cell division and enlargement has been carefully discussed by Kramer and Boyer(1995).

Exposing barley plant to water shortage resulted in a significant reduction in dry weight of plant organs, thus, spikes dry barley weight, grain, straw, and biological yields reflect significant decrease than those plants of adequate water supply (control plants). Data indicate that water stressed plant even watered regularly afterward did no recover to their normal behavior to compensate the adverse effect caused by the exposure to drought conditions. Such depression may be attributed to the general retardation of the enzymatic reaction particularly those concerning with the reduction in photosynthetic rates (Abd El- Gawad *et al.,* 1993).

It is clear also from Table (3) that barley plants appeared to be more sensitive to water stress during tillering stage, where, dry matter reduction per plants was more significantly decreased than adequate water supply plants and compared with missing an irrigation at heading and milk- ripe stages, respectively. Moreover, irrigation at late jointing is recommended due to its greater effect on tiller survival. This implies that developmental and physiological processes at late jointing are critical in determining the final grain yield and the water stress should be avoided at this growth stage, (Abo El-Kheir et al., 2001, Ahmed and Badr, 2004, and Ahmed et al., 2005).

The decrement in grain, straw, and biological yields was more obvious when skipping irrigation at tillering stage, where number of tillers and spikes were reduced markedly (Table 2).

Table (2) Effect of the interaction of water stress at certain developmental stages and polyamine concentration on growth characters of barley plant cv.Giza-129 (Average of 2011/2012 and 2012/2013 seasons

Water stress treatment	Polyamine treatments	Plant height cm	Number / plant			Dry wt / plant			Flag leaf blade area cm2	Blades area cm2 plant
			Tillers	Blades	Spikes	Tillers sheets	Blades	Spikes		
No skipping (control)	Tap water	113.11	5.31	48.9	5.00	11.83	6.59	7.86	22.75	639.04
	50mg/l put	118.75	5.56	54.8	5.17	12.14	7.23	8.44	23.60	648.1
	75mg/l put	124.80	6.22	60.7	6.00	12.95	7.50	9.12	24.13	673.0
	100mg/l put	136.20	6.75	67.33	6.5	13.04	8.02	9.50	25.00	689.50
	50mg/l sper	123.70	5.90	58.0	5.8	12.36	7.56	8.85	23.90	663.0
	75mg/l sper	129.6	6.40	64.5	6.33	14.29	8.00	9.60	24.50	684.0
	100mg/l sper	148.75	7.00	69.0	6.67	13.88	8.23	10.00	26.00	708.0
Skipping at tillering stage	Tap water	101.4	4.33	38.52	4.00	8.42	4.76	5.81	17.66	488.70
	50mg/l put	105.7	4.67	41.98	4.17	9.13	4.90	6.20	18.00	497.0
	75mg/l put	109.3	5.00	42.6	4.33	10.0	5.13	6.81	18.63	536.0
	100mg/l put	111.0	5.17	43.0	5.0	10.18	5.49	7.02	20.0	544.0
	50mg/l sper	107.0	5.33	43.0	5.17	9.58	5.08	6.63	19.30	504.0
	75mg/l sper	108.2	5.5	44.0	5.17	10.17	5.39	7.00	19.60	542.1
	100mg/l sper	109.0	5.67	45.0	5.33	10.5	5.94	7.17	21.00	560.0
Skipping at heading stage	Tap water	103.8	4.80	41.8	4.5	9.10	5.26	6.14	18.58	521.11
	50mg/l put	107.3	5.17	43.0	5.00	9.50	5.58	6.25	20.13	536.20
	75mg/l put	111.7	5.33	45.5	5.17	10.33	5.79	6.88	21.4	556.00
	100mg/l put	113.18	5.50	47.0	5.3	10.5	6.25	7.20	23.5	568.3
	50mg/l sper	109.2	5.4	45.6	5.33	10.0	6.10	6.38	21.3	548.1
	75mg/l sper	112.4	6.00	47.0	5.5	10.26	6.37	7.00	22.0	557.9
	100mg/l sper	115.0	6.33	49.0	6.00	10.87	6.82	7.20	23.25	589.0
Skipping at milk- ripe stage	Tap water	109.0	5.0	44.0	4.8	10.40	5.97	6.35	19.0	535.6
	50mg/l put	112.4	5.5	48.0	5.3	11.0	6.07	6.58	21.0	571.0
	75mg/l put	114.5	5.75	49.0	5.5	11.34	6.49	7.17	22.0	592.8
	100mg/l put	118.0	5.88	51.0	5.67	11.46	6.81	7.42	24.0	608.0
	50mg/l sper	115.8	5.6	50.0	5.5	10.43	6.33	7.00	22.0	611.20
	75mg/l sper	119.0	6.17	55.0	5.67	11.08	6.700	7.24	23.83	617.0
	100mg/l sper	123.0	6.50	60.9	6.30	11.47	7.00	8.18	24.4	643.3
L.S.D at 5% level		1.28	0.58	4.22	0.66	0.26	0.48	0.38	1.24	37.24

B-2- Effect of polyamines concentration:

Data presented in (Table 3) indicate that barley plants sprayed with 50mg/ put significantly increased control plants in yield and its components studied. Increasing concentration of put up to 75mg//l caused significant increases in grain, straw and biological yield /plant and straw, as well as biological yield/fed. Meanwhile, the increase in spikes dry weight/ plant and grain yield/ fed failed to reach the significant at 5 % level compared with 50mg/put concentration.

In addition, increasing concentration of put up to 100mg/l caused significant increase in yield and its components under study compared with control and 50mg/l conc., and also than 75mg/l put except spikes dry wt/ plant and grain yield /fed.

Regarding foliar application with spermidine, data illustrated in Table (3) show clearly that there are significant marked stimulatory effect on spikes dry weight / plant, grain; strew and biological yield per plant and. or fed. by foliar spraying with 50mg/1 spermidine compared with control treatment. In addition, increasing concentration of sper. up to 75mg/1 significantly enhanced spikes dry weight/ plant, grain and biological yield/ plant as well as biological yield/fed., in comparison with control and 50mg/1sper., meanwhile, the differences between 50 and 75 mg/1 sper spikes dry wt/plant failed to reach significant level at 5% On the other hand, increasing concentration of sper. up to 100mg/1caussed a significant positive effect and produced the height significant value from yield and attributes studied compared with other treatment under study.

The positive effect of polyamines on yield components may be due to that polyamines are now considered as a new class of growth substances and are also well known for their anti- senescence and anti-stress effects where their acid neutralizing and antioxidant properties, as well as, to their membrane and cell wall stabilizing abilities (Velikiva et al, 2000). Also, polyamines have been implicated in a large range of growth and developmental processes such as cell division, stimulation, support and development of flower buds, embryogenesis, fruit set and growth, fruit ripening, plant morphogenesis and response to environmental stress (Oztturk and Demir, 2003) Moreover, Sood and Nagar (2003) reported that peroxides and cellulose activities were retarted by polyamine treatment and accelerated by polyamine biosynthetic inhibitors. In addition polyamines inhibit senescence in plant (Sood and Nagar 2003), thus, the filling period and effective filling period and filling rate increased and these processes caused an increase in yield and its components.

Table (3) Effect of water stress at certain developmental stages and polyamine concentration on yield and its components of barley plant cv.Giza-129 (Average of 2011/2012 and 2012/2013 seasons

Water stress treatment	Poly amine concentration	Spikes dry wt. g/plant	Grain yield g/plant	straw yield g/plant	Bio yield g/plant	Grain yield ton/fed	straw yield ton/fed	Bio yield ton/fed
No skipping (control)		49.13	39.86	51.56	91.42	2.93	3.63	6.56
Skipping one Irrigation at Tailoring stage		41.12	30.24	42.76	73.00	2.54	3.11	5.65
Skipping one Irrigation at heading stage		44.15	34.71	45.36	80.07	2.69	3.11	5.80
Skipping one Irrigation at milk- ripe stage.		47.33	36.96	46.48	83.44	2.74	3.25	5.99
L.S.D at 5% level		2.17	0.35	2.04	4.58	0.03	0.12	0.11
	Tap water (control)	41.74	32.36	43.80	76.17	2.51	3.05	5.56
	50mg/l put	44.09	33.30	44.79	78.09	2.61	3.14	5.75
	75mg/l put	45.12	35.30	46.04	81.34	2.68	3.24	5.92
	100mg/l put	46.78	37.28	48.80	86.08	2.80	3.31	6.11
	50mg/l sper	45.06	34.79	45.94	80.73	2.71	3.24	5.95
	75mg/l sper	46.80	36.76	47.38	84.14	2.87	3.42	6.29
	100mg/l sper	48.48	38.33	49.05	87.38	2.92	3.52	6.44
L.S.D at 5% level		2.59	0.71	0.39	1.28	0.08	0.08	0.12

B-3- Effect of interaction between water stress and polyamines concentration:

The interaction between water stress at certain developmental growth stages and polyamines concentration caused significant effects on spikes dry weight/ plant, grain; straw and biological yields/ plant and/or fed (Table 4). Moreover 100 mg/1put. and or sper under regular water irrigation (no skipping irrigation) treatment produced the highest significant values from yield and its components, whereas, skipping an irrigation at tillering stage value under tap water treatment had the lowest values of yield and its components. Thus, it could be concluded that barley plants were more sensitive to water stress in tillering stage compared with heading and milk- ripe stage, respectively. Also, we can alleviate the harmful effect caused by water stress on growth characters and yield and its components using foliar application with polyamine especially 100mg/1 put. or 100mg/1sper.

Table (4) Effect of the interaction between water stress certain developmental stages and polyamine concentration on yield and its components of barley plant cv.Giza-129 (Average of 2011/2012 and 2012/2013 seasons

Water stress treatment	Poly amine concentration	Spikes dry wt g/plant	Grain yield g/plant	straw yield g/plant	Bio yield g/plant	Grain yield ton/fed	straw yield ton/fed	Bio yield ton/fed
No skipping (control)	Tap water	46.21	36.57	48.68	85.25	2.75	3.41	6.16
	50mg/l put	47.80	38.04	49.27	87.31	2.88	3.47	6.33
	75mg/l put	48.32	39.70	51.09	90.79	2.93	3.62	6.55
	100mg/l put	49.96	40.10	56.10	96.11	2.97	3.70	6.67
	50mg/l sper	48.16	39.50	51.00	90.50	2.90	3.50	6.40
	75mg/l sper	50.03	41.11	52.30	93.41	2.97	3.81	6.78
	100mg/l sper	53.45	44.00	52.49	96.49	3.08	3.88	6.96
Skipping at tillering stage	Tap water	37.25	27.93	40.67	68.60	2.33	2.87	5.30
	50mg/l put	39.80	28.16	41.39	69.55	2.41	2.96	5.37
	75mg/l put	41.16	30.41	42.15	72.56	2.45	3.08	5.53
	100mg/l put	42.77	31.55	43.00	74.55	2.64	3.19	5.83
	50mg/l sper	40.52	29.64	42.51	72.15	2.59	3.09	5.68
	75mg/l sper	42.71	31.78	43.4	75.18	2.68	3.16	5.84
	100mg/l sper	43.65	32.24	46.2	78.44	2.71	3.41	6.11
Skipping at heading stage	Tap water	39.88	31.52	42.35	73.87	2.42	2.91	5.33
	50mg/l put	42.96	32.36	43.17	75.53	2.54	2.98	5.52
	75mg/l put	43.47	35.01	44.62	81.63	2.62	3.04	5.66
	100mg/l put	45.01	38.00	48.51	86.51	2.78	3.11	5.89
	50mg/l sper	44.18	33.18	44.25	77.43	2.66	3.12	5.76
	75mg/l sper	46.35	35.90	46.63	82.53	2.87	3.29	6.16
	100mg/l sper	47.20	37.00	48.00	85.00	2.91	3.33	6.24
Skipping at heading stage	Tap water	43.60	33.40	43.51	76.91	2.53	3.02	5.55
	50mg/l put	45.78	34.63	45.32	79.95	2.59	3.14	5.73
	75mg/l put	47.51	36.08	46.29	82.37	2.70	3.22	5.92
	100mg/l put	49.38	39.46	47.58	87.04	2.80	3.25	6.05
	50mg/l sper	47.36	36.85	46.00	82.85	2.68	3.26	5.94
	75mg/l sper	48.10	38.24	47.18	85.42	2.94	3.40	6.34
	100mg/l sper	49.6	40.09	49.50	89.58	2.98	3.47	6.45
L.S.D at 5% level		5.18	1.42	0.78	2.56	0.16	0.12	0.2

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