Journal of Balkan Science and Technology
journal homepage: www.jbst.nku.edu.tr/

Effect of Drought Applications on Macro-Micro Nutrient Amounts of Some Exotic Vegetable Species

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Research Article

Keywords:
Japanese greens
PEG6000
Water stress
Macro-micro nutrients

Received: 09.04.2022
Accepted: 15.08.2022
Published: 14.09.2022

DOI: 10.55848/jbst.2022.14

ABSTRACT

All artificial drought conditions were created in a climate room with 400 µmol/m2s light intensity at 25/20°C (day/night) temperature, 65-70% relative humidity, 12/12 (light/night) hour photoperiod. In the experiment, Mibuna (Brassica rapa var. nipposinica), Mizuna (Brassica rapa var. Japonica), Misome (Brassica campestris var. narinosa), Komatsuna (Brassica rapa var. perviridis), Japanese mustard (Brassıca juncea L.), Chinese mustard (Brassica campestris var. chinensis), Coriander (Coriandrum sativum L.), Chives (Allium schoenoprasum), Basil (Ocimum basilicum), Molehiya (Corchorus capsularis), and Corchorus olitoruus) were used. Hoagland hydroponic solution was given by drip irrigation in hydroponic system during the emergence and seedling periods, and then water stress applications were launched. The experiment design was randomized plots with 5 replication consisting of 10 species (Mibuna, Mizuna, Misome, Komatsuna, Japanese mustard, Chinese mustard, Coriander, Chives, Basil, and Molehiya) and 4 PEG6000 concentrations (Control, -4 MPa, -8 MPa, and -12 MPa). Plant nutrient analyses were performed during the harvest period. According to the obtained results from the trial, when the PEG6000 concentrations in the Hoagland hydroponic solution were increased, amount of macro-micro nutrients decreased. As a result, in places with drought problems, chives, Molehiya, and Japanese mustard cultivation could be recommended due to being more drought-resistant than other species.

1. Introduction

The Mediterranean Basin, in which our country is located, is one of the most sensitive regions of the world within the framework of global climate change. A temperature increases of 2°C in the Mediterranean Basin would take effect and reveal itself as unforeseeable and unprecedented weather events, heat waves, increase in the number and impact of forest fires, drought and thus loss of biodiversity, decrease in tourism revenues, loss of agricultural productivity, and drought first and foremost. According to the Final Report of the Future of Turkey Project by WWF-Turkey (World Wildlife Fund), the leading effects of climate change will be manifested as follows: The temperature increase will be limited until the end of the 2030s, after this period, a rapid increase will be observed. Although the temperature increases vary with respect to seasonal and regional differences, the temperature increase is expected to reach around 4°C in winter and 6°C in summer (in comparison to the 1960-1990 period). While a decrease is observed in winter precipitation in Turkey, an increase in precipitation will be observed only in the eastern hemisphere of Northern Anatolia. The Climate Change National Action Plan, published in 2011, also proposes that the annual average temperature in Turkey will increase by 2.5°-4°C in the coming years, and that the increase will exceed 4°C in the Aegean and Eastern Anatolian Regions and 5˚C in the central regions. The plan also reveals that Turkey will have a warmer, more arid, and uncertain climate in terms of precipitation in the near future. The Climate Change Action Plan predicts that Turkey will be significantly affected by adverse impacts such as reduction of water resources, forest fires, drought and desertification, and ecological deterioration due to these factors [1].

For instance, up to 45% of the world agricultural lands are subject to continuous or frequent drought, wherein 38% of the world human population resides [2], and worldwide area mapped as being affected by salinity is more than 3 × 106 km2, or approximately 6% of the total land area [3].

Cultivated plants generally require large amounts of water for their growth. Lack of water often causes significant quality reductions as well as yield losses. The traditional solution to combating drought is irrigation. However, today, quality water resources are decreasing and different users such as farmers, industrialists, and municipalities are competing for the same water in many areas. Therefore, irrigation is not seen as a promising option for solving the drought problem even if the farmers can afford the irrigation water costs and the high costs of the necessary equipment. This opinion is becoming increasingly common and there is an increasing interest in plants that have the capacity to produce good yields under arid conditions[4].

As in all around the world, global climate change and drought have come into prominence in terms of cultivation in

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our country. Vegetable growing, which is mostly done in summer in our region, can coincide with dry and rainless conditions. In this study, it was tried to determine the chemical changes caused by 10 different exotic origin vegetable seedlings of Far East origin, which are new vegetables for Turkey, under artificial drought conditions created in the climate chamber.

2. Materials and Methods

As plant material, Mibuna (Brassica rapa var. nipposinica), Mizuna (Brassica rapa var. Japonica), Misome (Brassica campestris var. narinosa), Komatsuna (Brassica rapa var. perviridis), Japanese mustard (Brassica juncea L.), Chinese mustard (Brassica campestris var. chinensis), Coriander (Coriandrum sativum L.), Chives (Allium schoenoprasum), Basil (Ocimum basilicum), and Molehiya (Corchorus capsularis and Corchorus olitoruus) were used.

Plant Growing; Our trial has been established under controlled conditions in climate room where temperature could be adjusted between +40°C and –20°C. The plants were grown in a climate room with a temperature of 25/20°C (day/night), 65-70% humidity, 12/12 (light/dark) hour photoperiodical order, and a light intensity of 400 µmol m-2s-1. Seeds of above-mentioned species were sown into multi-cell plastic pot filled with seedling growing media (peat). They were grown until the seedling had 3 to 4 true leaves in the climate room under normal seedling growth condition [5]. After the germination of the seeds, the seedlings were placed in a hydroponic system containing Hoagland nutrient solution [6] until the transplant period. For drought conditions; PEG6000 was added to the nutrient tanks to provide a water potential of -4, -8, and -12 MPa after the seedling had first true leaves [7].

Analysis of chemical changes; During the seedling harvest period, the leaf samples were brought to the laboratory as soon as possible and dried in the oven at 70ºC after washing. The granulated leaf samples were made ready for analysis by passing through a 0.5 mm sieve [8]. For the analysis to be performed, service procurement was purchased from Tekirdağ Namık Kemal University Scientific Research Unit (NABİLTEM), and macro-micro nutrient analyzes were made on the samples.

Statistical analysis; In the study, which was established with 5 replications according to the randomized plots trial design, each replication included 10 species which were performed under 4 drought conditions (control, -4, -8, and -12 MPa PEG6000). In the experiment with a total of 200 plots (5 replications X 10 species X 4 drought environments), 10 plants were used in each plot and a total of 2000 plants were used in the whole experiment.

Statistical analyses of the data obtained from the experiment were performed using the MSTAT version 3.00/EM package program. The groups that were differentiated by the LSD control method were specified for the significant differences [9].

3. Results and Discussion

In order to determine the drought tolerance of some exotic vegetable species, nutrient analyses were made on randomly selected leaf samples from each plot in the seedling growing period. While there were no significant differences among drought levels in terms of nitrogen content of Mibuna plants, all macro and micronutrients content of other vegetable species in different drought levels were found statistically different (Table 1).

The results of the macronutrient analysis are given in Table 1 and Figure 2. Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) amounts are presented as percentage.

Once the macro nutrient distribution of Mibuna vegetable species is examined, it is seen that nitrogen (N) averages are between 2,15-2,89%; phosphorus (P) averages are between 0,31-0,45%, potassium (K) averages are between 1,51-2,00%; calcium averages were found to be between 1,19-2,18%; and magnesium (Mg) averages were found to be between 0,16-0,27%.

In the seedlings of the Mizuna, the average nitrogen content was between 1.42-3,29%, this ratio was between 0,23-0,39% in terms of phosphorus, 1,27-1,78% in terms of potassium, 0,84-1,68% in terms of calcium, and itwas found to be between 0,11-0,20% in terms of magnesium.

According to the leaf analyses of the Misome species, macro nutrient elements changes occurred as 1,26-2,19% for nitrogen, phosphorus 0,33-0,39% for phosphorus, 1,33-1,84% for potassium, 0,97-1,47% for calcium, and 0,15-0,22% for magnesium.

According to the analyses made in Komatsuna seedlings, the rate of nitrogen in the leaf is 1,16-2,33%; the rate of phosphorus is 0,20-0,38%; the rate of potassium is 1,10-2,26%; the rate of calcium is 0,88-2,67%; and the rate of magnesium ratio was determined to be 0,13-0,38%.

Changes of drought on macronutrients in vegetable seedlings of Japanese mustard were examined and given in Table 1 and Figure 1. Upon reviewing these averages, it is seen that nitrogen varies between 2,04-2,81%; phosphorus varies between 0,36-0,56%; potassium varies between 1,10-2,26%; calcium varies between 1,08-1,60%; and magnesium was found to vary between 0,18 and 0,24%.

According to the macro nutrient element changes in Chinese mustard leaves, the amount of nitrogen was determined to be between 1,55-2,05%; phosphorus was determined to be between 0,24-0,35%; potassium was determined to be between 1,48-2,09%; calcium was determined to be between 1,15-1,61%; and manganese was determined to be between 0,15-0,23%.

According to the leaf analysis results obtained from coriander seedling grown under different drought conditions, it was understood that the amount of nitrogen changed as 1,38-2,17%, while this change was 0,21-0,30% in phosphorus and 1,73-3,22% in potassium, 0,22-0,59% in calcium, and 0,09-0,15% in magnesium.

Nitrogen was determined as 2,37-4,01%, phosphorus as 0,33-0,46%, potassium as 2,29-3,74%, calcium as 0,39-0,59%, and magnesium 0,07-0,10% in the leaves of chives seedlings.

As it could be seen in Table 1 and Figure 1, the amount of nitrogen in the leaves of basil under artificial drought conditions is between 1,61-3,37%. Likewise, this change was 0,20-0,37% in phosphorus, 2,47-3,48% in potassium, 0,90-1,52% in calcium, and 0,18-0,34% in magnesium.

As a result of Molehiya leaf analysis, the change was determined for nitrogen as 1,36-2,54%, for phosphorus as 0,27-0,44%, for potassium as 1,62-2,46%, for calcium as 0,56-0,71%, and for magnesium as 0,10-0,16%.

The results of the analysis of micro nutrients are given in Table 1 and Figure 2. In the table, the amounts of zinc (Zn), manganese (Mn), copper (Cu), and iron (Fe) were expressed as ppm. When the zinc (Zn), manganese (Mn), copper (Cu), and iron (Fe) columns of the micro nutrient elements of the species discussed in Table 1 were examined, the species were evaluated among each other and were not compared with each other. Accordingly, it was found that there was a statistical difference at the level of 1% between the averages of all micro nutrients of the examined species.

When the micro nutrient elements of Mibuna seedling leaves were examined in Table 1 and Figure 2, it was seen that zinc was around 46,30-58,60 ppm. Likewise, in Mibuna, manganese (Mn) averages were found to be in the range of 36,78-53,80 ppm; copper (Cu) averages were around 8,00-13,10 ppm; and iron (Fe) averages were around 42,35-66,77 ppm.

The effects of different drought applications on the Mizuna with respect to the micro nutrient content of the leaves are shown in Table 1. Accordingly, the amount of Zn was found to be in the range of 24,57-48,80 ppm; the amount of Mn in the range of 30,87-46,77 ppm; the amount of Cu in the range of 4,55-7,48 ppm; and the amount of Fe in the range of 29,83-61,45 ppm.

According to the micro nutrient analysis results of the Misome kind, the change in zinc is 39,83-48,64 ppm; in manganese, this change is 48,12-57,92 ppm; the change in copper is in the range of 4,73-8,30 ppm; and the change in iron is in the range of 36,40-56,97 ppm.

Once the micro nutrient elements were evaluated as a result of Komatsuna leaf analysis, it was found that the change in zinc was 37,57-85,50 ppm; the change in manganese was 46,08-68,68 ppm; the change in copper was 3,85-7,35 ppm; and the change in iron was 34,08-70,35 ppm.

When the data of Japanese mustard is evaluated (Table 1 and Figure 2), it was determined that zinc element varies between the range of 36,38-44,20 ppm; manganese element varies between the range of 27,80-59,80 ppm; copper element varies between the range of 8,08-12,02 ppm; and iron element varies between in the range of 56,08-79,05 ppm.

According to the same table, the averages for Chinese mustard are concluded to be 37,77-63,40 ppm for Zn, 35,20-39,40 ppm for Mn, 5,47-7,85 ppm for Cu and 36,20-61,57 ppm for Fe.

Table 1 and Figure 2 show the micro nutrient results according to the leaf analysis of Coriander vegetables. According to these results, it was determined that zinc (Zn) averages were between 27,34-38,25 ppm; manganese (Mn) averages were between 37,79-57,50 ppm; copper (Cu) averages were between 2,65-6,80 ppm; and iron (Fe) were between 42,88-65,55 ppm.

Micro nutrient element changes of chives are as seen in Table 1. Accordingly, while the actualized change in zinc varies between 39,21-52,42 ppm, this change is 43,38-62,21 ppm in manganese, 5,05-6,40 ppm in copper, and 56,78-74,28 ppm in iron.

When the micronutrient elements of basil were examined, it was understood that there were changes in the form of 30,65-56,42 ppm in zinc, 29,55-47,80 ppm in manganese, 5,52-7,95 ppm in copper, and 50,44-113,57 ppm in iron.

The micro nutrient changes in the leaves of the vegetable seedlings of Molehiya as a result of artificial drought tests are given in Table 1 and Figure 2. According to the table, it has been determined that the averages vary between 16,35-26,55 ppm in zinc, 25,87-86,13 in manganese, 5,95-8,27 ppm in copper, and 35,80-101,42 ppm in iron.

In the evaluation of the measurements made as a result of the study, the nutrient intakes of 10 exotic vegetable species, which were evaluated in parallel with the increase in PEG6000 concentrations and provided artificial drought conditions from the control conditions, decreased.

When Table 1 was examined, it was determined that the macro nutrient intakes of all species decreased drastically as the PEG6000 application concentration increased. The highest % N, P, K, Ca, and Mg averages were taken under normal irrigation conditions, which are specified as control conditions.

Gözüacik [10] stated that the scarcity or lack of water in the growth environment limits the plant growth as well as the mineral substance uptake by plants from the soil, and as a result, the mineral substance concentration in different parts of the plant also changes. He reported that the transport of mineral substances in plants depends on the water balance, and that there are a lot of differences among plant species with respect to the uptake and transport of mineral substances by plants.

A number of researchers working on different kinds of vegetables also reported that the uptake of macro nutrients from the soil increased due to the increased irrigation rate, and these rates decreased in arid conditions or once the irrigation rate is decreased [11-16].

The species considered in the experiment in terms of micro nutrients were evaluated among each other, and it is understood from Table 1 that the amount of micro nutrients decreases as one proceeds on with respect to the control applications made under normal irrigation conditions in all types to the application of -4, -8, and -12 MPa PEG6000, where water restriction is applied. In other words, as the drought increases, the amount of micronutrients transported to the leaves decreases.

Researchers working on water stress and drought in different plant species obtained results similar to the findings

Table 1. The effects of different drought treatments on the macro (%), micro (ppm) nutrients in some exotic vegetable species and groups according to LSD test

	PEG6000 Appl.	Macro Nutrients					Micro Nutrients			
		N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)
Mibuna	**Control**	2,89	0,45 a	2,00 a	2,18 a	0,27 a	58,60 a	53,80 a	13,10 a	66,77 a
	-4 MPa	2,76	0,38 b	1,77 b	1,59 b	0,18 b	49,68 b	49,88 b	10,83 b	57,33 b
	-8 MPa	2,53	0,34 c	1,66 c	1,40 c	0,16 b	49,35 c	49,55 c	8,10 c	49,90 c
	-12 MPa	2,15	0,31 d	1,51 d	1,19 d	0,16 b	46,30 d	36,78 d	8,00 d	42,35 d
	LSD (%1)	Önemsiz	0,0317	0,0303	0,0952	0,0333	0,1658	0,3027	0,0303	0,2345
Mizuna	**Control**	3,29 a	0,39 a	1,78 a	1,68 a	0,20 a	48,80 a	46,77 a	7,48 a	61,45 a
	-4 MPa	1,74 b	0,26 b	1,43 b	1,16 b	0,17 ab	33,20 b	44,35 b	7,20 b	34,30 b
	-8 MPa	1,60 c	0,23 c	1,40 c	1,08 b	0,16 b	30,87 c	40,50 c	5,13 c	32,40 c
	-12 MPa	1,42 d	0,23 c	1,27 d	0,84 c	0,11 c	24,57 d	30,87 d	4,55 d	29,83 d
	LSD (%1)	0,0303	0,0287	0,0061	0,0903	0,0345	1,0914	0,5582	0,0345	1,3055
Misome	**Control**	2,19 a	0,39 a	1,84 a	1,47 a	0,22 a	48,67 a	57,92 a	8,30 a	56,97 a
	-4 MPa	1,85 b	0,36 ab	1,69 b	1,24 b	0,21 ab	43,30 b	57,00 b	6,13 b	49,15 b
	-8 MPa	1,67 b	0,34 b	1,54 c	1,21 b	0,18 bc	40,82 c	50,68 c	5,83 c	42,50 c
	-12 MPa	1,26 c	0,33 b	1,33 d	0,97 c	0,15 c	39,83 d	48,12 d	4,73 d	36,40 d
	LSD (%1)	0,2345	0,0332	0,0332	0,0851	0,0338	0,5155	0,5309	0,0295	0,4881
Komatsuna	**Control**	2,33 a	0,38 a	2,26 a	2,67 a	0,38 a	85,50 a	68,68 a	7,35 a	70,35 a
	-4 MPa	1,90 b	0,30 b	1,76 b	1,35 b	0,19 b	70,68 b	61,30 b	6,27 b	45,15 b
	-8 MPa	1,30 c	0,23 c	1,18 c	0,98 c	0,13 c	68,47 c	49,20 c	4,22 c	39,70 c
	-12 MPa	1,16 d	0,20 c	1,10 d	0,88 d	0,13 c	37,57 d	46,08 d	3,85 d	34,08 d
	LSD (%1)	0,1004	0,0317	0,0345	0,0883	0,0344	0,7353	0,9668	0,0957	0,9132
Japon mustard	**Control**	2,81 a	0,56 a	2,26 a	1,60 a	0,24 a	44,20 a	59,80 a	12,02 a	79,05 a
	-4 MPa	2,70 b	0,49 b	1,76 b	1,52 a	0,20 b	43,42 b	50,80 b	9,68 b	69,15 b
	-8 MPa	2,62 b	0,44 c	1,18 c	1,40 b	0,19 b	38,97 c	46,23 c	8,37 c	61,10 c
	-12 MPa	2,04 c	0,36 d	1,10 d	1,08 c	0,18 b	36,38 d	27,80 d	8,08 d	56,08 d
	LSD (%1)	0,0957	0,0345	0,0287	0,0923	0,0358	0,4281	1,2554	0,1658	1,7204
Chinese mustard	**Control**	2,05 a	0,35 a	2,09 a	1,61 a	0,23 a	63,40 a	39,40 a	7,85 a	61,57 a
	-4 MPa	1,90 b	0,29 b	1,70 b	1,41 b	0,21 b	42,05 b	37,80 b	6,62 b	43,50 b
	-8 MPa	1,70 c	0,26 bc	1,50 c	1,30 c	0,15 c	37,93 c	37,37 b	6,23 c	37,30 c
	-12 MPa	1,55 d	0,24 c	1,48 c	1,15 d	0,15 c	37,77 d	35,20 c	5,47 d	36,20 d
	LSD (%1)	0,0303	0,0358	0,0271	0,0938	0,0169	0,1354	0,4490	0,1915	0,4387

Table 1. (Continued)

	PEG6000 Uyg.	Macro Nutrients					Micro Nutrients			
		N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)
Coriander	**Kontrol**	2,17 a	0,30 a	3,22 a	0,59 a	0,15 a	38,25 a	57,50 a	6,80 a	65,55 a
	-4 MPa	2,05 b	0,26 b	3,02 b	0,40 b	0,11 b	29,75 b	50,18 b	4,05 b	60,43 b
	-8 MPa	1,62 c	0,23 c	1,76 c	0,36 c	0,09 b	28,90 c	39,00 c	3,50 c	51,48 c
	-12 MPa	1,38 d	0,21 c	1,73 d	0,22 d	0,09 b	27,34 d	37,79 d	2,65 d	42,88 d
	LSD (%1)	0,0317	0,0271	0,0933	0,0304	0,0325	0,2533	0,4591	0,2345	1,2843
Chives	**Kontrol**	4,01 a	0,46 a	3,74 a	0,59 a	0,10 a	52,42 a	62,21 a	6,40 a	74,28 a
	-4 MPa	2,94 b	0,45 a	3,55 b	0,45 b	0,08 ab	50,82 b	54,00 b	5,70 b	67,04 b
	-8 MPa	2,64 c	0,41 b	3,02 c	0,42 bc	0,07 b	42,13 c	52,98 c	5,62 b	64,13 c
	-12 MPa	2,37 d	0,33 c	2,29 d	0,39 c	0,07 b	39,21 d	43,38 d	5,05 c	56,78 d
	LSD (%1)	0,1658	0,0303	0,0952	0,3707	0,0234	1,4517	0,9525	0,1354	2,0863
Basil	**Kontrol**	3,37 a	0,37 a	3,48 a	1,52 a	0,34 a	56,42 a	47,80 a	7,95 a	113,57 a
	-4 MPa	2,62 b	0,27 b	3,24 b	1,00 b	0,34 a	42,22 b	46,10 b	7,50 b	89,00 b
	-8 MPa	2,13 c	0,22 c	3,10 c	0,93 c	0,23 b	38,10 c	39,92 c	6,32 c	84,35 b
	-12 MPa	1,61 d	0,20 c	2,47 d	0,90 c	0,18 c	30,65 d	29,55 d	5,52 d	50,40 c
	LSD (%1)	0,0957	0,0318	0,0306	0,0330	0,0428	1,8880	1,6635	0,1354	5,4454
Molehiya	**Kontrol**	2,54 a	0,44 a	2,46 a	0,71 a	0,16 a	26,55 a	86,13 a	8,27 a	101,42 a
	-4 MPa	1,84 b	0,32 b	1,79 b	0,65 b	0,11 b	20,77 b	79,60b	7,48 b	64,80 b
	-8 MPa	1,61 c	0,30 b	1,64 c	0,60 c	0,10 b	17,90 c	60,62 c	6,77 c	47,15 c
	-12 MPa	1,36 d	0,27 b	1,62 c	0,56 d	0,10 b	16,35 d	25,87 d	5,95 d	35,80 d
	LSD (%1)	0,1004	0,9525	0,0303	0,0378	0,0433	0,1354	0,9132	0,0957	1,5758

of our experiment and supported our findings [10, 17-21]. In the research, the amount of macro-micro nutrient elements decreased under increasing artificial drought conditions.

4. Conclusion

It is extremely important to reveal the defense mechanisms in plant species and varieties that can adapt to stress conditions and thus to minimize crop losses, to ensure effective use of water, nutrition, and agricultural economy. Water stress also adversely affects the growth and development of plants as well as yield and quality. The intake of macro-micro nutrients decreased under severe drought conditions compared to control conditions.

Declaration

Author Contribution : Conceive-G.A.; Design- G.A.; Supervision-M.D.; Experimental Performance, Data Collection and/or Processing-G.A; Analysis and/or Interpretation-G.A.; Literature Review-M.D.; Writer-M.D.; Critical Reviews –M.D.

Acknowledgment: This work was supported by grant from the Research Fund of the Tekirdağ Namık Kemal University, project numbers NKUBAP.03.YL.19.204.

Conflict of Interest: The authors have declared no conflicts of interest.

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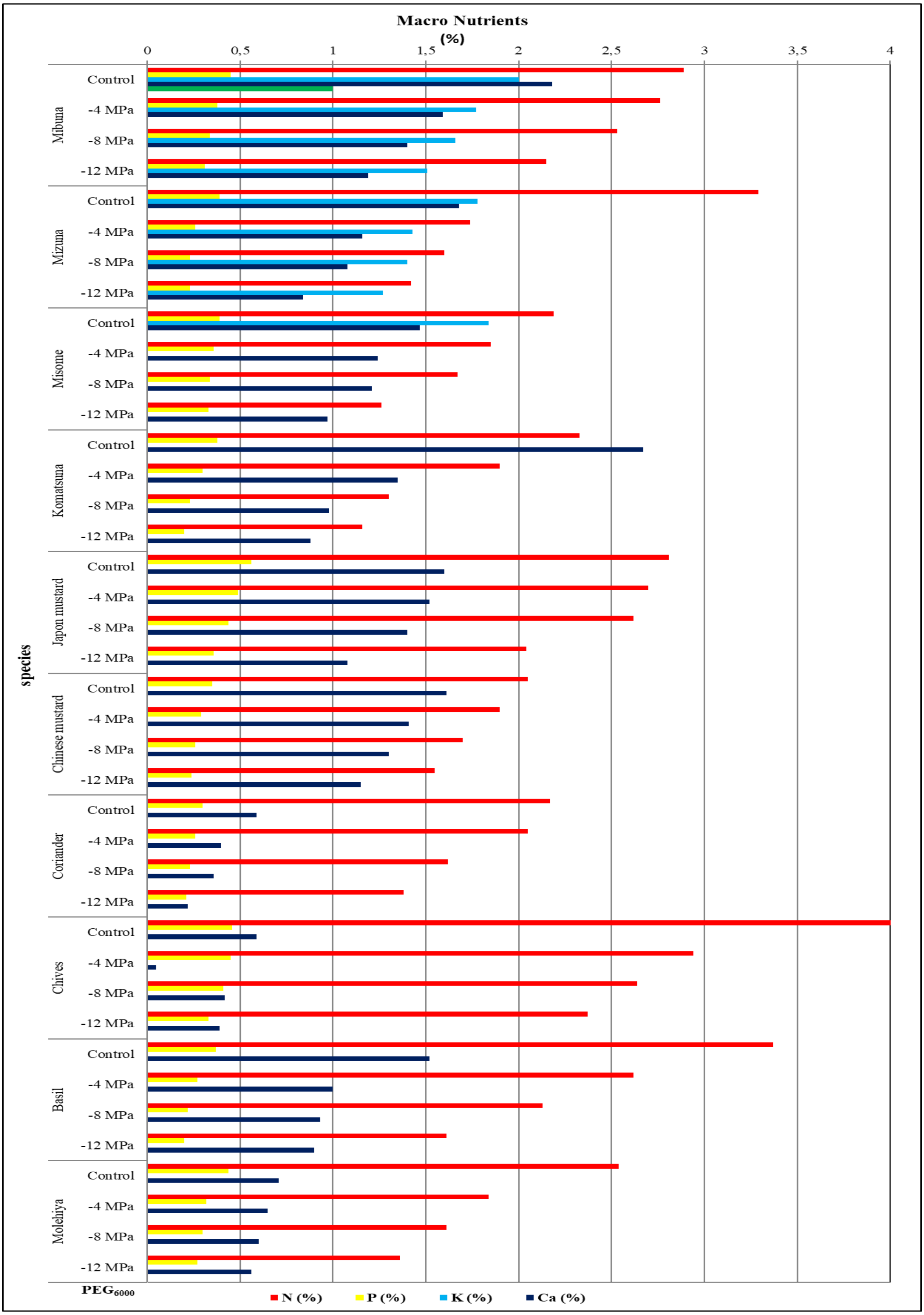

Fig. 1 The effects of different drought treatments on the macro (%) nutrients content of some exotic vegetable species.

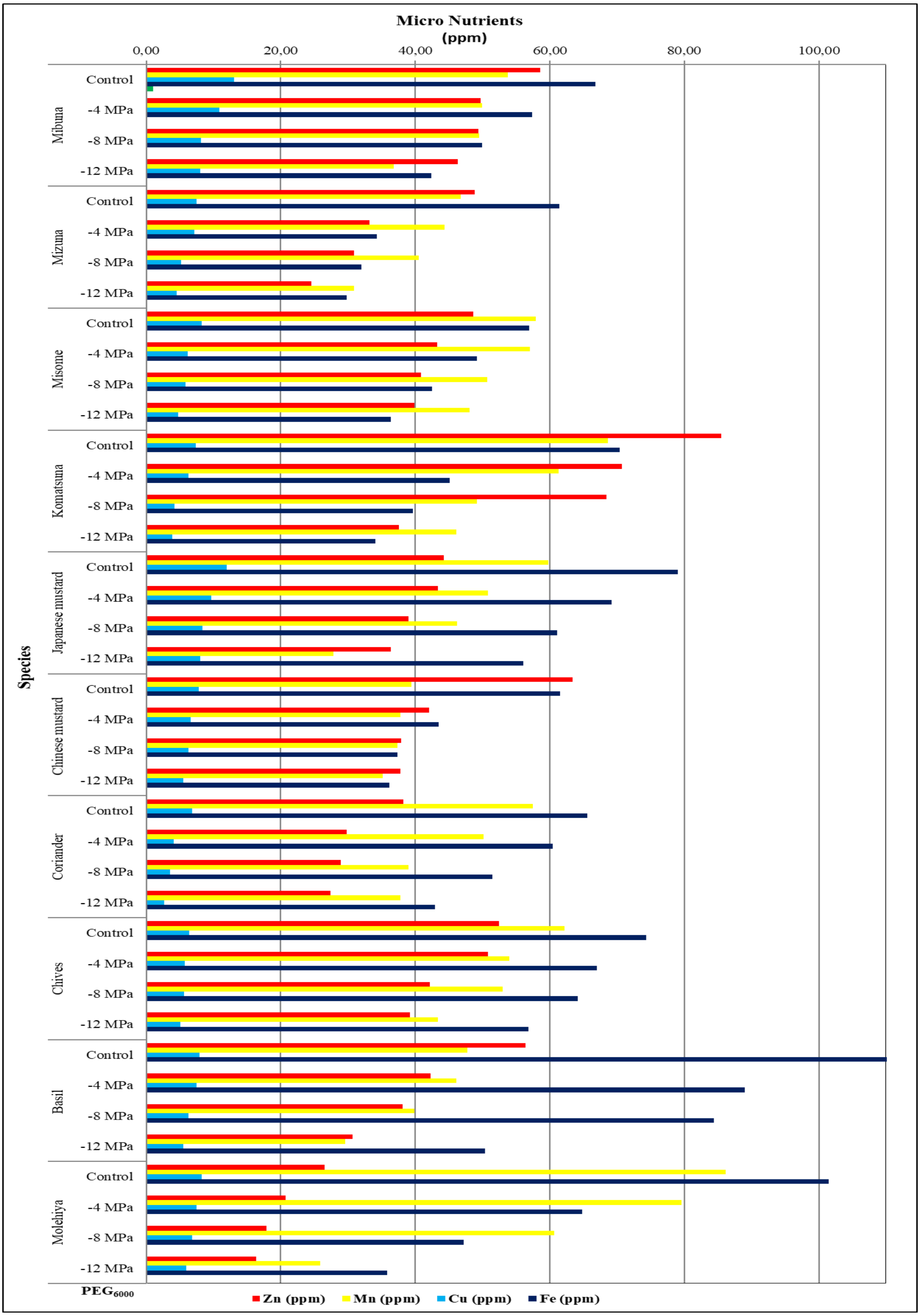

Fig. 2 The effects of different drought treatments on the micro (ppm) nutrient content of some exotic vegetable species.

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