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Research article

Growing Two Broccoli Cultivars under Different Mineral and Foliar Fertilization Treatments

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Abstract

Two field experiments were conducted in newly reclaimed soil for two winter seasons during 2013/2014 to 2014/20015 at El- Nubaria region, Beheira Governorate, Egypt. The aim of this study was to evaluate two broccoli *(Brassica oleraceae L.* var *italica)* cultivars, i.e. Sakura F1 Hybrid under four fertilization treatment (100% NPK recommended dose + without spray of amino magnical; 50% NPK recommended dose + One spray; 50% NPK recommended dose + Two sprays and 50% NPK recommended dose + Three sprays). Results indicate that the highest vegetative growth parameters expressed as plant height, leaves number as well as fresh and dry weight of leaves, stems, apical heads and total plant was obtained by Centauro c.v compared with Sakura F1 Hybrid. The abovementioned characteristics were also obtained by- 100% NPK recommended dose or 50% NPK recommended dose + One spray of amino magnical. Lower values of vegetative growth were obtained by Sakura F1 Hybrid or the other fertilization treatments. Total yield of apical heads and their quality expressed as (diameter, height and fresh weight) recorded higher values in Centauro c.v plants compared with Sakura F1 Hybrid. In addition, the 100% NPK recommended dose or 50% NPK recommended dose + One spray of amino magnical recorded the highest values of total yield and quality of apical heads compared with the other fertilization treatments. With respect to the interaction, Centauro c.v plants receiving 100% NPK recommended dose or 50% NPK recommended dose + One spray of amino magnical recorded the higher values of the vegetative growth, total yield of apical heads and their quality. On the contrary, lower values of vegetative growth, total yield of apical heads and quality were obtained by the other interaction treatments. The lowest values of vegetative growth, total yield of apical heads and their quality were obtained from Sakura F1 Hybrid plants receiving 50% NPK recommended dose + three sprays.

Key words: NPK fertilizers; foliar application; amino magnical; number of sprays; broccoli cultivars.

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1. Introduction

Cruciferous vegetable crops are large and increasingly important vegetables. Broccoli, a member of the *Cruciferae* family of vegetables, which found along the Mediterranean region [9]. Broccoli is an Italian vegetable crop, cultivated in Italy in ancient Roman times and about 1720 in England. On the other hand, in the USA it first appeared in 1806, but it was commercially cultivated around 1923 [9]. Broccoli is cultivated in Egypt in scattered areas around Cairo and Alexandria [3], [2]. However, due to increase in its popularity, there is a trend to increase its cultivation by farmers as well as consumption by consumers. Broccoli has high nutrients and good commercial value. New days, broccoli attracted more attention due its multifarious use and great nutritional value [34] [27].

Growing broccoli in the newly reclaimed soils is faced with various problems, such as cultivars, fertilization, low amounts of available nutrients and low organic matter content as well as poor hydrophilic, chemical and biological properties. The best means of maintaining soil fertility and productivity could be through periodic additions of organic manures such as poultry manures.

Some investigators dealt with broccoli varieties under the different environmental conditions [30], [31], [24], [16], [17], [15], [23]. Also, some investigators evaluated broccoli varieties under the Egyptian conditions [8], [5], [3], [2], [26], [18], [1].

The cultivars genotype plays an important role of growth, yield and quality of broccoli plants [3], [2], [18].

The requirements of amino acids in essential quantities is well known as a means to increase yield and overall quality of crops [29], [13], [14], [20].

Foliar fertilization of some commercial fertilizers was used in order to save mineral fertilizer quantities [20]. The present work was determined to spray a compound containing amino acids, Mg and calcium on broccoli plants in order to save mineral fertilizers. Foliar spray by Amifol K (containing amino acids, K and calcium) as a minor nutritional fertilizer grained the best plant growth, yield and quality of broccoli heads [20].

Foliar application of amino magnical, amino tec and root most on onion crop increased plant height, number of leaves, leaf length, neck and bulb diameters, fresh and dry weight of leaves, bulbs and total plant as well as total yield [25].

Other investigators also studied the effect of NPK fertilization on broccoli plant [32], [6], [35]. Therefore, this work was performed to evaluate vegetative growth, heads yield, heads quality of two broccoli cultivars under different mineral and foliar fertilization treatments.

2. Materials and Methods

Two field experiments were carried out on broccoli *(Broccoli oleraceae L.* var. *italica* cvs. Broccoli Sakura F1 Hybrid and Centauro, Family *Cruciferae*) in an area of newly reclaimed soil at El-Nuberia, Beheira Governorate, Egypt, during the two successive winter seasons of 2013/2014 and 2014/2015. The aim of this work was to evaluate two broccoli cultivars, i.e. Sakura F1 Hybrid and Centauro under Egyptian condition and study the effect of four different minerals and foliar fertilization treatments on growth, yield and quality of two broccoli cultivars. Soil samples were collected at random before planting from the top layer (0-30 cm depth) for physical and chemical analysis. Soil analysis is presented in Table 1. Soil physical properties were analyzed using the procedures described by [7] for particle size distribution and soil texture, while the soil chemical analysis was

measured according to the procedures described by [22].

Table 1. Physical and chemical properties of the experimental soil during the two seasons of 2013/2014 and 2014/2015.

A. Physical properties				
Season	**Sand %**	**Clay %**	**Silt %**	**Texture**
2013/2014	55.85	3.45	40.70	Sandy
2014/2015	56.72	3.72	39.56	Sandy

B. Chemical properties										
Season	**E.C. dSm^{-1}**	**pH**	**Meq./L**							
			Cations				**Anions**			
			Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**CO_3^{-}**	**HCO_3^{-}**	**Cl^{-}**	**SO_4^{--}**
2013/2014	2.18	7.81	8.61	4.80	4.64	1.59	Nil	1.40	1.80	17.40
2014/2015	1.26	7.76	7.60	2.20	3.79	0.91	Nil	1.40	1.60	12.20

Seeds of two broccoli cultivars (cvs. Broccoli Sakura F1 Hybrid and Centauro) were imported from India and Japan from Takii Seed, respectively. Seeds were sown in the nursery in foam trays filled with a mixture of peat moss and vermiculite (1:1 volume) on 1st of August in 2013 and 2014 seasons. Seedlings were transplanted in the open field at 45 days age.

Treatments were as follows:-

Cultivars: Two broccoli cultivars were evaluated.

a) - Sakura F1 Hybrid
b) – Centauro

Fertilization treatments

NPK was applied at a rate of 100: 60: 40 N:P:K units per Fadden as recommended doses in four different combinations with foliar application of Amino magnical.

a) 100 % NPK recommended dose without spray.
b) 50 % NPK recommended dose + one spray of amino magnical.
c) 50 % NPK recommended dose + two sprays of amino magnical.
d) 50 % NPK recommended dose + three sprays of amino magnical

Organic fertilizer (compost) and calcium super phosphate were added through the ditches before transplanting and ditches were covered by soil. Drip irrigation lines were spread over the ditches. Mineral fertilizer was added to the soil using ammonium nitrate (33.5 % N) as a source of nitrogen at a rate of 100 N unit, calcium super phosphate (15.5 % P_2O_5) as a source of phosphorus at a rate of 60 P_2O_5 units/fed and potassium sulphate (48 % K_2O) as a source of potassium at a rate of 40 K_2O units/fed. The quantities of the chemical fertilizers were splinted into two equal doses (21 and 42 days after transplanting) beside plants. Seedlings were transplanted on one side of each row in 75 cm width and 50 cm apart. Each plot included three rows, plot area was 10.5 m^2.

Experimental design

A split plot design with four replicates was followed. Cultivars of broccoli were located in the main plots, whereas the different

fertilization treatments were assigned in the sub plots.

Data recorded

Vegetative growth characters

A random sample of five plants was collected from each experimental treatment 60 days after transplanting and the following data were recorded during the two seasons.

1) Plant height.	2) Leaves number per plant.
3) Leaves fresh weight.	4) Stems fresh weight.
5) Apical head fresh weight.	6) Total plant fresh weight.
7) Leaves dry weight.	8) Stems dry weight.
9) Apical head dry weight.	10) Total plant dry weight.

Split-plot design was followed in which cultivars were allotted in the main plots and fertilization treatments were arranged in the sub-plots. Statistical is of variance was followed according to Snedecor et al. [33].

Apical heads yield and Physical bulb quality

All broccoli heads of each plot were harvested at vegetative mature stage in order to record these data:-

1. First main heads yield (ton/ fed): main yield of the apical heads.
2. Head diameter (cm).
3. Head height (cm).
4. Mean head weight (g/ plant).

3. Results and Discussion

Vegetative growth characteristics

Evaluation of cultivars

Vegetative growth of broccoli plants expressed as plant height; leaves the number/plant and fresh weight of leaves, stems and total plant was affected by cultivars (Table 2). Vegetative growth was widely varied between the two cultivars of broccoli crops. Results indicate that plant of cv. Centauro recorded higher and significant values of vegetative growth parameters (fresh weight of leaves, stems apical heads and total plant as well as stems and apical heads dry weight) compared with cv. Sakura hybrid. No statistical differences were recorded in plant height and leaves dry weight between the two tested cultivars. These results were similar in the two seasons of the experiment. Leaves number was denser in Sakura hybrid, but the differences were not significant in the first season. In general, it seems from the data of the two seasons that Centauro cv. recorded higher values of vegetative growth compared with Sakura hybrid.

The differences among cultivars in vegetative growth might be due to their genetic differentiation which allows some to use the natural resources with high potentiality. The genetic potentiality of some cultivars enables their plants to absorb more nutrients of the soil and more photosynthetic surfaces which allow better photosynthetic capacity. Centauro c.v recorded denser leaves and higher values of fresh weight of leaves, stems and total plant which offered wider photosynthetic surface and enables Centauro plants to higher photosynthetic capacity leading to higher dry matter accumulation in its leaves, stems and consequently total plant. Diputado et al. [11] showed that leaves number varied with cultivars and appeared to be related to their varying time to curd initiation. They added that plant dry matter production varied with cultivars. Hassan, [19] reported that leaves weight of the plant was significantly affected by cultivars. He added that broccoli cvs. differed in their number of leaves, stem diameter, length as well as dry matter content. Many investigators studied the

differences between cultivars in their vegetative growth parameters [10], [3], [2], [12], [4], [1].

Some investigators studied the differences among cultivars vegetative growth under Egyptian conditions. They recorded a wide variation among the vegetative growth of the different cultivars of broccoli [8], [24], [30], [5], [3], [2], [26], [4], [18], [1].

Effect of fertilization

Vegetative growth of broccoli plants expressed as plant height, leaves number and fresh and dry weight of leaves, stems, apical heads and total plant were statistically affected by fertilization treatments (Table 3). The highest value of vegetative growth parameters of broccoli plants was obtained by applying the 100% NPK recommended dose or 50% NPK recommended dose one foliar spray of amino magnical treatment without significant differences. Application of 50% NPK recommended dose two foliar sprays of amino magnical lies in the second order. The lowest values of vegetative growth were obtained by the application of 50% NPK recommended dose + two foliar sprays. These results were similar and significant in the two seasons of the experiment.

Hassan *et al*., [20] came to similar results. They reported that the highest values of vegetative growth expressed as plant height, leaves number as well as fresh and dry weight of leaves were obtained by Amifol K. These results might be due to its content of amino acids and potassium. Amino acids and potassium play a great role in the physiology of the plants. Amino acids are the base components in protein synthesis. In addition, potassium molecule is the carrier of the photosynthetic products especially carbohydrates so that they enhance protein and carbohydrate synthesis. Hassan et al. [20] added that Amifol K foliar spray recorded the highest N, P and K percentages in broccoli leaves. In addition, leaves content of chlorophyll A and B were increased by Amifol K spray. Consequently, the higher vegetative growth of broccoli plants. Resulting by foliar application of amino magnical might be due to its favorable effect on protein, carbohydrates and N, P and K contents. In addition, chlorophyll A and B are the major light absorbing pigments of the plant leaves and play an important role in the metabolic activities in plant tissues, consequently, higher vegetative growth and economic yields.

Many investigators reported that, mineral fertilizer plus foliar application increase vegetative growth of broccoli of onion [28], [35], [25].

Effect of the interaction: The obtained data revealed that the interaction treatments (Table 4) significantly affected all growth parameters. These results were true and nearly similar in both seasons of the experiment. Generally, it could be summarized that, the highest vegetative growth of broccoli plants expressed as plant height, leaves number as well as fresh and dry weight of leaves, stems and apical heads were obtained by Centauro c.v plants when fertilized by 50% NPK recommended dose one foliar spray of amino magnical. On the contrary, the lowest values of the abovementioned parameters were obtained by Sakura hybrid plants receiving 50% NPK recommended dose three foliar sprays of amino magnical. Other interaction treatments ranged in between these two treatments. These results were similar and true in the two seasons of the experiment.

Table (2) :Effect of two broccoli cultivars on vegetative growth and apical head yield during two seasons 2013/2014 and 2014/2015.

Cultivars of broccoli	Plant height (cm)	Leaves No./ plant	Head diameter (cm)	Head height (cm)	Fresh weight (gm / plant)				Dry weight (g /100 g F*W*)			Heads yield (ton/fed.)
					Leaves	Stems	Spears	Total	Leaves	Stems	Spears	
(2013/2014)												
Sakura F1 Hybrid	34.67	13.83	11.50	9.25	111.04	67.88	77.72	256.64	12.15	13.60	14.83	2.156
Centauro	34.92	12.50	13.17	11.42	150.17	86.60	168.42	405.20	11.73	16.23	24.01	3.404
L.S.D at 0.05	N.S.	N.S.	0.97	0.64	6.38	3.33	22.30	31.69	N.S.	0.70	0.33	0.266
(2014/2015)												
Sakura F1 Hybrid	35.83	14.33	11.78	8.83	117.79	72.55	85.05	275.39	12.98	14.10	16.33	2.313
Centauro	36.33	12.50	13.80	11.79	156.76	91.69	179.59	428.03	12.56	17.98	27.81	3.595
L.S.D at 0.05	N.S.	0.24	0.51	0.79	2.32	0.80	6.61	9.04	N.S.	0.70	0.52	0.076

Table (3) :Effect of NPK rates on vegetative growth and apical head yield of broccoli during two seasons 2013/2014and 2014/2015.

Mineral fertlizer of NPK (unit/fed.)	Plant height (cm)	Leaves No./ plant	Head diameter (cm)	Head height (cm)	Fresh weight (gm / plant)				Dry weight (gm /100 gm F*W*)			Heads yield (ton/fed.)
					Leaves	Stems	Spears	Total	Leaves	Stems	Spears	
(2013/2014)												
100% Recommended doses without spray	36.17	13.17	13.00	11.17	147.58	85.56	169.94	403.07	11.72	15.66	22.65	3.386
50% Recommended doses One spray	34.67	14.33	14.50	10.17	164.45	86.63	158.02	409.10	11.50	15.65	21.08	3.436
50% Recommended doses Two sprays	34.17	12.50	11.00	10.17	84.88	70.73	79.45	235.05	11.85	14.02	18.49	1.974
50% Recommended doses Three sprays	34.17	12.67	10.83	9.83	125.53	66.05	84.88	276.46	12.69	14.30	15.46	2.322
L.S.D at 0.05	1.11	0.89	0.71	N.S.	5.95	5.04	17.22	18.45	0.38	0.91	0.89	0.155
(2014/2015)												
100% Recommended doses+ without spray	37.58	13.42	13.50	10.67	152.91	89.39	185.27	427.57	12.47	16.79	25.30	3.592
50% Recommended doses+ One spray	35.92	14.58	14.83	10.33	171.45	91.30	165.02	427.76	12.25	16.78	23.73	3.593
50% Recommended doses+ Two sprays	35.42	12.75	11.44	10.25	92.22	76.23	86.78	255.22	12.60	15.15	21.14	2.144
50% Recommended doses+ Three sprays	35.42	12.92	11.40	10.00	132.53	71.55	92.21	296.29	13.77	15.43	18.11	2.489
L.S.D at 0.05	0.92	0.51	0.37	N.S.	2.17	2.23	7.05	8.22	0.50	0.57	0.55	0.069

Total yield of apical heads

Evaluation of cultivars

Data tabulated in Table 2 Show clearly that, Centauro c.v out yielded Sakura hybrid in the two seasons of the experiment Total yield of apical heads of Centauro recorded an increase amounted to 1.24% and 1.282 ton/Fed. compared with Sakura hybrid which equals 57.9 and 55.4% in the two seasons, respectively. The increases in the total yield of Centauro may be referred to the higher values of vegetative growth of Centauro c.v.

This result might be expectable because the total yield of apical heads yield was the function of the vegetative growth, photosynthetic activity and dry matter accumulation. Since Centauro c.v was the denser leaves with higher fresh and dry weight of leaves, stems and total plant, it recorded the highest total head yield. Since head yields were the function of vegetative growth, water and nutrient uptake, photosynthesis as well as fresh and dry weight. So that, Centauro c.v plants outyielded those of Sakura hybrid owing to superiority in its vegetative growth, nutrient uptake and fresh and dry matter accumulation.

Many investigators reported that head yield variation within broccoli cultivars [19], [3], [2], [12], [18], [4], [1].

Effect of fertilization

Data presented in Table 3 indicated that the total yield of apical heads was widely affected by fertilization treatment. The highest total yield of apical heads was obtained by the application of the 100% NPK recommended dose without spray or 50% NPK recommended dose + one spray of amino magnical without significant differences. Treatment of 50% NPK recommended dose three sprays lies in the second order with respect to the total yield. The lowest yield of apical yield was recorded with 50% NPK recommended dose two sprays. These results were similar and statistical in the two seasons. Application of 100% NPK recommended dose without spray recorded 1.412 and 1.448 increase in the total yield per feddan in the two seasons of the experiment which equal 71.5 and 67.5%. Application of 50% NPK recommended dose + one spray of Amino magnical reflect an increase in the total yield amounted to 1.462 and 1.449 ton/ feddan which equal 74.1 and 67.6% in the two seasons, respectively. These results assure that 50% NPK recommended dose one spray can substitute 100% NPK recommended dose without spray. This treatment may save the costs of 50% of the recommended dose, their transport and application costs. These results indicated that the costs of fertilizing broccoli could be reduced by 50% by foliar application of one spray of Amino magnical. This treatment might reduce fertilization costs of broccoli by 50%. The superiority of this treatment was the result of foliar application of one spray of Amino magnical. These results might be due to the role of the Amino magnical in substituting the decrease in NPK in the plant tissues.

Amino magnical contains amino acids, Mg++ and calcium. The requirement of amino acids in essential quantities is well know as a means to increase yield and overall quality of crops [29], [13], [14]. Hassan H.A. et al. [20] found that using Amifol K as foliar spray to broccoli plants recorded higher yields of apical heads. These results were also in agreement with those obtained by Islam M. H et al. [21] on broccoli. Foliar application of Amifol K enhanced physical and chemical quality of broccoli heads. Head weight and diameter as well as vitamin C and TSS values in

apical heads were increased by foliar application of Amifol K.
Foliar application of Amino-magnical, Amino Tec and Root Most increased onion bulb yield and quality [25].

Effect of interaction
Interaction of cultivars with mineral fertilization statistically affected the apical heads yield of broccoli as shown in Table 4. Total yield of apical heads was widely affected by interaction treatments. The highest values of the total yield of apical heads was obtained by Centauro plants receiving the 100% NPK recommended dose without spray followed by Centauro plants receiving the 50% NPK recommended dose with one spray of Amino magnical. On the contrary, the lowest total yield was obtained from Sakura hybrid plants which receiving 50% NPK recommended dose with three sprays of Amino magnical. The other interaction treatments ranged in between these two interaction treatments. These results were similar and true in the two seasons of the experiment.

Quality of apical heads
Evaluation of cultivars
The two tested cultivars varied widely in their apical head quality (Table 2). Centauro c.v recorded higher values of apical head diameter, height and fresh weight compared with Sakura hybrid. This superiority in the quality characteristics of Centauro yield was similar in the two seasons compared with Sakura hybrid. The superiority of Centauro apical heads might be referred to the higher vegetative growth resulting by the higher environmental resources. It might be also due to the genetic ability of this cultivar which enables its plants to consume more natural resources. Its potentiality was higher in absorbing higher quantities of minerals from the soil solution and consumes more other natural resources.
Many investigators studied head quality of broccoli in the different cvs. [3],[2],[4],[1].

Effect of fertilization
Quality of apical heads of broccoli expressed as diameter, height, fresh and dry weight was statistically affected by fertilization treatments (Table 3). Apical heads recorded its highest quality by application of 50% NPK recommended dose one foliar spray of Amino magnical treatment. Lower quality was obtained by the other fertilization treatments.

Effect of interaction
The quality of apical heads expressed as diameter, height and fresh and dry weight of the apical head followed the same trend of the vegetative growth and total yield in relation to the interaction (Table 4). The highest values of quality parameters were obtained by Centauro plants receiving 50% NPK recommended dose one foliar spray of Amino magnical treatment and Centauro plants receiving 100% NPK recommended dose without spray. On the other hand, the lowest quality was obtained by Sakura hybrid plants receiving 50% NPK recommended dose three foliar sprays of Amino magnical. The other interaction treatments ranged in between these two treatments. These results were similar and true in the two seasons of the experiment.

Table (4) :Effect of interaction (Cultivars x Nitrogen rates) on vegetative growth and apical head yield of broccoli during two seasons 2013/2014and 2014/2015.

Cultivars of broccoli	Mineral fertlizer of NPK (unit/fed.)	Plant height (cm)	Leaves No./ plant	Head diameter (cm)	Head height (cm)	Fresh weight (gm / plant)				Dry weight (gm /100 gm F*W*)			Heads yield (ton/fed.)
						Leaves	Stems	Spears	Total	Leaves	Stems	Spears	
						(2013/2014)							
·Hy 1	**100% Recommended doses without spray**	34.67	13.67	9.00	8.67	93.36	49.73	50.31	193.40	12.00	10.40	10.67	1.625
Sakura F	**50% Recommended doses One spray**	33.67	16.33	14.67	9.33	139.36	70.26	107.72	317.34	11.40	13.13	15.02	2.666
	50% Recommended doses Two sprays	35.67	13.33	8.67	8.67	68.27	71.42	34.64	174.33	12.18	14.74	13.91	1.464
	50% Recommended doses Three sprays	34.67	12.00	13.67	10.33	143.19	80.10	118.19	341.48	13.01	16.10	19.72	2.868
Centaure	**100% Recommended doses without spray**	37.67	12.67	17.00	13.67	201.79	121.38	289.57	612.74	11.44	20.92	34.64	5.147
	50% Recommended doses One spray	35.67	12.33	14.33	11.00	189.54	103.01	208.31	500.85	11.59	18.17	27.14	4.207
	50% Recommended doses Two sprays	32.67	11.67	13.33	11.67	101.50	70.03	124.25	295.78	11.52	13.31	23.07	2.485
	50% Recommended doses Three sprays	33.67	13.33	8.00	9.33	107.87	52.00	51.57	211.44	12.36	12.50	11.20	1.776
	L.S.D at 0.05	1.57	1.26	1.00	N.S.	8.42	7.13	24.35	26.09	N.S.	1.29	1.26	0.219
						(2014/2015)							
·Hy 1	**100% Recommended doses without spray**	35.83	14.17	9.25	8.33	98.69	51.90	57.31	207.90	12.75	10.90	12.17	1.746
Sakura F	**50% Recommended doses One spray**	34.83	16.83	14.75	8.92	146.36	75.76	114.72	336.84	12.15	13.63	16.52	2.829
	50% Recommended doses Two sprays	36.83	13.83	8.88	8.08	75.93	76.92	42.31	195.16	12.93	15.24	15.41	1.639
	50% Recommended doses Three sprays	35.83	12.50	14.25	10.00	150.19	85.60	125.86	361.64	14.09	16.60	21.22	3.038
Centaure	**100% Recommended doses without spray**	39.33	12.67	17.75	13.00	207.13	126.88	313.23	647.24	12.19	22.67	38.44	5.437
	50% Recommended doses One spray	37.00	12.33	14.92	11.75	196.54	106.84	215.31	518.68	12.34	19.92	30.94	4.357
	50% Recommended doses Two sprays	34.00	11.67	14.00	12.42	108.50	75.53	131.25	315.28	12.27	15.06	26.87	2.648
	50% Recommended doses Three sprays	35.00	13.33	8.55	10.00	114.87	57.50	58.57	230.94	13.45	14.25	15.00	1.940
	L.S.D at 0.05	1.31	0.73	0.53	0.64	3.07	3.16	9.97	11.62	N.S.	0.81	0.78	0.098

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