African Journal of Biotechnology Vol. 11(46), pp. 10494-10503, 7 June, 2012
Available online at http://www.academicjournals.org/AJB
DOI:10.5897/AJB10.2357
ISSN 1684–5315 © 2012 Academic Journals

Full Length Research Paper

Influence of urea application on growth, yield and mineral uptake in two corn (*Zea mays* L.) cultivars

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Accepted 25 November, 2011

A pot experiment was conducted in a wire netting green house in order to assess the beneficial effect of urea on corn cultivars (C-20 and C-79) differing in yield production. Corn plants were grown in loam soil with alkaline in reaction. Application of varying urea levels did not change the physico-chemical properties of soil. Four weeks-old corn plants were subjected to varying levels of urea (0, 50, 100, 175 and 225 kg/ha urea) for 8 (mid-season harvest) and 15 weeks (final harvest). After which, plants growth, yield and mineral nutrient status of the two corn cultivars were assessed for both mid-season and final harvest. It was observed that cv. C-20 showed higher (P<0.1) growth and yield. Addition of varying levels of urea enhanced the growth and yield of both the corn cultivars. However, 175 kg urea /ha was found to be more effective (P<0.1) in enhancing growth and yield of both the cultivars. The rate of urea application at a rate of 175 kg/ha had greater beneficial effect on cv. C-20 due to improved mineral nutrient (N, P, K, Cu, Fe, Mn and Zn) status of the cultivar.

Key words: Corn cultivars, fertilizer treatment, urea, mineral nutrition, plant growth.

INTRODUCTION

Corn (*Zea mays* L.) is grown as a cash crop, ranking third after wheat and rice in Pakistan and is mainly used (60 %) for feeding livestock. Pakistan grows about 0.97 million hectare of corn with total annual production of 1.73 million tons. An average yield of 1790 kg/ha is obtained (Government of Pakistan, 2003), which is much lower than other developing countries of the world. The continuous cultivation of crops and the adverse environmental factors make the arable soil deficient in nitrogen (N) along with other plant nutrients.

Nitrogen alters plant composition much more than any other mineral nutrient as it is an indispensable elementary constituent of many organic metabolites including amino acids, proteins, nucleic acids, and phytochromes (Marschner, 1995; Mengal and Kirkby, 1987). Thus, N is the motor of plant growth and makes up1 to 4% of dry matter of the plants (Taize and Zeiger, 2010). It is widely accepted that crops grown on soils deficient in N, exhibit very distinctive N-deficiency symptoms such as poor growth, chlorosis, necrosis and causes disorder in many physiological/biochemical characteristics of plants (Epstein and Bloom, 2004; Taize and Zeiger, 2010). The use of N-fertilizers along with other nutrients has been suggested to enhance the crop productivity (Marschner, 1995). According to an estimate, 33% N-fertilizers are being used worldwide for improving cereal production (Raun and Johnson, 1999).

Of the various N-fertilizers, urea (46% N) is widely used in the agricultural sector. The primary objective of the study was to assess the effect of urea application on the growth enhancement in two corn cultivars via changes in mineral nutrient status.

MATERIALS AND METHODS

A pot experiment was conducted in a wire netting green house at Bahauddin Zakariya University, Multan, Pakistan. Seeds of two cultivars of *Zea mays* L. (C-20 and C-79) were sown in earthen pots (28 × 18 cm) filled with 20 kg garden compost Seeds were obtained

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Table 1. ANOVA for various growth parameters of two corn cultivars (C-20 and C-79).

SOV	df	Mean Square					
		Shoot fresh weight (g/plant)	**Shoot dry weight (g/plant)**	**Root fresh weight (g/plant)**	**Root dry weight (g/plant)**	**Shoot length (cm/plant)**	**Root length (cm/plant)**
C	1	2707.5***	456.30***	853.3ns	4.033ns	288.3ns	0.833^{ns}
F	4	3775.0***	740.70***	1544.6ns	462.1***	2082.0***	84.45^{ns}
c*f	4	361.7***	20.63***	313.8ns	184.2**	549.1^{ns}	257.5^{ns}
Error	20	47.5	11.37	902.5	59.06	307.3	310.06
Total	29						

SOV	df	Mean Square				
		Fresh wt. of kernels/cob	**Dry wt. of kernels/cob**	**No. of cob/plant**	**No. of kernels/cob**	**Leaf area (cm^2/plant)**
C	1	1333.0***	1584.10***	0.533^{ns}	924.07^{ns}	067584.6^{ns}
F	4	3532.8***	18685.2***	0.583^{ns}	46627.2***	432902.5^{ns}
cxf	4	208.0^{ns}	82.1000^{ns}	0.283^{ns}	2016.49^{ns}	1276997.3^{ns}
Error	20	120	50.9000	0.633	10450.55	1408755.9
Total	29					

*,**,***Significant at 0.05,0.01, and 0.1 levels, respectively; ns = non-significant. C = cultivars; F = fertilizers

from Ayub Agriculture Research Institute, Faisalabad, Pakistan. The plants were thinned to one plant per pot after a week. The pots were arranged in a complete randomized manner with six repli-cates. Two weeks old plants were subjected to different levels of urea (46% N). Five levels of urea (0, 50, 100, 175 and 225 kg/ha) with constant (150 kg/ha) TSP (46% P_2O_5) and SOP (50% K_2O) were applied in two steps half dose at the seedling stage and the remaining half was supplied at vegetative stage (6 weeks) at constant (100 kg/ha) sulfate of potash (SOP) and triple super phosphate (TSP).

Half of the plants were harvested after 8 weeks and the final harvest was taken after 15 weeks. Fresh weight of shoots and roots was recorded. Dry weight was taken after drying plants in an oven at 80°C for 48 h. Data for different growth (shoot fresh and dry weight, root fresh and dry weight, shoot length, root length and leaf area) and yield attributes (kernel yield, number of kernels/cob) were recorded.

Determination of mineral elements in plant tissues

Potassium ion (K^+) content in the leaves and roots were determined by the methods described by Allen et al. (1986). 1 g of ground dry plant samples were digested in 2 ml of sulfuric-peroxide digestion mixture until a clear and almost colorless solution was obtained. After digestion, the volume of the sample was made up to 100 ml with distilled de-ionized water. Potassium ions ($K^{+)}$ were determined with a flame photometer (Jenway PFP7) and N by titration method following Allen et al. (1986). Phosphorous in leaves, shoots and roots were determined following the method of Jackson et al. (1962). Cu^{2+}, Fe^{2+}, Mn^{2+} and Zn^{2+} were measured in the plant di-gests using atomic absorption spectrometer (Perkin Elmer, Analyst 100, USA). In addition, nutrient status of soil was also determined. Data were subjected to a two-way analysis of variance using CoStat version 6.3 and means were compared using LSD following Snedecor and Cochran (1980).

RESULTS

Analysis of variance of the data for fresh and dry weight of shoots of corn cultivars is presented in Table 1. It was observed that the addition of nitrogen in the form of urea increased (P<0.1) the fresh and dry weights of shoots and roots of both the corn cultivars, particularly at 175 kg/ha (Figure 1). However, this increased was not observed in fresh weight of roots and leaf area (Figures 1 and 2). Number of cob/plant and number of kernel /cob were also increased (P<0.1) by the application of N fertilization. Maximum increase (P<0.1) in these yield attributes was recorded at 175 kg/ha urea concentration (Figure 2). In addition, increase in yield due to different levels of urea was more in cv. C-20 as compared to cv. C-79. Moreover, urea-N treated plants showed significantly (P<0.1) greater N accumulation in different plant parts of both corn cultivars as compared to control (Table 2; Figure 3). The results of cv. C-20 showed more N accumulation in leaves and kernels than in cv. C-79. Accumu-lation of P in kernels increased with increasing level of urea (Figure 3). The K accumulation in kernels was maximum at 175 kg/ha urea

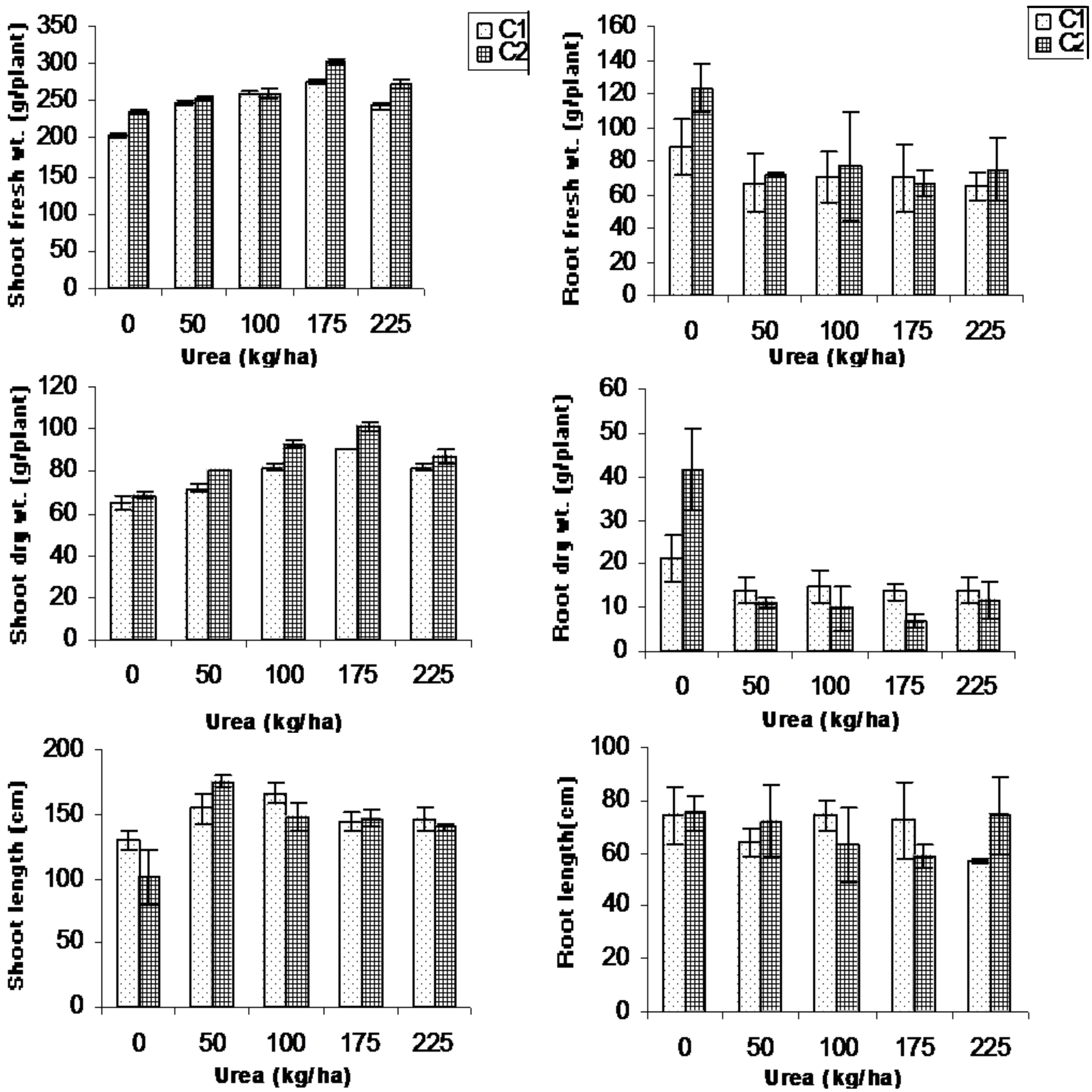

Figure 1. Mean values of fresh and dry root weight (g/plant) and shoot and root length (cm) of two corn cultivars C-20 and C-79. Values are given as mean ± S.E; n = 5; C1= C-20; C2= C-79.

(Figure 4). Cultivar cv. C-20 showed greater P and K accumulation in kernels.

Copper (Cu), manganese (Mn) and zinc (Zn) accumulation in kernels significantly increased in different plant parts due to the addition of urea (100, 175 and 225 kg/ha) in both cultivars (C-20 and C-79). Fe in leaves increased significantly due to increasing levels of urea. Higher concentrations of Fe were observed at 175 and 225 kg/ha urea. Mn accumulation in leaves, stem and kernels was increased at all levels of urea in both the cultivars of corn. Maximum Zn accumulation in leaves, stem, roots and kernels also occurred at 50 and 100 kg/ha urea.

DISCUSSION

The demographic development and the depleting natural resources in Asia make it mandatory to increase the agricultural productivity of land (Chrispeels and Sadava, 2003). Use of urea as N-fertilizer is one of the options

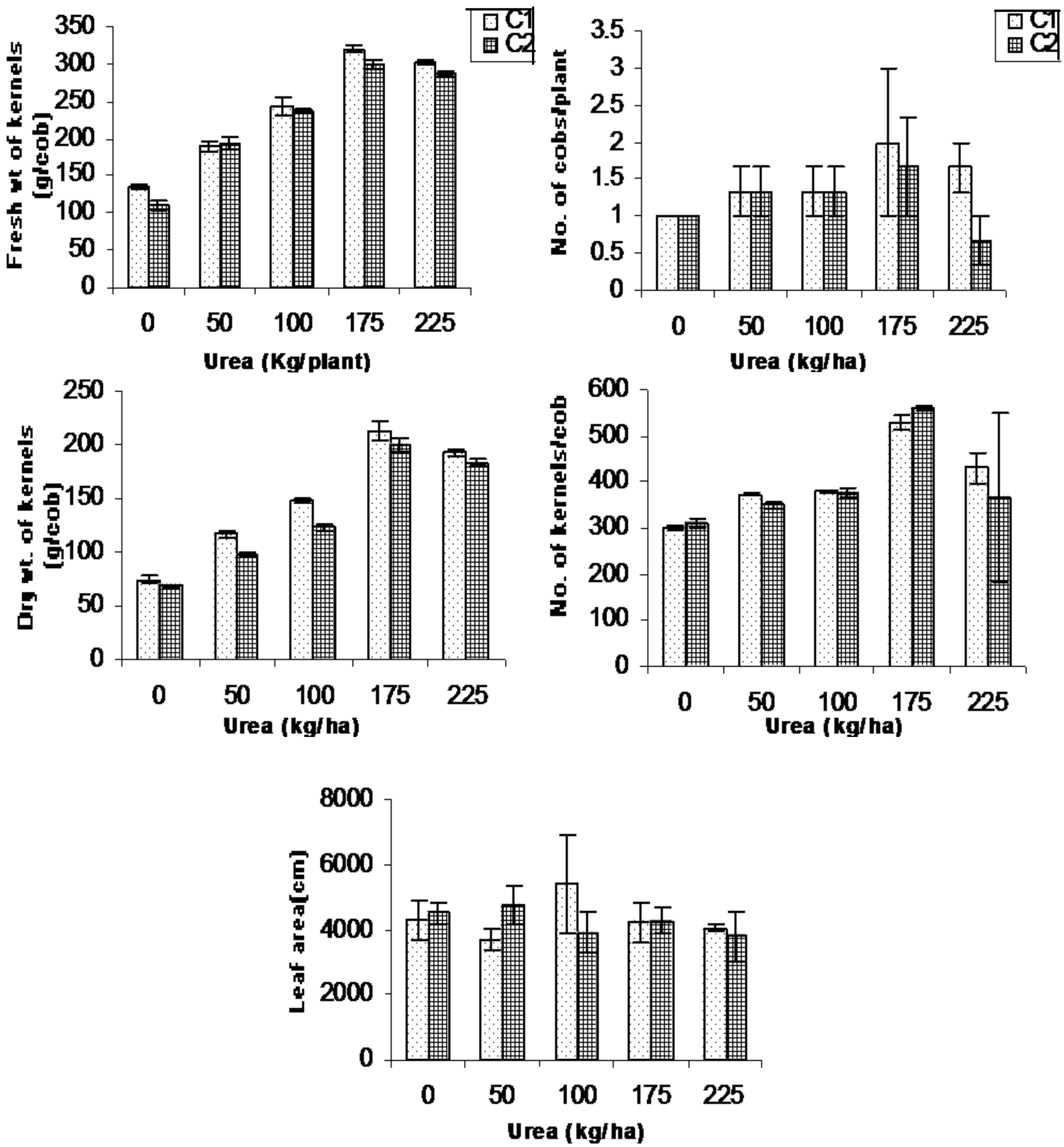

Figure 2. Mean values of yield components and leaf area (cm^2) of two corn cultivars C-20 and C-79. Values are given as mean ± S.E; n = 5; C1= C-20; C2= C-79.

that can increase crop yield. In the present study, it was found that growth and yield of both the corn cultivars increased with increasing application of urea fertilizers. These results were similar to Ashraf and Rehman (1999) who reported that increasing supply of N improved growth of corn. Ashraf et al. (2002) while assessing the effects of sub- and supra-optimal N regimes on wheat. It was also found that the dry matter production of wheat increased by increasing nitrogen levels. Khalid et al. (2003) working with rice, reported that plant growth was improved when

Table 2. ANOVA for mineral nutrients of two corn cultivars (C-20 and C-79).

SOV	df	Mean Squares			
		%N in leaves	**%N in stem**	**%N in roots**	**%N in kernels**
C	1	0.232***	0.151***	1.109***	0.517***
F	4	0.165***	0.214***	0.208***	0.108**
cxf	4	0.001*	0.005***	0.009***	0.022^{ns}
Error	20	7.2×10^{-4}	$2.4^{e-4<-}$	$2.133^{e-4<-}$	0.02116
Total	29				
SOV	**df**	**%P in leaves**	**%P in stem**	**%P in roots**	**%P in kernels**
C	1	0.001***	0.015***	0.006***	0.011***
F	4	0.019***	0.011***	0.009***	0.013***
cxf	4	0.001***	1.95e-4*	0.001***	2.717*
Error	20	$8.6667^{e-5<-}$	$8^{e-5<-}$	$7.333^{e-5<-}$	$7.3333^{<-}$
Total	29				
SOV	**df**	**%K in leaves**	**%K in stem**	**%K in roots**	**%K in kernels**
C	1	0.239***	0.097***	0.005*	0.190***
F	4	0.115***	0.035***	0.034***	0.032***
cxf	4	5.383^{ns}	0.002^{ns}	0.004**	0.009***
Error	20	9.6333	$0.002^{<-}$	$0.0012^{<-}$	$5^{e-5<-}$
Total	29				

*,**,***Significant at 0.05,0.01, and 0.1 levels, respectively; ns, non-significant; C= cultivars; F= fertilizers.

urea (N), potassium (K) and phosphorus (P) fertilizers were used. Robson and Deacon (1978) and Gastal and Saugier (1986) showed that urea application increases the leaf area of plants and canopies to greater extent than leaf and canopy photosynthesis. The relationship between N and leaf area index (LAI) depends on the pattern of biomass and N allocation to either photosynthetic leaf tissues or supporting structural tissues (stems), which is associated with differences in the intrinsic morphology of crops or genotypes. It is interesting to note that root growth was inhibited almost at all levels of urea application, which can be explained in view of Klemm (1966) who suggested that trade of photo-assimilates between shoots and roots is one of adaptive strategy in plants. Thus, in the present study, reduced root growth at higher urea application might have caused growth promotion of shoots.

In this study, yield components (number of kernels/cob, number of cobs/plant, fresh and dry weight of kernels/cob) showed a greater increase up to 175 kg/ha urea. The present results are in agreement with the findings of several workers who reported similar results for a variety of plants. Agba and Long (2005) found that nitrogen produced the best corn grain yield of 2.43 and 2.96 tons/ha by use of 210 kg/ha urea. However, Khan et al. (2005) while working with sugarcane found that 200 N kg/ha, 120 P_2O_5 kg/ha and 150 K_2O kg/ha were the suitable fertilizer for obtaining higher cane and sugar yield. Similarly, Heeb et al. (2006) recorded an impact of organic and inorganic fertilizers on yield, taste, and nutritional quality of tomatoes, while Smolders et al. (2007) reported that with increasing nitrogen levels both biomass and onion yield were increased. Nitrogen nutrition enhances metabolic processes that influence the physico-chemical environment at the soil root interface, modify the rhizospheric conditions, interact with cations and anions, and also enhance the activity of several enzyme systems (Fernandes and Rossiello, 1995). In the present study, N accumulation in vegetative plant parts and in kernels increased with increasing applications (kg/ha) of urea fertilizer. N accumulation increased up to the 175 kg/ ha urea and then almost remained constant up to the highest level of urea (225 kg/ha). The pattern of N accumulation in both the corn cultivars (C-20 and C-79) was comparable to the findings of Ashraf et al. (2002) who had observed that higher N accumulation at high external N regime in case of wheat.

Furthermore, the study depicted that K and P accumulation increased in leaves and kernels of both corn cultivars due to urea application. It is well accepted that good yielding crop can accumulate up to third-fourth of the phosphate and about one-third of the potash in their grains. However, partitioning of P and K in grains depends on the available P and K to plants from the soil. The enhancement in yield due to urea application in the present study is in lines with those of Ahmad et al. (2007), who reported that application of N and L-tryptophan enriched compost supplemented with 50% N fertilizer

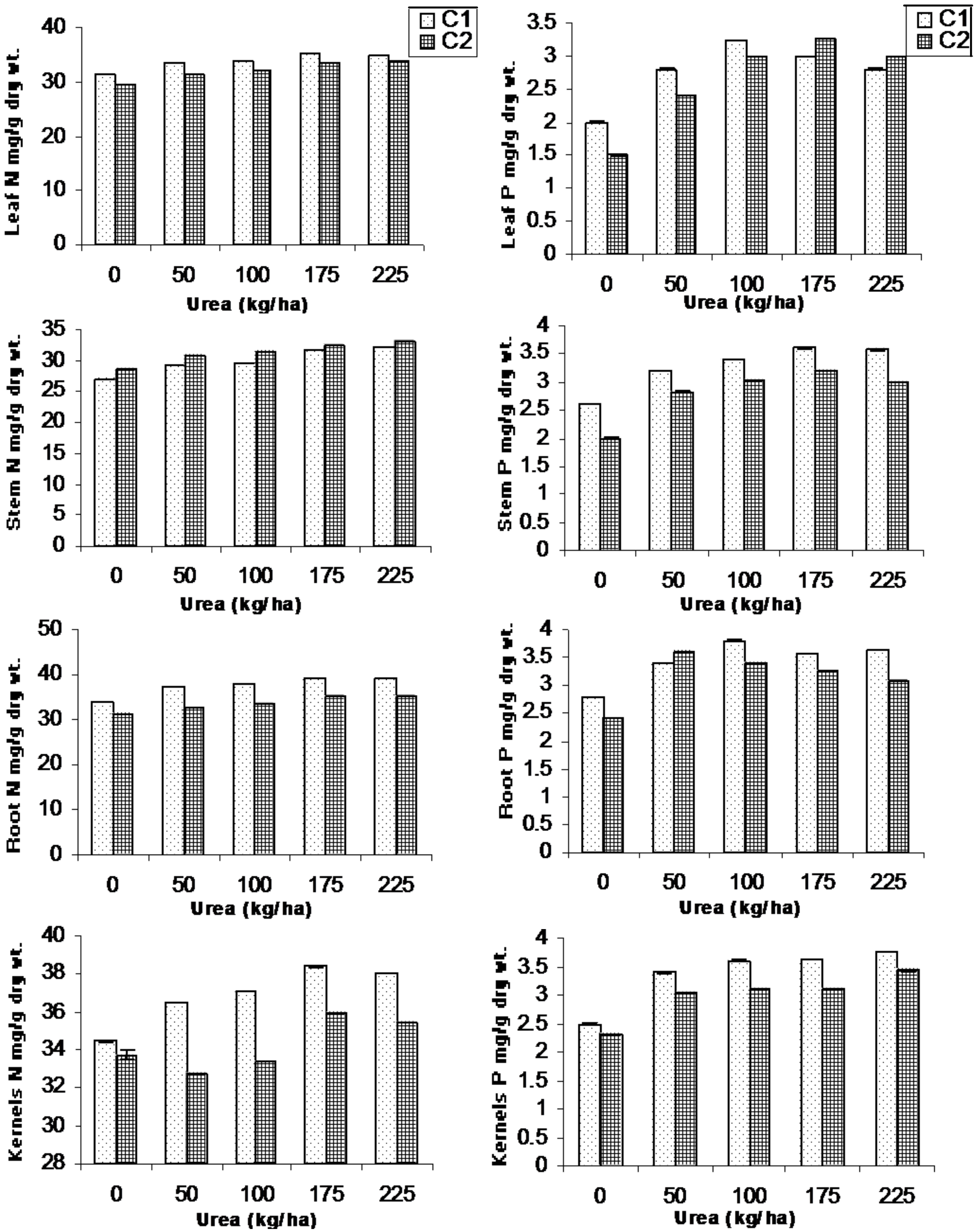

Figure 3. Mean values of N (%) and P (%) accumulation in different plant parts of two corn cultivars C-20 and C-79. Values are given as mean ± S.E; n = 5; C1= C-20; C2= C-79.

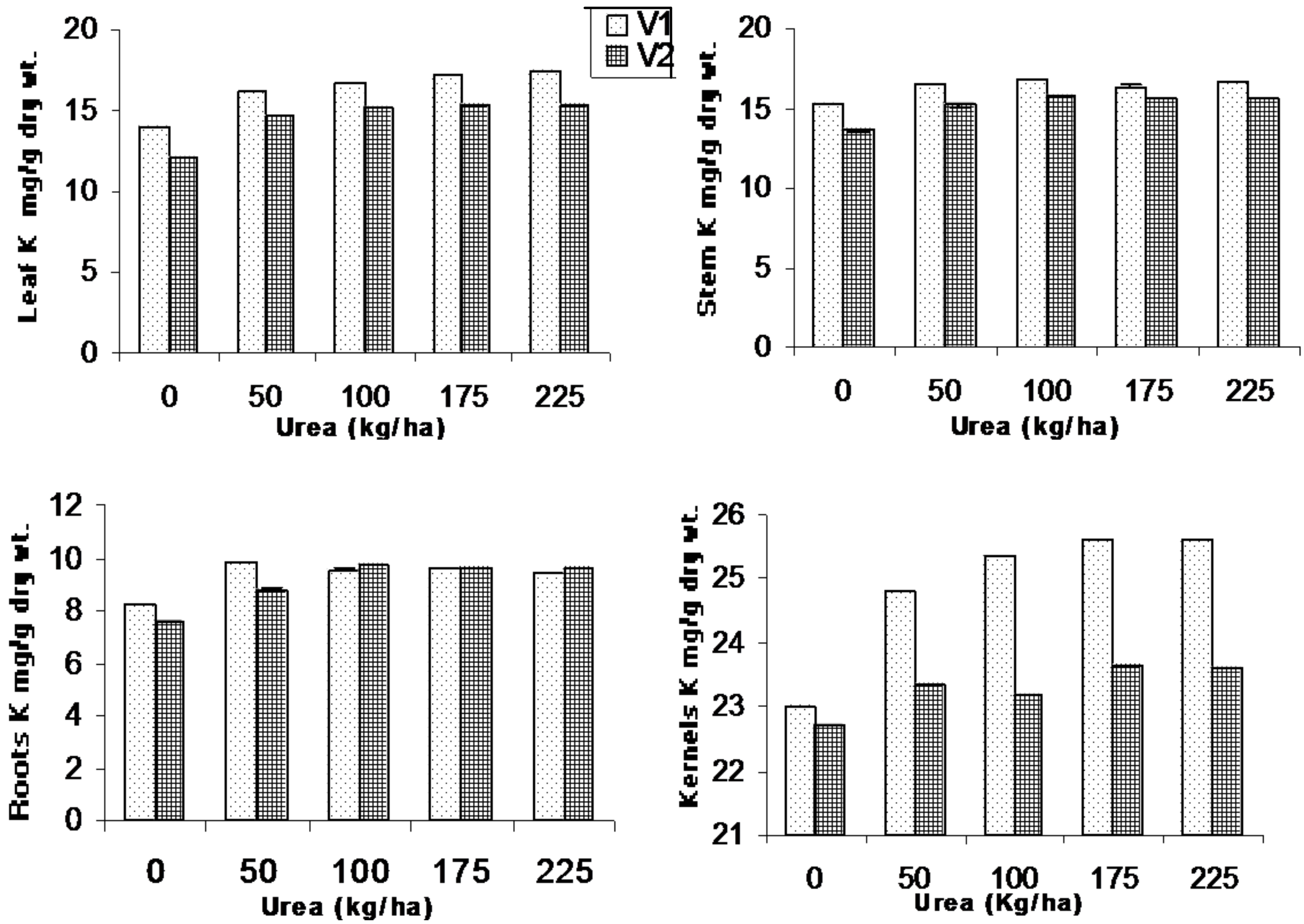

Figure 4. Mean values of K (%) accumulation in different plant parts of two corn cultivars C-20 and C-79. Values are given as mean ± S.E; n = 5; C1= C-20; C2= C-79.

enhanced N, P and K content of corn plants which in turn increased corn yield. In addition, it was clear from the data that under different concentrations of urea fertilizer, micronutrients (Cu, Fe, Mn and Zn) uptake was also enhanced Figures 5 and 6). These micronutrients are essential in various physiological and biochemical processes including photosynthesis, carbohydrate metabolism, ion homeostasis, plant antioxidant capacity etc. that overall control growth and yield (Taiz and Zeiger, 2010). Thus, urea induced increase in growth and yield in corn cultivars due to improvement in micronutrient uptake. Thus improved nutrient status had ultimately improved kernels, which is an associated trait of growth and yield. This effect was more pronounced on cv. C-20 than in C-79, pointing to the fact that the improving effect of urea is cultivar specific. Thus, use of 'right fertilizers for plants is more important.

From these results, it can be concluded that the plants growth, yield and mineral nutrient status of two corn cultivars can be enhanced by applying urea fertilizer. It was evident that cv. C-20 showed higher ($P<0.1$) growth and yield as compared to cv. C-79. However, 175 kg urea /ha was found to be more effective ($P<0.1$) in enhancing growth and yield of both the cultivars. Our results also indicated that K and P accumulation increased in leaves and kernels of both maize cultivars due to urea applcation which is an important attribute of good yielding crops. Application of urea had induced an improvement in micronutrient uptake which affected growth and yield of kernels. 175 kg/ha urea application appeared to be more beneficial for cv. C-20 as it improved mineral nutrients (N, P, K, Cu, Fe, Mn and Zn). Moreover, genotypic differences at varying levels of urea application was not apparent at lower level of urea application from which it can also be concluded that both maize cultivars were unable to extract sufficient N from low urea level. However, a positive interaction between urea and nutrient uptake may offer an opportunity for considerable savings towards the cost of urea fertilizer. Thus, better production at low cost will defiantly assure food security for rapidly expanding

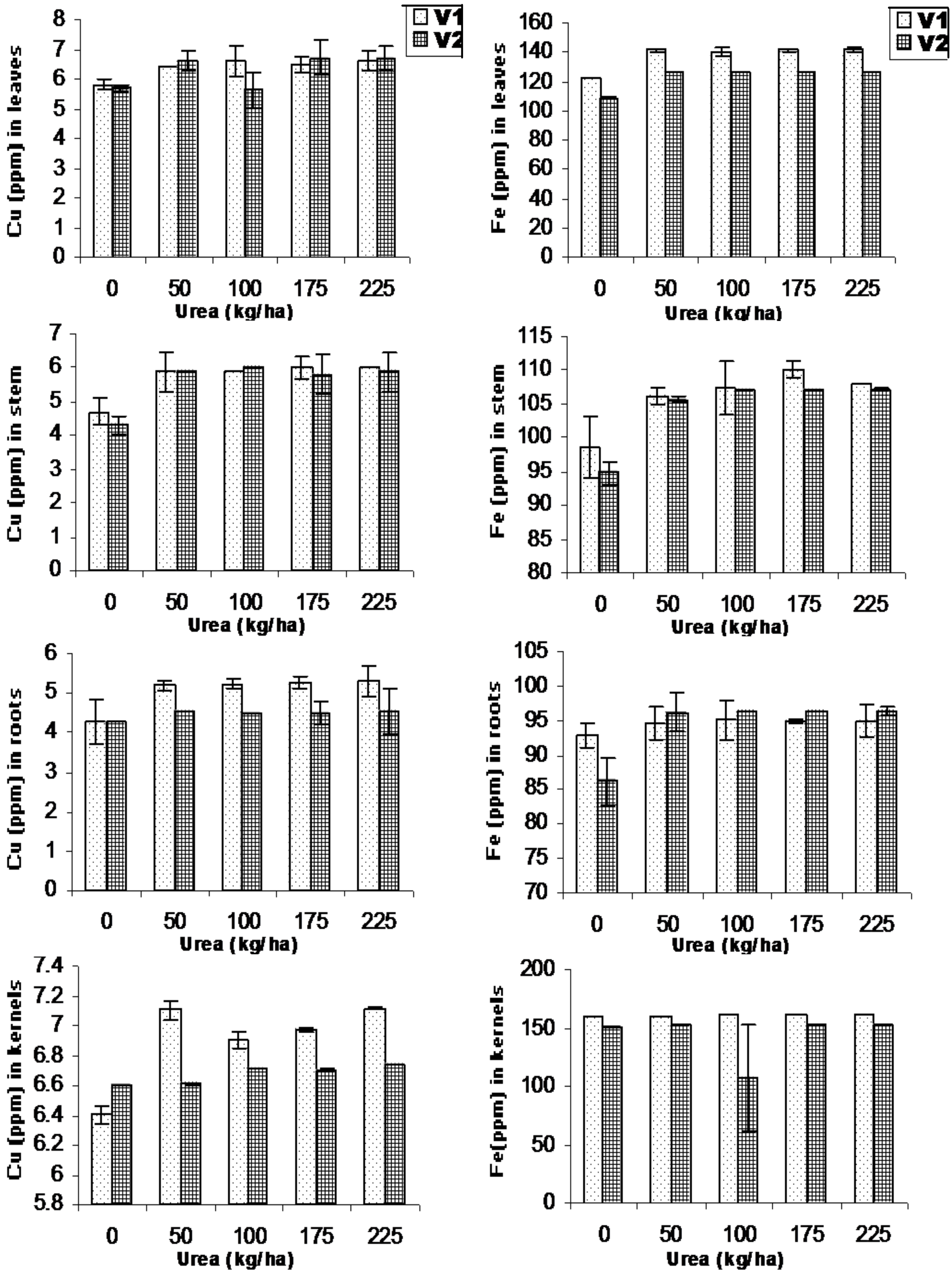

Figure 5. Mean values of copper (ppm) and iron (ppm) accumulation in different plant parts of two cultivars corn cultivars C-20 and C-79. Values are given as mean ± S.E; n = 5; C1= C-20; C2= C-79.

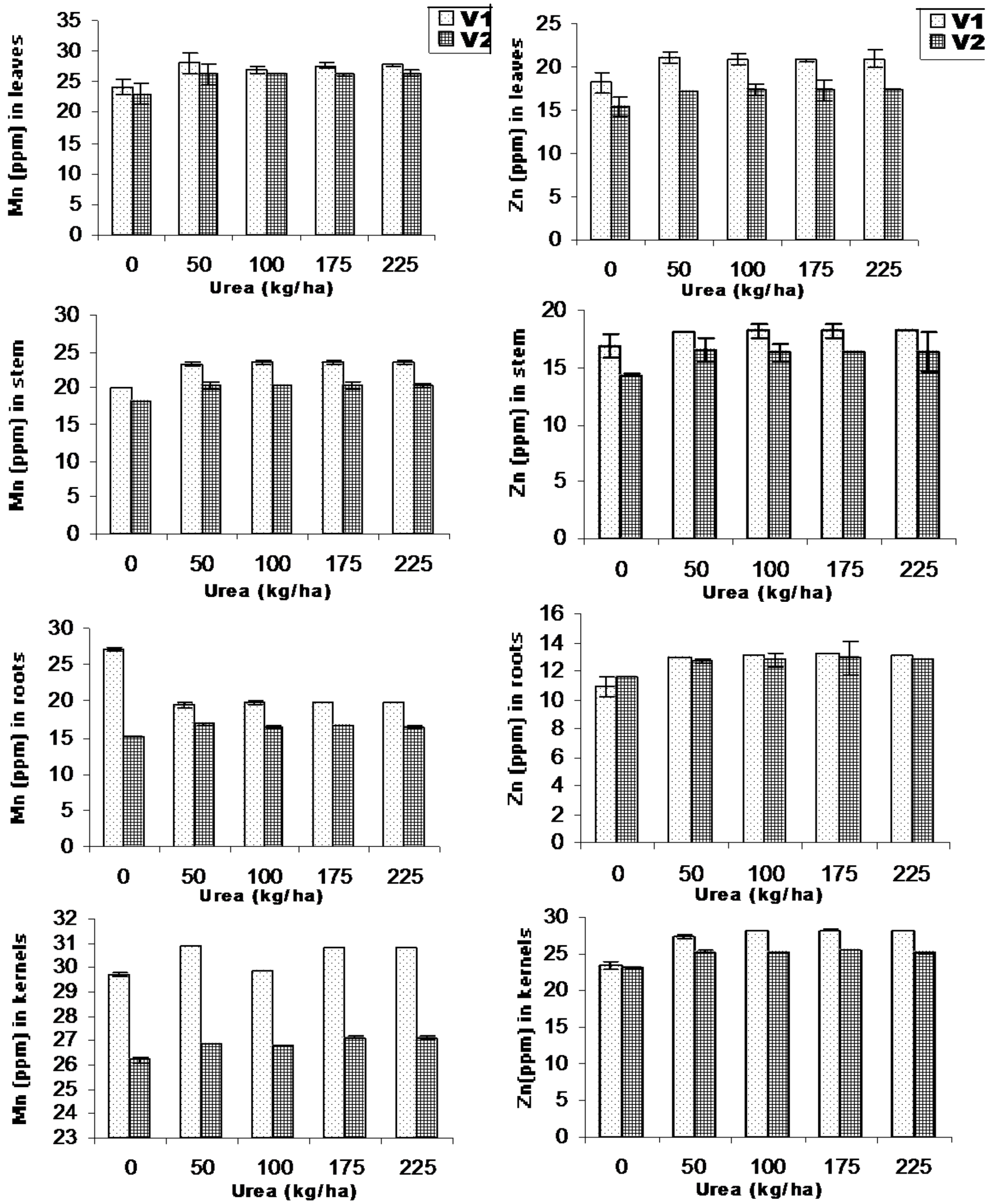

Figure 6. Manganese (ppm) and zinc (ppm) accumulation in different plant parts of two corn cultivars C-20 and C-79. Values are given as mean ± S.E; n = 5; C1= C-20; C2= C-79.

human population of Asian countries.

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