The Role of Zinc (Zn) and Potassium (K) on the Reduction of Nitrate (NO_3) and Cadmium (Cd) Contaminants in Potato and Onion

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INTRODUCTION

The metabolic functions of Zn are based on its strong tendency to form tetrahedral complexes with N-, O-, S-ligands. Therefore, Zn plays functional and structural roles in enzyme reactions. Although more than 70 metallo-enzymes containing Zn have been identified, these account only for a small portion of the total Zn in a plant (Malakouti and Tabatabaei 1996, Alloway 2004, Malakouti et al. 2006). Potassium is an essential element for all living organisms. It is the most important cation in terms of abundance in plant tissues and physiological and biochemical functions. Potassium occupies a vital role in regulating crop yield and quality (Malakouti et al. 2005). Insufficient Zn and K supply prevent the full exploitation of yield potential and crop quality, especially of potatoes (*Solanum tuberosum* L.) and onions (*Allium cepa* L). Due to the role of Zn and K on strengthening plant-cell walls and translocating carbohydrates from leaves to other plant parts and due to their action as counter ions, there is a possibility of increasing dry matter yield and reducing contaminants in potatoes and onions, and it seemed necessary to do investigations.

METHODS

To evaluate the effect of Zn and K-fertilizers sources and rates on yield and quality, namely on levels of dry matter, nitrate (NO_3) and Cd in potatoes and onions, three different field experiments (1 and 2: potato; 3: onion) were carried out in 2001-2003. The first experiment, a completely randomized block experiment with 3 treatments and 4 replications, was carried out at Bonab fields in East Azarbaijan, and repeated as experiment 2 at the Zanjan Agricultural Research Center to evaluate the effect of K and Zn-fertilization on potato yield and quality. The treatments included: T_1 = conventional fertilizer use method (NP); T_2 = NP + potassium sulphate at rates based on soil test and T_3 = T_2 + zinc sulfate. The third experiment was designed as a completely randomized block with 3 treatments of zinc sulfate (0, 25 and 50 kg ha^{-1}) and 3 replications in the Khosroshahr region, East Azarbyjan. Soil samples were analyzed for $CaCO_3$, organic carbon and macro- and micronutrient contents. The results were statistically analyzed using MSTAT.

RESULTS AND DISCUSSION

In experiment 1, the analysis of variance showed significant differences at the 1% level in potato yield, and tuber size, starch content, and K and Zn levels. The highest yield of 50 tons ha^{-1} was obtained with T_3. Treatment T_3 yielded more and produced higher dry matter for tubers, which was significant at the 5% level when compared to the control yield of 44 tons ha^{-1}. While concentrations of NO_3 and Cd in control plots were 250 mg kg^{-1} FW and 0.38 mg kg^{-1} DW, the values decreased to 50 mg kg^{-1} FW and 0.17 mg.kg^{-1} DW, respectively.

In experiment 2, the analysis of variance indicated significant effects at the 1% level between treatments. While the average control yield was 18.3 tons ha^{-1}, T_2 and T_3 yielded 34.6 and 37.9 tons ha^{-1}, respectively. There were significant differences at the 5% level in

NO_3, Cd and dry matter contents of tubers between different treatments. Treatment T_3 had the lowest levels of NO_3 and Cd and the highest yield and percentage of dry matter (Fig. 1 and 2). While on control plots, the concentrations of NO_3 and Cd were 320 mg kg^{-1} FW and 0.29 mg kg^{-1} DW, these values decreased to 85 mg kg-1 FW and 0.10 mg kg^{-1} DW, respectively.

The results of experiment 3 revealed that yield, TSS, ascorbic acid, NO_3 and Cd contents in onion bulbs varied significantly (Table 1). The highest yield (49 tons ha^{-1}) was obtained with 50 kg ha^{-1} zinc sulphate. Regarding quality, the application of 50 kg ha^{-1} zinc sulphate resulted in onions with higher ascorbic acid content (14 mg kg^{-1}) and titrateable acidity. The highest NO_3 and Cd contents (220 mg kg^{-1} FW and 0.27 mg kg^{-1} DW) in onion bulbs were obtained on control plots. The lowest NO_3 and Cd contents (80 mg kg^{-1} FW and 0.10 mg kg^{-1} DW, respectively) were obtained with 50 kg ha^{-1} zinc sulphate (Table 1 and Fig. 2).

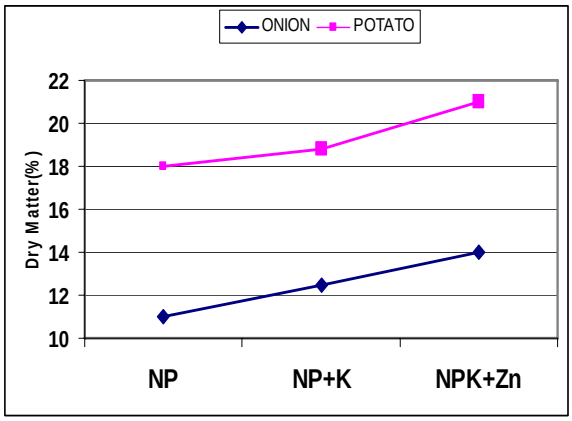

Fig. 1. The role of balanced fertilization on dry matter percentage.

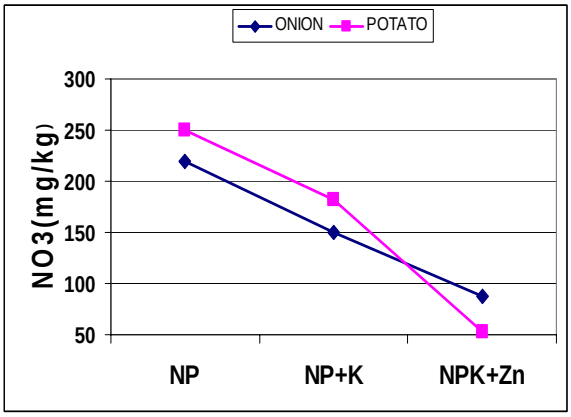

Fig. 2. The role of balanced fertilization on the reduction of nitrate contaminants.

Table 1. The effect of zinc sulfate application on the yield and quality of onion

Treatment	Yield	Nitrate	Cadmium	Ascorbic acid	Dry Matter
	ton ha^{-1}	mg kg^{-1} FW	mg kg^{-1} DW	mg $100g^{-1}$	%
T_1	43.8 C	229 A	0.27 A	12.0 C	11.0 C
T_2	47.5 B	170 B	0.10 B	13.0 B	13.8 B
T_3	49.0 A	80 C	0.10 B	14.0 A	14.0 A

CONCLUSIONS

In the third millennium, the promotion of human health should be a priority of crop producers. Thus, balanced fertilization should be seriously practiced on the basis of soil and plant analysis data. The accumulation of NO_3 and Cd in edible parts of vegetables depends on various factors, especially on the amount and sources of N and P-fertilizers, Cd concentration of P-fertilizers and cultivars. Therefore, decreasing these types of contaminants is necessary for human health promotion. In the conventional method (overuse of N and P-fertilizers), the shelf-life of potatoes and onions decreased due to a lower percentage of dry matter in tubers and bulbs. The highest NO_3 and Cd levels in potato and onion were obtained with unbalanced fertilization. Increasing Zn and K-fertilizer rates was associated with the highest yield and better quality. Dry matter contents were increased in Potato and onions by applying Zn and K. By increasing the percentage of their dry matter, the shelf-life increased, significantly. Zinc and K application increased K and Zn contents, decreased NO_3 and Cd concentrations in potato tubers and onion bulbs, and hence it may promote the health of consumers.

ACKNOWLEDGEMENT

The authors wish to thank from Mr. H. Amirmokri for editing this paper.

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