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EFFECT OF SEASON AND SOIL CONCENTRATION ON THE UPTAKE OF MINERALS IN *Portulaca-oleracea*

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ABSTRACT

To study the effect of season and soil concentration on the uptake of minerals in *Portulaca-oleracea*, it was grown on minerals (Cr, Zn, Mn, Cu, Mg and Fe) supplemented soil both in winter and summer seasons, respectively. For this purpose a plot was prepared having 12 sub-boxes. *Portulaca-oleracea* was grown in these boxes and supplemented either with individual element or combination of elements except in box-12 for comparison. Before sowing seeds, soil samples were taken and analyzed for pH, electrical conductivity (EC), texture, organic matter, lime content ($CaCO_3$), Potassium, Phosphorus and concentrations of extractable metals (Cr, Zn, Mn, Cu, Mg and Fe). Irrigation water was also analyzed for different parameters that is pH, conductivity (EC), chloride, sulphate and extractable metals (Cr, Zn, Mn, Cu, Mg and Fe). After harvesting, vegetable samples were dried, acid digested and analyzed for Cr, Mn, Zn, Cu, Fe and Mg on Hitachi Zeeman Japan Z-8000, Atomic Absorption Spectrophotometer. Maximum concentration of Cr, Zn, Mn, Cu, Mg and Fe (54±0.50, 316±4.00, 110±1.40, 22±0.30, 23120±14and 3548±12) mg/Kg on dry weight basis in winter samples and (24±0.30, 352±2.00, 184±1.80, 36±0.30, 24840±24and 2792±22) mg/Kg on dry weight basis in summer samples were observed. From the present study it can be concluded that for enhancing chromium, magnesium and iron contents, winter season, while for zinc, manganese, copper, and magnesium summer season is best. An attempt was made to see whether it is possible to enhance the level of nutritionally and therapeutically important minerals in the same plant grown in different seasons. The study revealed that it is possible.

Keywords: *Portulaca-oleracea*, season, soil minerals concentration, minerals uptake, nutrition, therapeutic role.

INTRODUCTION

Plants are known to accumulate various chemicals from their environment (Singh, 1984 and Griffith, 2001). Humans require a suite of mineral elements in varying amounts for proper growth, health maintenance and general well-being (Linder, 1991). With a well-balanced diet that includes mixed sources of grains, fruits and vegetables, plant foods can make a significant contribution to daily mineral needs at all stages of the life cycle (Dwyer, 1991). Climate may effect the mineral concentration in plant as shown by the deficiency of Zn in cool and wet season which is associated with insufficient solubility of Zn in soil (Reuter, 1975). Metals accumulation in plant depends on plant species, growth stages, type of soil, metals, soil conditions, weather and environment (Chang, 1984 and Petruzzelli, 1989). Plants grown in heavy metal contaminated soil often show metal accumulation, particularly in root tissue and the rate of Cr uptake is dependent on several soil and plant factors (Kabata-Pendias, 2001).

The study of how plants absorb and assimilate inorganic ions is called mineral nutrition. In fact, yields of most crop plants increase linearly with the amount of fertilizer that they absorb (Loomis, 1992). The entry point of mineral elements to the biosphere is predominantly through the root systems of plants so that, in a sense, plants act as the “miners” of the earth's crust [Epstein, 1994].

Which minerals can plants absorb, and thus provide in the diet? An obvious initial list includes the 14 mineral elements defined as essential for plant growth and reproductive success (Marschner, 1995). These are N, S, P, K, Ca, Mg, Cl, Fe, Zn, Mn, Cu, B, Mo, and Ni. Because of their essentiality, all plant foods contain some level of each of these elements, and it should come as no surprise that plants have developed various forms of molecular machinery (i.e., membrane transporters) to acquire these mineral nutrients from their soil environment (Kochian, 1991 and Maathuis, 2002). Of these 14 elements, human essentiality has been confirmed for all but B and Ni, although circumstantial evidence for their essentiality has been reported (Nielsen, 1996). Na, Cr, I and Se also are required by humans, but not by plants. Fortunately for humans, however, plants can acquire these other elements through non-specific influx processes using existing transporters localized to their roots (Kabata-Pendias, 1992).

The overall uptake of these plant non-essential elements depends on their availability in the soil, in conjunction with the extent of their influx through non-specific transporters. In fact, a wide range of plant non-essential elements (both benign and detrimental) have been measured in plant tissues, with concentrations sometimes-reaching dramatic levels if soil availability is high (e.g. Cr, Se). A number of these elements also referred to as the ultra trace elements, have been demonstrated to provide various health benefits in humans (Nielsen, 1996) and thus their incorporation into plant tissues is of dietary relevance.

The most challenging aspect of providing trace elements in a plant-based material is to obtain a sufficient concentration for the supplement to be ingested without consuming large quantities of plant tissue. The use of forage crops enriched in Se from Se enriched soils to supplement the diets of animals has been proposed (Banuelos, 1997).

Minerals work in combination with each other and with other nutrients, so imbalances of any mineral can cause health problems - too little of any essential mineral can lead to deficiency diseases, and too much of any mineral can be toxic (Shils, 1999). We get essential minerals primarily through the foods we eat. Good sources of essential minerals include fruits, vegetables, meats, nuts, beans and dairy products. Unfortunately, much of the soil in which food is grown has been depleted of these nutritive minerals; therefore the mineral content in food is reduced (Wauchope, 1978 and Lappalainen, 1981). "Soil is the basis of all human life and our only hope for a healthy world. All of life will be either healthy or unhealthy according to the fertility of the soil. Minerals in the soil control the metabolism of cells in plant, animal and man. Variations in the distribution of certain minerals in the environment are known to have an effect on health (Charles, 1989). The present study was an attempt to see whether it is possible to enhance the level of nutritionally and therapeutically important minerals in vegetables to reduce their serving size.

MATERIALS AND METHODS

Preparation of soil

Before sowing seeds, the soil was cultivated to a depth of more than one foot, removed stones and broken large clods until a smooth and fine texture reached. A plot was prepared having three columns A, B, C and each row composed of three boxes (Box-A, Box-B and Box-C), which were further divided in to four rectangular sub-boxes (A-1, A-2, A-3, A-4, B-5, B-6, B-7, B-8 and C-9, C-10, C-11, C-12), respectively. Moreover, the sub-boxes from 1 to 12 represent one sample grown in these boxes (twelve samples of one vegetable) which was supplemented either with individual element or combination of elements except in box-12. The dimensions of each sub-box were; length 1.25 feet and width 1 foot. There was 1/2 foot distance between each sub-box with in the main box, while a distance of approximately 1 foot in case of main boxes. Boxes were separated with polyethylene plastic to avoid water and mineral penetration. Before sowing seeds, soil samples were taken by combination of five drills (0-15cm, 15-30cm and 30-45cm) from the corners and center of the plots. Soil samples were air dried in shade, ground with a wooden mortar and sieved through a 2mm nylon mesh size sieve. The samples were then tightly packed in polythene bags and labeled for further analysis.

Purchasing, planting and fertilizing seeds

Portulaca-oleracea seeds were planted about 1/2-inch deep in the soil. Two dozen seeds were sown 1-inch apart in three rows with eight seeds per row.

Application of fertilizer

On the basis of soil test results there was no need for K fertilizer, while P and N were required in minute quantity. For this purpose 4 gram of Diammonium phosphate (DAP) fertilizer per box was used. The fertilizer was broadcast on the surface and then watered into soil.

Application pattern of Fe, Zn, Mn, Cr, Mg, and Cu to soil

Solution of each Fe, Zn, Mn, Cr, Mg, and Cu salts was prepared. Different concentration of Fe, Mn, Cr, Mg and Cu were applied to roots of each experimental vegetable in the soil either individual element or in combination. The purpose of this supplementation was to provide the vegetable samples the soil environment with different mineral concentrations, so that their uptake in both the seasons could be evaluated.

Box-A Supplementation of elements

Sub-boxes:

A-1……………. Com-1. Cr, Cu, Mg
A-2……………. Com-2. Cr, Mn, Zn
A-3……………. Com-3. Cr, Fe, Zn
A-4……………. Com-4. Cr, Cu, Mg, Zn, Mn, Fe

Box-B

Sub-boxes:

B-5……………. Ind-5. Cr
B-6……………. Ind-6. Zn
B-7……………. Ind-7. Mg
B-8……………. Com-8. Cr, Mg, Zn

Box-C

Sub-boxes:

C-9……………. Ind-9. Cr
C-10…………… Ind-10. Zn
C-11…………… Ind-11. Mg
C-12 ………….. Sample not supplemented

Com = combination, Ind = Individual

For supplementation specified volume of these elements was taken (Table-1) in a one liter beaker, added tap water and this was then spread around 1"-2" area of roots of *Portulaca-oleracea* samples grown in different sub boxes except box-C-12. The samples in winter and summer seasons were supplemented after 10 and 13 days respectively. The beaker was rinsed many times with approximately three liters more water to ensure the complete transfer of elements. The soil was not watered for a week prior this application, so that proper penetration of the mineral solution in the soil could be achieved. *Portulaca-oleracea* grown in winter was harvested after 42 days and in summer after 35 days.

Table-1. Amount of Fe, Zn, Mn, Cr, Mg, and Cu taken for application to experimental plants.

Element	**Concentration of element per milliliter of 0.1 M solution** (mg/ml)	**Volume taken of 0.1 molar solution** (ml)	**Volume taken containing total concentration** (mg) **of element**
Fe	5.585	10	55.85mg
Zn	6.537	25	163.425mg
Mn	5.494	10	54.94 mg
Cr	5.2	6	31.2 mg
Mg	6.354	5	38.124 mg
Cu	2.430	50	121.5 mg

Watering plants

In winter, *Portulaca-oleracea* was watered 14 liters per sub-box once a week and in summer twice a week that is 20 liters per week. The water was applied very slowly through bucket in intervals to prevent water runoff from the box and to ensure maximum penetration.

Care throughout growing period

To protect the plants from any rain water, a wooden frame was constructed on the plot to cover with polyethylene plastic in case of rain.

Harvesting

After harvesting vegetable samples were brought to the laboratory and washed with tape water to remove the soil followed three times with distilled water. Samples were cut into small pieces with plastic knife before oven drying at 70^0C until the weight became stable. Samples were then ground with mortar and 0.5g of each sample was wet digested with HNO_3: $HClO_4$ (2:1) for 2-3 hrs on heating mantle (A O. A. C. 1984). Digested samples were filtered through 0.45 µm pore size Millipore filter and volume was made to 100 ml with distilled water. Minerals concentration was determined on Hitachi Zeeman Japan Z-8000, Atomic Absorption Spectrophotometer equipped with standard hallow cathode lamps as radiation source and air acetylene flames was used for absorption measurement of elements. The elements analyzed were Cr, Mn, Zn, Cu and Fe and Mg.

Soil analysis

Soil samples were analyzed for soil pH, electrical conductivity (EC), texture, organic matter, lime content ($CaCO_3$), potassium, phosphorus and extractable metals. The pH and EC of the soil samples were determined in 1:1 soil and water suspension by pH meter and conductivity meter respectively at 25^0C (Richard, 1960). Texture was determined by Bouyoucos Hydrometer method using Na_2CO_3 as dispersing agent (Kochler, 1984) Organic matter by Walkly and Black method as described by Jackson (Jackson, 1958) Lime content ($CaCO_3$) by the acid neutralization method according to Black [Black, 1965] Potassium (K) by Flame Photometer, phosphorous (P) by rapid and sensitive colorimetric method using spectrophotometer. DTPA-Extractable minerals in each soil sample were estimated with the help of Atomic Absorption Spectrophotometer Model Hitachi Polarized Z-8000 Japan by using NH_4HCO_3-DTPA extracting solution. 20 ml NH_4HCO_3-DTPA (diethylene triamine penta acetic acid) extracting solution was added to exactly 10g weighed air dried soil sample and shaken for 15 minutes. After shaking, the suspension was filtered through whatman filter paper No. 42. The filtrate was then analyzed for extractable, Cu, Fe, Zn, Cr, Mg, and Mn (Halvin, 1981).

Water analysis

Tap water used for irrigation purpose was analyzed only for: pH, electrical conductivity (EC), chloride as Cl^{-1}, sulphate as SO^-_4, and minerals by Atomic Absorption Spectrophotometer (A P. H. A, 1998).

Fertilizers and minerals salts applied [Alam, 2001]

Diammonium Phosphate $(NH_4)_2$ HPO_4, Ferrous Sulfate (Sigma) (Fe $SO_4.7H_2O$), Zinc Sulfate (Merck) extra pure(Zn $SO_4.7H_2O$), Manganese Sulphate (Sigma) (Mn $SO_4.H_2O$), Chromium (III)-chloride pure crystal RieDel-De-Haen AG. Seelze-Hannover) [$CrCl_2$ $(H_2O)_4$] Cl. $2H_2O$, Magnesium Sulfate (Merck) extra pure Mg SO_4. $7H_2O$ and Copper Sulfate (Sigma) Cu $SO_4.5H_2O$.

RESULTS AND DISCUSSIONS

The chemical analysis and minerals results of soil and water are given in Table-2 to 5.

Soil

The result of the soil texture revealed that it was mainly clay-loam. The results obtained for organic matter of different depths; 0.92% (0-15cm); 1.19% (15-30cm) and 1.18% (30-45cm) in which the top soil was having less organic matter than the mid and bottom depths. In case the soil test value for organic matter is above 1.00%, then 60kg/ha nitrogen (N) is recommended (Rehman, 2001).

Phosphorus results obtained for different depths were in the order of; 7.23 mg/Kg (0-15cm); 6.66 mg/Kg (15-30cm) and 6.32 mg/Kg (30-45cm) with an average of 6.74 mg/Kg. Likewise, potassium results for different depths were; 208 mg/Kg (0-15cm); 192 mg/Kg (15-30cm) and 185 mg/Kg (30-45cm) with an average of 195 mg/Kg.

If the soil's test Phosphorus (P) level is 5-10 mg/Kg then phosphorus (P_2O_5) 60kg/ha is recommended. Similarly if the soil test potassium (K) level is above 150 then no K_2O is required (Rehman, 2001).

The lime content ($CaCO_3$) at different depths found was: 12.66% (0-15cm); 13.33 % (15-30 cm) and 13.45% (30-45 cm) with an average of (13.15%). The lime content at different depths was almost the same. Generally the lime content of NWFP soils ranges 3.85 to 24.2 % (Bhatti, 1997), pH of soil at different depth level was; 7.4 (0-15cm); 7.3 (15-30cm) and 7.3 (30-45cm), with an average of pH 7.3, which is considered as neutral or slightly alkaline. In acidic soil Cd, Hg, Ni and Zn are relatively mobile while As, Be and Cr are moderately mobile and Cu, Pb and Se are slowly mobile (Fulter, 1977).

The electrical conductivity (EC) at different depths was in the order of 0.10 dsm^{-1} (0-15cm); 0.11 dsm^{-1} (15-30cm) and 0.11 dsm^{-1}(30-45cm) whereas the average EC was 0.12 dsm^{-1}. The electrical conductivity is the same in all the three depths showing the uniformity of free cations and anions like Na^+, K^+, Cl^{-1}, NO_2^{-1} etc. The soil is non-saline and such soils present no harm to agricultural crops (Maas, 1986).

The concentrations of Cr, Zn, Mn, Cu, Mg and Fe found in soil on dry weight basis at different depths were: 2.42±0.01, 5±0.02, 20.69±0.20, 6.90±0.04, 35.30±0.35 and 39.00±0.40 mg/kg at (0-15cm) 2.40±0.01, 4.26±0.01, 19.54±0.15, 5.40±0.01, 33.82±0.20 and 38.92±0.30 mg/kg at (15-30 cm); 2.44±0.02, 4.50±0.03, 19.37±0.12, 5.20±0.01, 32.86±0.15 and 38.46±0.25 mg/Kg at (30-45cm). (Table-4) Thus the soil was adequate in Cu, Fe, Mn, and Zn in terms of their concentrations for agricultural crops (Halvin, 1981).

Water

As pH of the water determined (7.2) was almost same that of soil pH 7.3, hence pose no effect to the soil pH (Table-3). The electrical conductivity (EC) of the water determined was 0.38 dS/m. It was different to EC of soil which is mainly due to the number of free cations and anions like Na^+, K^+, Cl^{-1}, NO_2^{-1} etc. The chloride content of the water was; 31.14 mg/L. This is quite low. Crops are sensitive to high chloride contents. For chlorides there is a maximum limit of (100 mg/L) for irrigation water and above this limit is dangerous for crops. The amount of sulphate was 30.19 mg/L. where as the recommended limit for sulphate is (250 mg/L) (USEPA, 1985).

Table-2. Chemical analysis of soil.

Soil sample depth	Textural class			Lime content $CaCO_3$ %	Organic matter %	P (mg/Kg)	K (mg/Kg)	pH	EC dS/m
	Clay %	Silt %	Sand %						
(0-15cm)	28.8	32.0	39.2	12.66	0.92	7.23	208	7.4	0.10
(15-30 cm)	28.8	28.0	43.2	13.33	1.19	6.66	192	7.3	0.11
(30-45 cm)	28.0	28.4	43.6	13.45	1.18	6.32	185	7.3	0.11
(0-45cm) average	28.53	29.46	42	13.15	1.10	6.74	195	7.3	0.12

Table-3. Chemical analysis of water.

Sample	pH	Electrical conductivity dS/m	Chloride as Cl^{-1} (mg/L)	Sulphate as SO^-_4 (mg/L)	Potassium as K^+ (mg/L)
Water	7.2	0.38	31.14	30.19	3.2

Table-4. Minerals in soil (mg/Kg) dry weight basis.

Soil sample	Cr	Zn	Mn	Cu	Mg	Fe
Depth (0-15cm)	2.42±0.01*	5.00±0.02	20.69±0.20	6.90±0.04	35.30±0.35	39.00±0.40
Depth (15-30 cm)	2.40±0.01	4.26±0.01	19.54±0.15	5.40±0.01	33.82±0.20	38.92±0.30
Depth (30-45 cm)	2.44±0.02	4.50±0.03	19.37±0.12	5.20±0.01	32.86±0.15	38.46±0.25

*Average of triplicate determination ±S.D (Standard Deviation)

Table-5. Minerals in Water (mg/L).

Sample	Cr	Zn	Mn	Cu	Mg	Fe
Water	0.06±0.00*	0.07±0.01	0.02±0.00	0.05±0.00	21.81±0.07	2.39±0.02

*Average of triplicate determination ±S.D (Standard Deviation)

***Portulaca-oleracea* (Pot purslane): winter**

The concentration of Cr, Zn, Mn, Cu, Mg and Fe in control samples observed was (14±0.15, 88±0.90, 90±1.00, 14±0.10, 13660±18, and 2864±38 with a maximum concentration of Cr, Zn, Mn, Cu, Mg and Fe (54±0.50, 316±4.00, 110±1.40, 22±0.30, 23120±14and 3548±12) mg/Kg on dry weight basis in sub-boxes (B-8), (B-8), (A-4), (A-1),(B-6) and (A-4), respectively. The total increase of Cr, Zn, Mn, Cu, Mg and Fe recorded was (40, 228, 20, 8, 9460 and 684) mg/Kg dry weight basis. While in sub-boxes (B-6), (C-11), (C-11), (C-10), (A-2) and (C-11) minimum concentration of Cr, Zn, Mn, Cu, Mg and Fe (12±0.10, 78±0.70, 66±0.40, 12±0.10, 12680±14 and 1802±18 with total decrease of 2,10, 24, 2, 980 and 1062) mg/Kg dry weight basis was observed. (Table-6).

Table-6. Concentration of Cr, Zn, Mn, Cu, Mg and Fe (mg/Kg) dry weight basis portulaca-*oleracea.* (Winter).

Sub-boxes samples	**Concentration** (mg/Kg) **dry weight basis**					
	Cr	**Zn**	**Mn**	**Cu**	**Mg**	**Fe**
A-1	22±0.35*	86±0.70	84±0.80	22±0.30	12760±12	2824±48
A-2	18±0.13	180±1.80	100±1.20	16±0.16	12680±14	2640±16
A-3	16±0.15	194±3.00	90±0.90	16±0.15	14640±14	2946±26
A-4	20±0.30	160±1.60	110±1.40	20±0.14	14280±28	3548±12
B-5	34±0.21	84±0.80	88±0.70	16±0.14	15840±18	2604±26
B-6	12±0.10	250±3.00	92±0.80	16±0.15	23120±14	2606±30
B-7	18±0.14	100±1.00	88±0.60	16±0.14	20860±52	2626±12
B-8	54±0.50	316±4.00	92±0.80	18±0.15	15340±26	2840±22
C-9	36±0.25	80±0.80	84±0.50	14±0.10	13740±16	2478±60
C-10	16±0.17	190±2.00	90±1.00	12±0.10	13480±12	2852±10
C-11	16±0.17	78±0.70	66±0.40	18±0.15	12880±22	1802±18
C-12	14±0.15	88±0.90	90±1.00	14±0.10	13660±18	2864±38

*Average of triplicate determination Mean ± S. D (Standard Deviation)
C-12= Sample not supplemented with minerals

Portulaca-oleracea (Pot purslane): summer

The concentration of Cr, Zn, Mn, Cu, Mg and Fe in control samples observed was (12±0.14, 290±4.00, 158±1.80, 16±0.15, 24180±28, and 2768±40 with a maximum concentration of Cr, Zn, Mn, Cu, Mg and Fe (24±0.30, 352±2.00, 184±1.80, 36±0.30, 24840±24and 2792±22) mg/Kg on dry weight basis in sub-boxes (B-5), (B-6), (A-2), (A-1),(A-1) and (A-4), respectively. The total increase of Cr, Zn, Mn, Cu, Mg and Fe recorded was (12, 62, 26, 20, 660 and 24) mg/Kg dry weight basis. While in sub-boxes (B-6), (A-1), (B-6), (A-2), (B-7) and (B-8) minimum concentration of Cr, Zn, Mn, Cu, Mg and Fe (10±0.08, 142±1.20, 112±1.15, 10±0.08, 15560±36 and 2208±46 with total decrease of 2, 148, 46, 6, 8620 and 560) mg/Kg dry weight basis was observed. (Table-7).

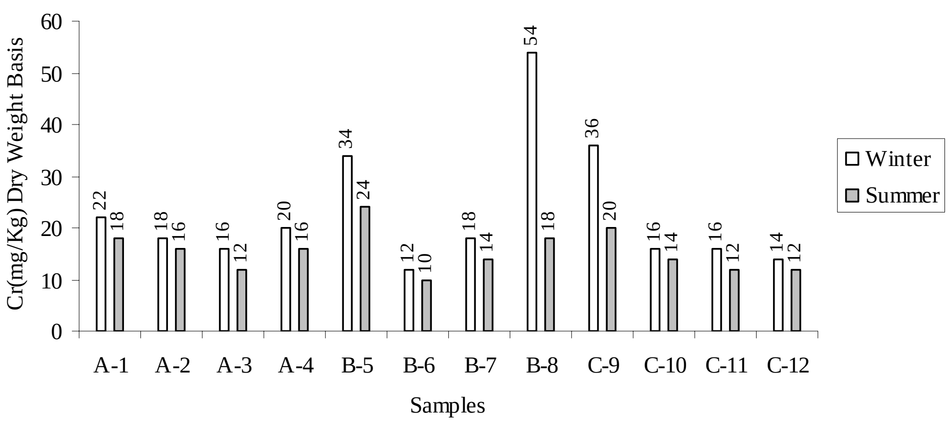
Table-7. Concentration of Cr, Zn, Mn, Cu, Mg and Fe (mg/Kg) dry weight basis *portulaca-oleracea.* (Summer).

Sub-boxes samples	**Concentration** (mg/Kg) **dry weight basis**					
	Cr	**Zn**	**Mn**	**Cu**	**Mg**	**Fe**
A-1	18±0.20*	142±1.20	140±1.20	36±0.30	24840±24	2620±26
A-2	16±0.18	318±2.00	184±1.80	10±0.08	21120±10	2650±32
A-3	12±0.14	306±4.00	156±1.50	18±0.18	23620±26	2420±18
A-4	16±0.17	314±2.00	172±1.60	34±0.25	20620±18	2792±22
B-5	24±0.30	236±2.00	142±1.20	18±0.18	20900±22	2228±42
B-6	10±0.08	352±2.00	112±1.15	18±0.18	19640±16	2662±12
B-7	14±0.15	284±4.00	158±1.70	16±0.14	15560±36	2712±32
B-8	18±0.19	334±4.00	158±1.80	18±0.18	24440±22	2208±46
C-9	20±0.26	232±2.00	154±1.40	16±0.15	21660±18	2268±12
C-10	14±0.15	346±2.00	150±1.20	14±0.12	23660±18	2600±36
C-11	12±0.14	280±4.00	134±1.10	16±0.15	22760±16	2242±12
C-12	12±0.14	290±4.00	158±1.80	16±0.15	24180±28	2768±40

*Average of triplicate determination Mean ± S.D (Standard Deviation)
C-12= Sample not supplemented with minerals

As shown in Figure-1 both to the winter and summer season samples chromium was applied in the form of combinations (1, 2, 3, 4, 8) and individually (5, 9). In case of winter season increase in chromium content was observed in all samples with marked increase in sample B-8 (54±0.50 mg/Kg). Only decrease was observed in sample B-6 (12±0.10 mg/Kg). Chromium content was increased where magnesium and zinc were applied alone. While in case of summer season increase in chromium content was occurred in all samples with a marked increase in sample B-5 (24±0.30 mg/Kg). Chromium content was decreased in sample B-6 (10±0.08 mg/Kg) and increased in sample C-10 (14±0.15 mg/Kg) due to zinc supplementation. Similarly, in case of magnesium supplementation increase occurred in sample B-7 (14±0.15 mg/Kg) with no change in sample C-11 (12±0.14 mg/Kg). The chromium uptake by plants has been found to be positively correlated to chromium application by many workers (Kick, 1977, Zlatareva, 1999, Tang, 2001, Samantaray, 2001and Zurayk, 2001).

Fig: 1Concentration of Cr (mg/Kg) Dry Weight Basis *(Portulaca-oleracea)*



As shown in Figure-2 both to the winter and summer season samples, zinc was applied in the form of combinations (2, 3, 4, 8) and individually (6, 10). In case of winter season, zinc content was increased in all sub-boxes with significant increase in sample B-8 (316±4.00 mg/Kg). Zinc content was decreased where magnesium and chromium were applied alone. While in case of summer season, zinc content was increased in all samples with marked increase in sample B-6 (352±2.00 mg/Kg). Zinc content decreased where magnesium and chromium

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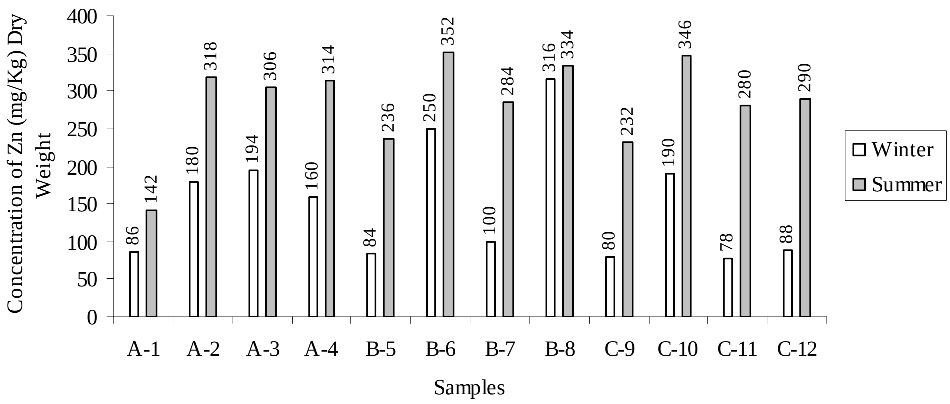
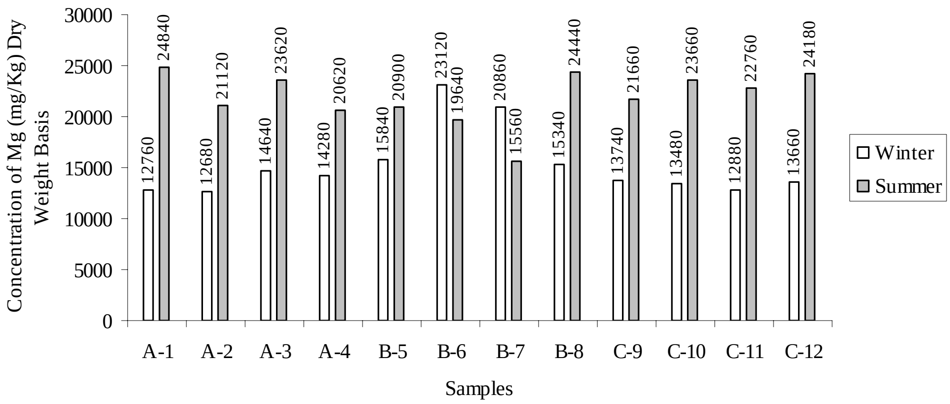
were applied alone and also in sample A-1 142±1.20 mg/Kg). Zinc concentration in wheat grown with the aid of Zn-containing fertilizers was about twice that of wheat grown on the same soils with out Zn applications (Hambidge, 1986).

Fig: 2 Concentration of Zn (mg/Kg) Dry Weight Basis *(Portulaca-oleracea)*



As shown in Figure-3 both to the winter and summer season samples magnesium was applied in the form of combinations (1, 4, 8) and individually (7, 11). In case of winter season samples magnesium concentration was decreased in samples A-1 (12760±12mg/Kg) and C-11 (12880±22mg/Kg), while increased in other samples. Marked increase was occurred in sample B-6 (23120±14 mg/Kg) where zinc was supplemented. While in case of summer season, magnesium concentration was increased only in samples A-1 (24840±24 mg/Kg) and B-8 (24440±22 mg/Kg). Marked increase occurred in sample A-1 (24840±24 mg/Kg). The concentration was decreased in samples supplemented with chromium and zinc. Magnesium concentration generally decline as the plant matures (Allcroft, 1954).

Fig: 3 Concentration of Mg (mg/Kg) Dry Weight Basis *(Portulaca-oleracea)*



As shown in Figures (4, 5 and 6) copper, manganese and iron were applied in combinations (1, 4), (2, 4) and (3, 4) respectively. In case of winter season samples, increase in concentration of copper, manganese and iron was occurred in all samples with significant increase in A-1 (22±0.30 mg/Kg), A-4 (110±1.40 mg/Kg) and A-4 (3548±12 mg/Kg) respectively. While in case of summer season, increase in concentration of copper and manganese was occurred in all samples with significant increase in sample A-1 (36±0.30mg/Kg) and A-2 (184±1.80 mg/Kg), respectively. Iron content was decreased in sample A-3 (2420±18 mg/Kg) and increased in sample A-4 (2792±22 mg/Kg). The application of Cu-containing fertilizers to soils low in plant-available-Cu invariably increases the Cu concentration in the herbage and often increases yield [Underwood, 1981]. Copper and zinc are mutually competitive as well as competitive to other micronutrients at the carrier sites for plant root uptake (Tisdale, 1985).

Fig: 4 Concentration Cu (mg/Kg) Dry Weight Basis *(Portulaca-oleracea)*

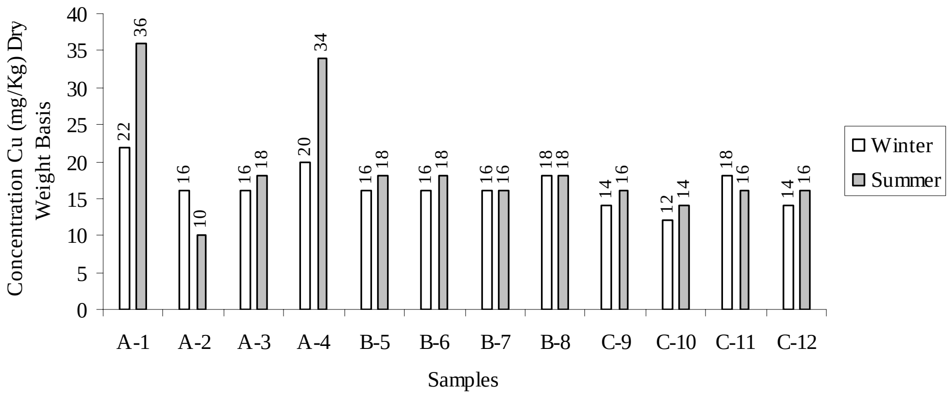


Fig: 5 Concentration of Mn (mg/Kg) Dry Weight Basis *(Portulaca-oleracea)*

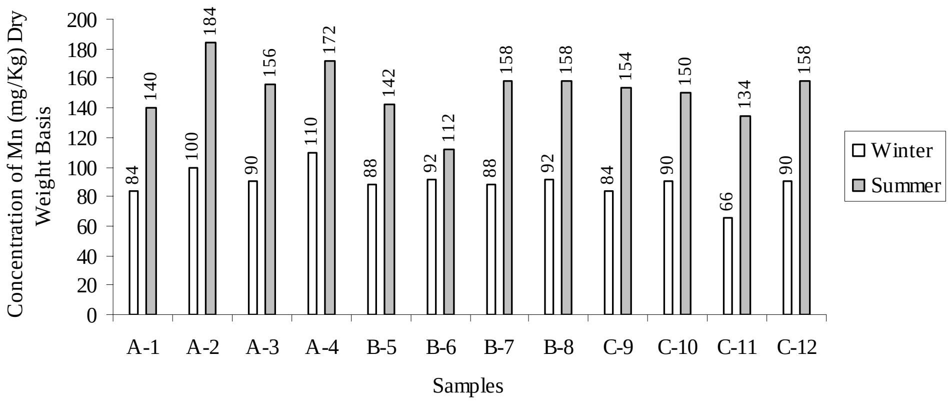
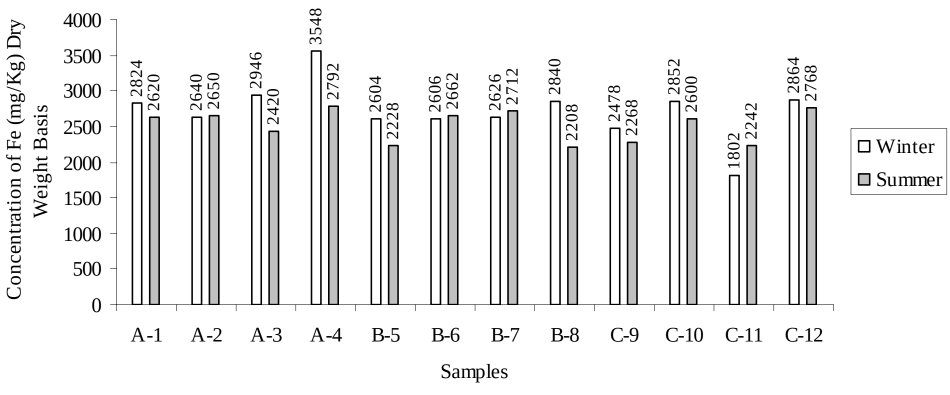


Fig: 6 Concentration of Fe (mg/Kg) Dry Weight Basis *(Portulaca-oleracea)*



CONCLUSIONS

Thus comparing control results of *Portulaca-oleracea* it can be concluded, that chromium and iron content was higher in winter samples, while Zn, Mn, Cu and Mg content was higher in summer samples. Enhancement of chromium and iron content is also greater in winter than summer season. Another important finding is significant increase in zinc, magnesium and iron contents after supplementation. Zinc, manganese, copper, and magnesium content were increased in all summer vegetables. The results suggest that for enhancing chromium, magnesium and iron contents, winter season is best. Similarly, for zinc, manganese, copper, and magnesium summer season is best. From the present study it revealed that seasons have important effect on plant minerals absorption. By changing the soil minerals environment the uptake of required mineral content of vegetables, perhaps could be enhanced. Thus vegetables can be enriched with selected minerals of nutritional and therapeutic importance through their roots. This will reduce serving size of vegetables and increase dietary intake of these minerals.

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