Res. Bull. Obihiro Univ., **20** (*1998*) : *223~229*

Effect of Continuous Cropping of Corn on the Mineral Uptakes

Shinrô YAMAMOTO and Yosuke MINO

(Received : October 28, 1997)

Abstract

Effect of continuous cropping of corn (*Zea mays* L. cv. P3358) on the mineral uptakes was examined using fields cultivated with corn/barley (summer/winter) (continuous cropping) or Italian ryegrass (control) for 12 years. Dry weight of corn was suppressed during the growing period by continuous cropping. The suppression was remarkable in the ear and leaf blade at late growth stage. K concentration was increased slightly by continuous cropping, while Ca, Mg, Zn, Mn and Cu were suppressed. The suppression in Mn concentration was remarkable at late growth stage. Uptakes of K and Fe mostly occurred before milk ripe stage and were scarcely affected by continuous cropping. Uptakes of Ca, Mg, Zn, Mn and Cu, on the other hand, continued until the late growth stage and were suppressed by continuous cropping. The suppression of Mn and Zn uptakes increased at late growth stage. The results obtained imply that decreases in mineral uptakes at late growth stage are one of the causes of injury by continuous cropping of corn.

Key words : continuous cropping, growth suppression, mineral uptake, *Zea mays*.

Introduction

Corn cultivation has the advantage of dry matter production and digestibility as feed stuff. The yield of corn, however, declines after several years of continuous cropping. Three factors are considered as the causes of the decline : a) disease and insect damage, b) unbalance of soil nutrients and c) allelopathy. In terms of the soil nutrients, a research on the mineral uptakes by corn is considered effective. The present study deals with the effect of continuous cropping of corn on the uptakes of minerals.

Materials and Methods

Experimental fields

The study was conducted on an experimental field of National Grassland Research Institute, Nishinasuno, Tochigi. The soil was composed of brown forest soil. Fields cultivated with corn/barley (summer/winter) or Italian ryegrass for 12 years were used as continuous cropping (CC) and control fields, respectively. Two hundred/100 and 200 kg/ha/year of each of N, P_2O_5 and K_2O had been applied to the corn/barley and Italian ryegrass cultivations, respectively.

Laboratory of Environmental Botany, Obihiro University of Agriculture and Veterinary Medicine, Obihiro, Hokkaido 080, Japan

Plant materials

After adjusting the soil pH to 6.7 with calcium carbonate, 200 kg/ha of each of N, P_2O_5 and K_2O were applied to both fields. The seeds of corn (*Zea mays* L. cv. P3358) were sown with space of 70×21 cm on May 18.

Measurement of mineral concentrations

Mineral concentrations of corn were measured at milk ripe (August 10) and yellow ripe (September 20) stages. After being dried at 80 C in forced air and ground, minerals in the sample were extracted with 1 M HCl for 1 day with occasional shaking for determination by atomic absorption analysis. Mg and Ca were measured in the presence of Sr.

Results

Effect on dry matter growth

Effect of CC on corn dry weight was shown in Fig. 1. Dry weight of corn was suppressed during the growing period, especially at the late growth stage. The changes in dry weights of corn organs were shown in Fig. 2. Leaf blade, leaf sheath and stem of control increased until late July and thereafter remained almost unchanged. Growth of these organs was suppressed after late July by CC, and leaf blade decreased at late growth stage. Dry weight of ear increased rapidly after late July, while the increase was suppressed at late growth stage by CC.

Effect on mineral concentrations

Effect of CC on the mineral concentrations of whole corn plant was shown in Table 1. Ca, Mg,

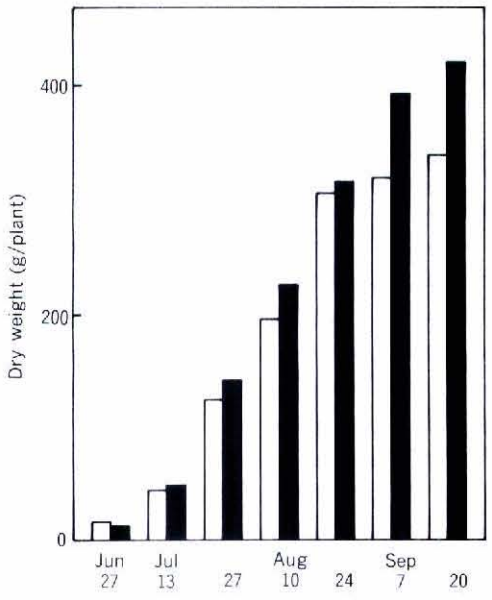

Fig. 1 Effect of continuous cropping on the dry weight of corn.

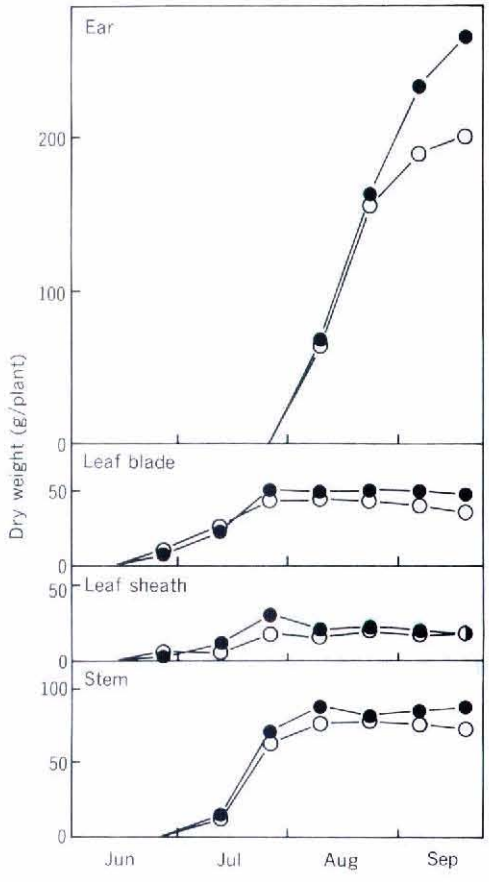

Fig. 2 Effect of continuous cropping on the dry weights of corn organs.

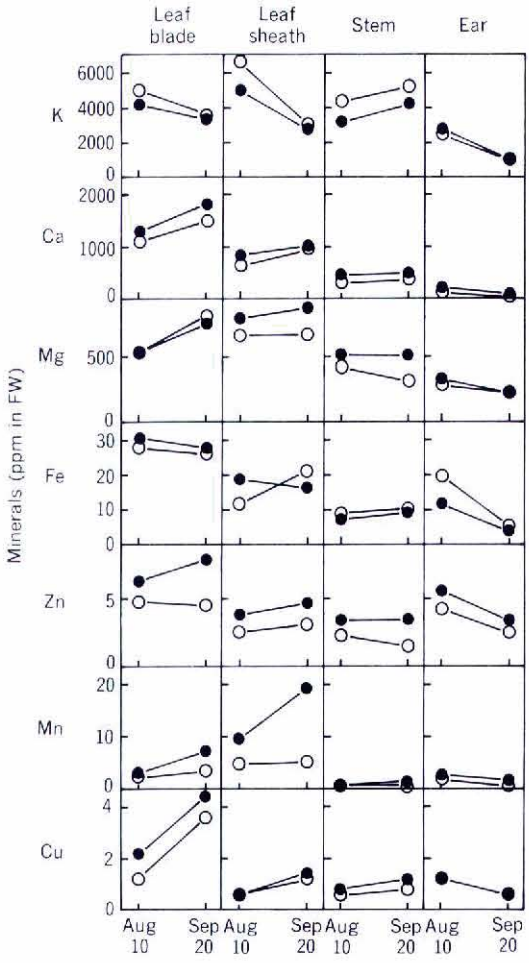

Fig. 3 Effect of continuous cropping on the mineral concentrations in corn organs. Open and closed circles indicate continuous cropping and control, respectively.

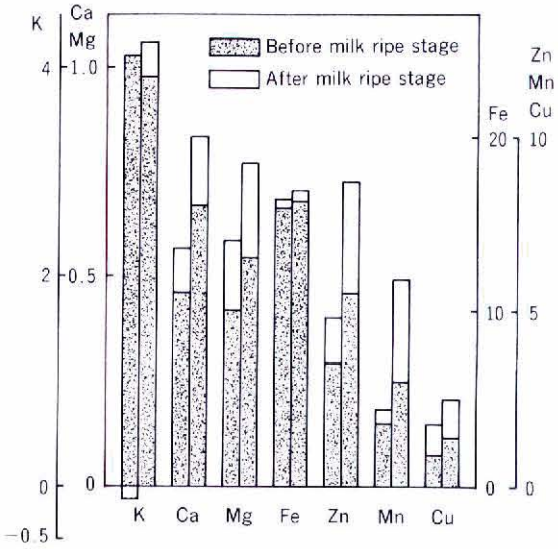

Fig. 4 Effect of continuous cropping on the mineral uptakes of corn. The left and right ordinates indicate uptakes of g and mg/plant, respectively.

Zn, Mn and Cu concentrations were decreased at both milk and yellow ripe stages by CC. Zn concentration ratio of CC to control decreased at yellow ripe stage. Effect of CC on the mineral concentrations of corn organs was shown in Fig. 3. K concentrations in leaf blade, leaf sheath and stem was increased at milk and yellow ripe stages by CC, while Ca, Zn, Mn and Cu decreased.

Effect on mineral uptakes

Effect of CC on the mineral uptakes of total corn plant was shown in Fig. 4. K and Fe uptakes mostly occurred before milk ripe stage and were scarcely affected by CC. Ca, Mg, Zn, Mn and Cu uptakes continued until late growth stage and were suppressed by CC, especially Mn and Zn. Effect of CC on the mineral uptake ratio after milk ripe stage was shown in Fig. 5. Mn and Zn uptakes after milk ripe stage were suppressed by CC.

Effect on mineral balance

Effect of CC on equivalent ratio of K/(Ca+Mg) in whole corn plant was shown in Table 2. K/(Ca+Mg) ratio was increased by CC at both milk and yellow ripe stages.

Discussion

The present study examined the effect of CC on mineral uptakes of corn for elucidation of mechanism of injury by CC. Dry weight of corn was suppressed throughout the growing period by

Table 1. Effect of continuous cropping of corn on the mineral concentrations of the whole plant.

Growth stage and Field	K	Ca	Mg	Fe	Zn	Mn	Cu
	(%)	(ppm)					
Milk ripe stage							
Continuous cropping	0.42	460	420	16.1	3.6	1.8	0.92
Control	0.37	660	528	15.7	5.3	2.9	1.36
Ratio	1.14	0.70	0.80	1.03	0.68	0.62	0.68
Yellow ripe stage							
Continuous cropping	0.34	448	476	13.5	3.9	1.8	1.5
Control	0.30	660	540	12.0	6.2	4.2	1.8
Ratio	1.13	0.75	0.88	1.13	0.63	0.43	0.83

The concentrations are indicated as in FW.

Table 2. Effect of continuous cropping of corn on the equivalent ratio of K/(Ca+Mg) in whole plant.

Field	K/(Ca+Mg)	
	Milk ripe stage	Yellow ripe stage
Repeated cropping	1.84	1.35
Control	1.28	1.03

The value indicates equivalent ratio.

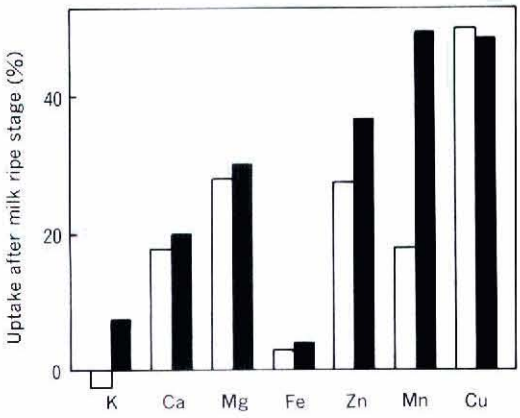

Fig. 5 Effect of continuous cropping on the ratios of mineral uptakes after milk ripe stage. Ratio of mineral uptake after milk ripe was calculated by division of the uptake after milk ripe stage with uptake until yellow ripe stage.

cultivation on CC field (Fig. 1). The suppression was remarkable at late growth stage due to the repression of ear growth with concomitant decrease in leaf blade, suggesting that decrease in photosynthesis was responsible for the repression of the ear growth (Fig. 2).

Uptakes of K and Fe having occurred mostly before milk ripe stage were scarcely affected by CC, while uptakes of Ca, Mg, Zn, Mn and Cu having continued until late growth stage were suppressed by CC, suggesting that decreases in mineral uptakes at late growth stage were largely responsible for the suppression by CC (Fig. 4). Most of the uptake ratios of these minerals after milk ripe stage were in fact suppressed by CC (Fig. 5). Mn and Zn uptakes were conspicuously suppressed at late growth stage by CC, and concentrations of Mn in the whole plant and Zn in the leaf blade were 2 and 7 ppm, respectively. Deficiencies of Mn and Zn have been reported to occur at less than 10 and 20–25 ppm in many plants, respectively[2,3]. Aldrich and Leg[1] noted that corn is the most sensitive to Zn deficiency. Although the hunger signs were not observed in the present study (data not shown) and it is generally recognized that corn contains low level of minerals as compared with other crops, and yet

Mn and Zn concentrations in CC corn in the present study were low, implying that the corn had been in a state of deficiency.

Suppression of dry weight at the late growth stage by CC coincided with decreases in mineral uptakes, implying that decreases in mineral uptakes at late growth stage are one of the causes of injury by CC of corn. Elucidation of the mechanism of decreases in mineral uptakes at the late growth stage will be the subject in the future.

Acknowledgment

The authors thank Dr. L. A. PERERA for revising this manuscript.

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トウモロコシの連作がミネラル吸収に及ぼす影響

山本紳朗・美濃羊輔

帯広畜産大学環境植物学研究室
(北海道帯広市稲田町)

要　　旨

トウモロコシの連作障害の機構を明らかにするため，連作がミネラル吸収に及ぼす影響を調べた。連作により生育全期間をとおして乾物重が減少した。この減少は生育後期の雌穂と葉身で顕著であった。連作によりK濃度は少し増加し，Ca, Mg, Zn, Mn, Cu濃度は減少した。Mn, Zn濃度の減少は生育後期に顕著であった。K, Feの吸収は主に乳熟期前におこなわれ，連作の影響はほとんど認められなかった。Ca, Mg, Zn, Mn, Cuは生育後期まで吸収され，連作により減少した。Mn, Zn吸収の抑制は生育後期に顕著であった。以上の結果から，後期におけるミネラル吸収の低下が連作障害の一因であることが示唆された。

キーワード：ミネラル吸収，連作，生育抑制，トウモロコシ