Plant and Soil **49**, 427–432 (1978) Ms. 3470

SHORT COMMUNICATION

A relationship between premature sprouting on the cob and the molybdenum and nitrogen status of maize grain

Summary

In glasshouse and field experiments, premature sprouting of maize grain on the cob was shown to be controlled by the molybdenum concentration of the grain and also to be related to nitrogen status. When the concentration of molybdenum fell below 0,05 ppm Mo sprouting occurred, the severity of which was enhanced by heavy, late side-dressings of nitrogenous fertilizer.

Introduction

The premature sprouting of maize grain on the cob has been recorded in several maize-growing areas[4 5]. Predisposition to premature sprouting has been shown to be genetically controlled[4], and also to be affected by various environmental factors[5 6]. Heavy, and in particular late applications of nitrogen fertilizer may stimulate sprouting, and in a survey undertaken in France, plants susceptible to premature germination were found to suffer from a decreased ability to reduce nitrate[5]. A mixture of trace-elements has been found to alleviate the problem and it has been postulated that sprouting may be due to an Fe/Mn imbalance affecting dormancy through an oxidation-reduction mechanism[6].

This note reports observations on the severity of sprouting in five field experiments and the results of two glasshouse experiments testing the effects of molybdenum and nitrogen application on the sprouting of maize grain on the cob.

Materials and methods

1) Field trials. In five field trials on acid clay-loam soils that were known to be molybdenum deficient numbers of cobs with sprouted grains and numbers of normal cobs were counted on plots variously treated with molybdenum. Any cobs infected with rots were excluded from the count. Molybdenum treatments applied in the trials were:

Mo 0: Nil = No molybdenum

Mo 1: Mo on maize seed = 500 ppm sodium molybdate applied to the maize seed pre-planting

Mo 2: Mo on seed + spray = foliar spray with 0,1% sodium molybdate applied 28 days after germination in addition to seed treatment.

Two differing, but genetically related maize hybrids were used. A tall long-season single hybrid (SR 52) was used at all sites and in addition a small short-season three-way hybrid (R 200) was used at one site and also in the glasshouse trials. Details of soil characteristics and experimental methods have been reported elsewhere[7].

2) Glasshouse experiments. An acid, yellow-brown clay-loam soil (pH 4.5 in 0.01 *M* $CaCl_2$), known to be Mo-deficient, was used. Pots contained 7 kg soil and a basal fertilizer application of 10 g granular fertilizer (8% N; 6,5% P; 6,6% K; 9% S) was banded below the maize seed.

The molybdenum treatments were the same as in the field trials described above. Two experiments with different nitrogen treatments were done. In the first experiment all treatments received 1.0 g N as NH_4NO_3 at 55 days after germination. Control treatments (N 0) had no additional nitrogen. The remainder received either 1.0 g N (N 1) or 2.0 g N (N 2) at 70 and at 90 days after germination, giving total applications of 1 g, 3 g and 5 g N. In the second experiment the importance of time of application of nitrogen was investigated. Nitrogen was applied either at 60 or at 90 days after germination. Rates of N tested were 2.0 or 4.0 g per pot.

One plant (cultivar R 200) per pot was grown through to maturity; cobs were harvested and numbers of normal and sprouted grains were recorded.

3) Analytical. Molybdenum in grain samples ashed at 600°C was determined colorimetrically by a $KCNS/SnCl_2$ method with concentration in iso-amyl alcohol[3]. Soil pH was determined by glass electrode in a 1 : 5 suspension of soil in 0.01 *M* $CaCl_2$.

TABLE 1

Effect of molybdenum treatment on percentage of sprouted cobs and on molybdenum concentration of maize grain

Site	Soil pH	Age (days) at top-dressing*	Sprouting *Mo in grain*	Control	Mo on seed	Mo on seed + spray
Norton	4.34	30	% sprouted	0.0	0.0	0.0
			Mo, ppm	*0.02*	*0.02*	*0.11*
Enterprise	4.58	40	% sprouted	1.5	0.2	0.0
			Mo, ppm	*0.03*	*N.D.*	*0.33*
Wedza	4.46	55	% sprouted	0.8	0.0	0.0
			Mo, ppm	*0.03*	*N.D.*	*0.07*
Salisbury	4.66	70	% sprouted	8.0	4.3	0.0
			Mo, ppm	*0.01*	*0.02*	*0.09*
Banket (SR 52)	4.68	85	% sprouted	20.0	5.8	–
			Mo, ppm	*0.02*	*0.03*	–
Banket (R 200)	4.68	85	% sprouted	21.0	17.0	–
			Mo, ppm	*0.02*	*0.02*	–

* No of days after germination to final top-dressing with 250–300 kg/ha amm. nitrate
N.D. = Not determined

Results

1) Field trials. The severity of sprouting on plots which received no molybdenum varied greatly between sites (Table 1) but was always reduced by molybdenum application. The effect of seed-treatment with molybdate on the Mo content of grain produced was small, but nevertheless sufficient to markedly decrease sprouting of variety SR 52 at all sites. However seed treatment was ineffective on R 200 (Table 1) apparently because the R 200 seeds were very small and the amount of Mo taken up by the crop was insufficient to increase grain Mo concentration. Where foliar sprays of molybdate were applied, concentrations of Mo in the maize grain were greatly increased and sprouting eliminated.

The risk of premature sprouting in the field trials was greatest when the concentration of molybdenum in the maize grain fell below 0.03 ppm (Fig. 1). A limited amount of sprouting occurred where grain Mo concentration ranged from 0.03 to 0.05 ppm, but the problem was fully controlled when concentrations were raised over 0.05 ppm Mo. Although the risk of sprouting was related to molybdenum concentration, many crops with very low molybde-

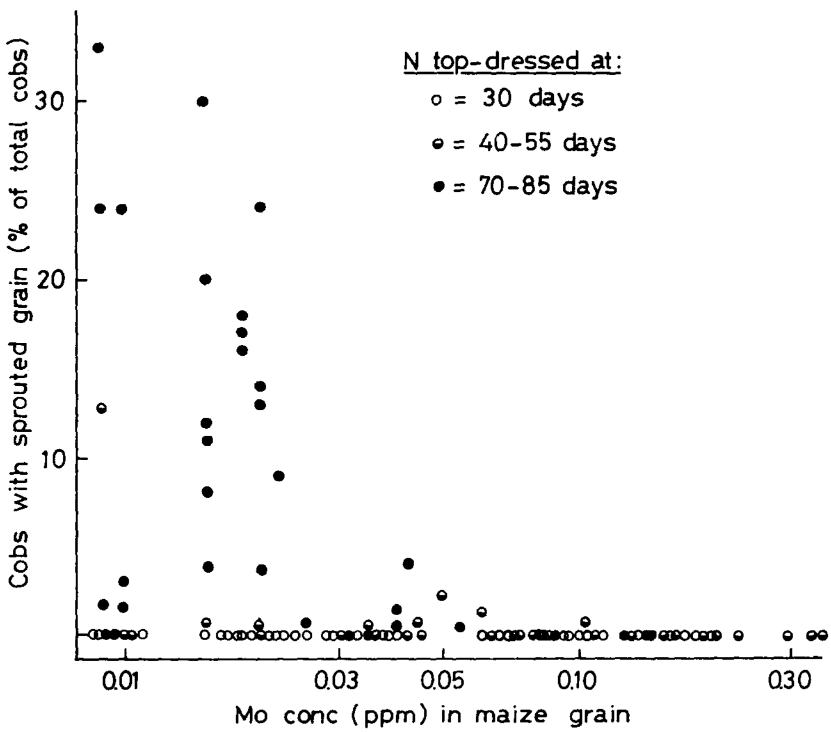

Fig. 1. Effect of Mo concentration in maize grain and of time of nitrogen top-dressing on percentage of sprouted cobs found on field plots.

num content were not affected. The severity of sprouting appeared to be related to the time of application of nitrogenous top-dressings: little sprouting occurred when top-dressing with ammonium nitrate was done before 60 days after germination, but sprouting was marked in two experiments where ammonium nitrate was applied at 70 and 85 days after germination (Table 1).

2) Glasshouse experiments. The concentration of molybdenum in the maize grain was extremely low for plants grown without molybdenum treatment. Seed-treatment with molybdate had little effect but the foliar

TABLE 2

Effect of molybdenum and nitrogen on sprouting and Mo concentration of maize grain

Topdressing	Sprouting (% of grain)			Mo concentration (ppm)		
	Mo 0	*Mo 1*	*Mo 2*	*Mo 0*	*Mo 1*	*Mo 2*
1 g N/plant	2	0	0	0.02	0.04	0.68
3 g N/plant	54	0	0	0.02	0.04	0.97
5 g N/plant	33	20	0	0.02	0.03	0.77
Mean	30	7	0	0.02	0.04	0.81

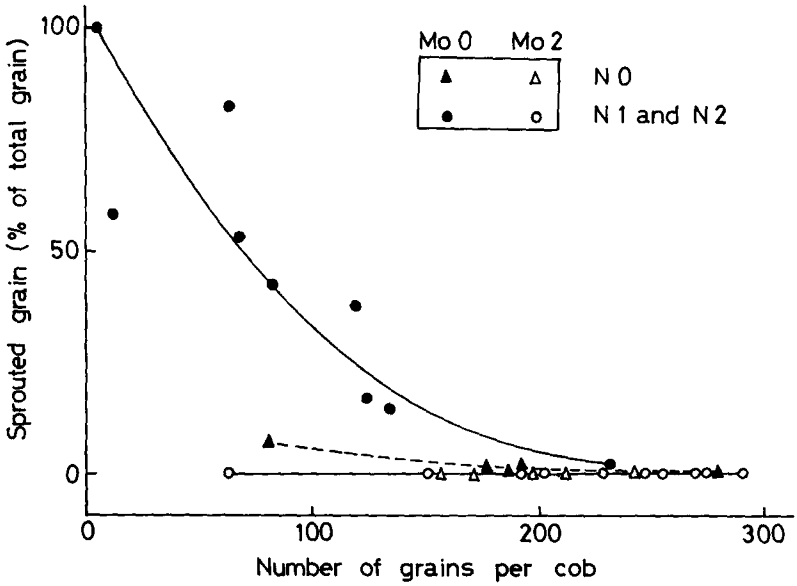

Fig. 2. Effect of molybdenum, nitrogen and numbers of grains per cob on percentage sprouting.

TABLE 3

Effect of nitrogen top-dressed at 60 or 90 days on sprouting of Mo-deficient and Mo-treated seed (Sprouted grains as percentage of total number)

Top-dressing	*Mo-deficient*		*Mo-treated*	
	60 days	90 days	60 days	90 days
Nil	0	0	0	0
2 g N/plant	0	9	3	11
4 g N/plant	22	37	0	7

spray resulted in large increases in grain-Mo concentration (Table 2). Sprouting of grain on the cob was nevertheless greatly reduced by the seed treatment and it was completely eliminated by the foliar spray in addition to molybdate seed dressing. In the first experiment the amount of sprouting of grain of low molybdenum content depended on nitrogen treatments and was increased by top-dressing with ammonium nitrate at 70 and 90 days; grain of high molybdenum content was not similarly affected. The severity of sprouting was also inversely related to the numbers of grains per cob (Fig. 2), the percentage sprouting increasing as the number of grains decreased. The number of grains per cob in the Mo 0 $\times$ N 1 treatment was fortuitously low, because of poor pollination, and the percentage of sprouting correspondingly high.

In the second experiment sprouting of maize grain was closely associated with late dressings of ammonium nitrate, and the effect was greater when application was delayed until 90 days as opposed to 60 days after germination (Table 3).

Seed treatment with sodium molybdate decreased the incidence of sprouting but did not eliminate it.

Discussion

These experiments show that the molybdenum concentration of maize grain is a controlling factor in the premature sprouting of grain on the cob, and where the level of molybdenum is marginal, sprouting is enhanced by late applications of nitrogen.

It is known that molybdenum deficiency decreases nitrate reductase activity in plants[1] and plants with sprouting grain have a decreased ability to reduce nitrate[5]. Inorganic nitrogenous compounds such as potassium nitrate have been shown to increase the germination of dormant seeds[2]. Therefore the effect of molybdenum deficiency on premature sprouting is likely to operate through its limitation of nitrate reductase activity and the consequent accumulation of inorganic nitrate which promotes sprouting. This mechanism would explain the increased severity with decrease in numbers of grains per cob (shown in Fig. 2) as it is possible that the smaller grain 'sink' results in greater concentrations of nitrates within the remaining grains.

Increasing the availability of molybdenum by any treatment, including liming, should decrease the severity of sprouting.

P. D. TANNER

Soil Productivity Research Unit
Chemistry and Soil Research Institute
P. Bag 757, Marandellas, Rhodesia

Received 11 May 1977

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