DIFFERENT RESPONSE OF LUCERNE (MEDICAGO SATIVA L.) CULTIVARS TO P AND ZN FERTILISATION AND SUSCEPTIBILITY TO PHOSPHORUS-INDUCED ZINC DEFICIENCY ON CALCAREOUS SOILS, GANSU, CHINA

Chen Wen[AB], Graham Eagleton[A] and Graeme Blair[B]

[A] China-Australia Gansu Grassland Agriculture Systems Research and Development Project, P.O Box 61 Lanzhou, China.

[B] Department of Agronomy and Soil Science, University of New England, Armidale, N.S.W 2351, Australia.

ABSTRACT

The three pot experiments were carried out at the Qingyang Research Station, Gansu, China to determine the yield response of P and Zn, and examine the effect of soil types on P and Zn requirement of the local and introduced lucerne cultivars in the establishment phase on calcareous soils. The results showed marked growth and dry matter yield benefit at lucerne establishment when P fertiliser was applied on both soils. There were no consistent difference among the three cultivars in response to added P. A significant shoot yield response to Zn was only recorded at high P supply in the two cultivars.

KEYWORDS

Lucerne, P, Zn, P-induced zinc deficiency, Yield, China

INTRODUCTION

The Loess soils of Qingyang, Gansu, China usually have a moderate clay content (20%), high soil pH (8.2 in 1:5 water) and a low cation exchange capacity (7.0 meq/100g) with the exchange capacity dominated by calcium (Qingyang Soil Survey, 1983). According to soil surveys (Qingyang Soil Survey, 1983; Jian and Wong, 1987), although total P and Zn are generally high (P:0.1%, Zn:68ppm), plant-available P and Zn levels (P:6ppm, Zn:0.45ppm) are insufficient to meet plant requirements. There are also large differences in soil extractable P and Zn between the two major soil types (Chen, 1993). Three pot experiments were carried out at the Qingyang Research Station, Gansu, China. The first two experiments were to determine the response of P and Zn in three lucerne cultivars on Hwangmian soil, and the following third experiment was carried out to examine the effect of soil type on P and Zn requirement of two lucerne cultivars in the establishment phase.

MATERIALS AND METHODS

(a) Experiment 1 and 2: The surface 15cm of a Hwangmian soil layer was taken from the typical slopeland. The soil was air-dried, thoroughly mixed and sieved. In experiment 1 calcium superphosphate ($Ca(H_2PO_4)2.2CaSO_4$, the main commercial phosphatic fertiliser used in the region with 12% P_2O_5) was ground, sieved, added and thoroughly mixed in the pots at rates of 0, 20, 40, 80, 160 Kg P/ha. In experiment 2 $ZnSO_4.7H_2O$ was added and thoroughly mixed in the pots at rates of 0, 5, 10 and 20 Kg Zn/ha. The treatments in experiment 1 and 2 were arranged in a completely randomised block design with 3 replicates.

(b) Experiment 3: The top 15 cm Hwangmian and Heilu soils were taken from the typical slope and cropping land. Calcium superphosphate and $ZnSO_4.7H_2O$ were added and mixed in the pots at rates of 0, 80 Kg P/ha and 0, 7 Kg Zn/ha respectively. Treatments were arranged in a 2 (soil types) x 2 (cultivars) x 2 (P levels) x 2 (Zn levels) combinations with 3 replicates.

The three lucerne cultivars used in the above experiments had very different growth in the establishment year. Dk-135 and OA.Minto from Canada, had good early growth, high dry matter production in comparison with the local cultivar Qingyang (Chen, 1993). The details in basal nutrients application, experimental management and plant and soil measurements were referred to Chen (1993).

RESULTS

In the experiment 1, there was a significant tops yield response to applied P ($P<0.01$) with the greatest response between 0 and 20 Kg P/ha. There was a significant cultivar x P interaction ($P<0.05$). In general, there was no consistent difference among the three cultivars ($P>0.05$), however, in the 80 Kg P/ha treatment, top yield of DK-135 and OA.Minto was significantly higher than Qingyang. In root yield there was a significant interaction between cultivar and P treatment ($P<0.01$). At zero P application, the root dry matter yield of Qingyang was twice that of the two introduced cultivars, although this difference was not statistically significant. At 80 Kg P/ha, the root dry matter yield of the introduced cultivars was significantly higher than Qingyang (Figure 1). In the experiment 2, there was no significant response to Zn application in either shoot and root dry matter yield of either Dk-135 or Qingyang. In the experiment 3, there was a significant shoot dry matter yield response to P application in both cultivars on both soil types. The shoot dry matter yield response to Zn was dependent on soil type, soil P supply and cultivar. In the Hwangmian soil, there was significant shoot dry matter yield response to Zn application only in DK-135 at high P supply (80 Kg P/ha), while in the Heilu soil, a significant shoot yield response to Zn application was recorded for both cultivars at high P supply (Table 1).

DISCUSSION

All cultivars showed a marked response in shoot and root dry matter yield to P additions. Such a strong response of lucerne to P addition has also been found in a similar soil type of this region by Zhang and Li (1990). The strong yield response reported here was also directly related to the marked increase in soil extractable P after P applications (Chen, 1993). The shoot dry matter yield response to P addition in both introduced cultivars was up to 80 Kg P/ha; this result agrees with the research conducted on highly calcareous soil where Rehm and Sorensen (1973) found that lucerne yields increased linearly with P rates of 0 to 90 Kg P/ha. The relatively large amount of added P needed to obtain maximum yields on this soil can be attributed to the reversion of the soluble phosphate to products considerably less soluble in water at this high pH. The experiment also indicated that there were no consistent differences between the local and introduced lucerne cultivars in response to P additions.

In experiment 2 there was no shoot or root response in either cultivar to Zn addition in spite of the dramatic increase in soil extractable Zn as Zn application increased (Chen, 1993). A lack of lucerne yield response to Zn was also reported in other research (Stout *et al*.,1987; Gupta, 1989). The shoot Zn concentration of lucerne cultivars grown on the pots at zero P supply was well above the critical level reported in the literature even under very low soil DTPA-extractable Zn (Chen, 1993). This could explain why there was a lack of lucerne yield response to Zn reported in experiment 2. The yield response of two lucerne cultivars to Zn at high P supply observed in experiment 3 was due to P-induced zinc deficiency, which was also reported in other crops (Singh *et al*., 1986). In this experiment, the introduced lucerne cultivar Dk-135 seemed to be more susceptible to P-induced zinc deficiency than the local cultivar Qingyang. The lower susceptibility in Qingyang to P-induced zinc deficiency than Dk-135 could be due to the long period of adaptation of this cultivar to low P and low Zn soils.

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Table 1
Effect of P and Zn application on shoot dry matter yields of two lucerne cultivars grown on two soil types

Treatment		Hwangmian		Heilu	
P	Zn	Dk-135	Qingyang	Dk-135	Qingyang
(kg/ha)		(g/pot)			
0	0	0.17	0.18	0.39	0.34
	7	0.21	0.15	0.41	0.39
80	0	0.58	0.57	0.80	0.51
	7	0.76	0.63	0.94	0.81

LSD(P<0.05)=0.12 (P x Zn x CV x Soil interaction)

Figure 1
Response of shoot and root dry matter yield to P additions