Potassium and Phosphorus Deficiency Symptoms of Ixora

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SUMMARY. Ixoras (*Ixora* L.) growing in calcareous sandy soils are highly susceptible to a reddish leaf spot disorder. Symptoms appear on the oldest leaves of a shoot and consist of irregular diffuse brownish-red blotches on slightly chlorotic leaves. Symptoms of K deficiency, P deficiency, and both K and P deficiency were induced in container-grown *Ixora* 'Nora Grant' by withholding the appropriate element from the fertilization regime. Potassium-deficient ixoras showed sharply delimited necrotic spotting on the oldest leaves, were stunted in overall size, and retained fewer leaves per shoot than control plants. Phosphorus-deficient plants showed no spotting, but had uniformly brownish-red older leaves and olive-green younger foliage. Plants deficient in both elements displayed symptoms similar to those observed on landscape plants. Symptomatic experimental and landscape ixoras all had low foliar concentrations of both K and P.

Ixoras are important flowering landscape shrubs throughout the world's tropics and subtropics. Although several species and numerous hybrids and cultivars are grown, their susceptibility to nematodes and Fe deficiency on calcareous sandy soils has limited their usage where these soils occur. One cultivar, 'Nora Grant' is largely resistant to nema-

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Fig. 1. Older leaves (some shoot tips have been trimmed off) of *Ixora* 'Nora Grant' growing in a calcareous sand landscape soil.

todes (Giblin-Davis et al., 1992) and Fe deficiency, but like most other ixora cultivars, is highly susceptible to a reddish blotch leaf spot disorder that is concentrated on the oldest leaves of a shoot. These brownish-red blotches are irregular in shape and have diffuse, poorly delimited margins (Fig. 1). Affected shoots also appear to retain fewer leaves than shoots without symptoms. These symptoms are rarely observed on container-grown ixoras receiving complete fertilizers.

Potassium deficiency is known to be a common disorder in southern Florida landscapes (Broschat, 1989), and the concentration of these spots on the oldest leaves suggested that a mobile element such as K may be involved in this disorder. Since the severity of this disorder was thought to be greater during cooler winter months and on plants growing in full sun, a preliminary experiment was set up to determine if these factors could cause the symptoms described. Containerized *Ixora* 'Nora Grant' were grown with and without K in their fertilization program in a full sun nursery, a 55% shadehouse, and a 10% shade greenhouse heated to a minimum 70 °F (21 °C). Results of that experiment indicated that light intensity, cool temperatures, and K deficiency by themselves did not cause the symptoms observed on plants grown in the landscape. Potassium-deficient ixoras exhibited extensive necrotic spotting on the oldest leaves, but these symptoms were not comparable to those found on landscape plants.

Since the concentration of symptoms on older leaves within a shoot suggested a deficiency of a mobile macronutrient element, and reddish discoloration on older leaves is a common symptom of P deficiency on other plants (Mengel and Kirkby, 1979), an experiment was conducted to induce deficiencies of K, P, and their combination in container-grown ixoras.

Materials and methods

Liners of *Ixora* 'Nora Grant' were potted up into 1-gal (3.8-L) plastic containers using a 5 pine bark: 4 sedge peat: 1 sand substrate amended with 1.5 lb of Micromax (Scotts Co., Marysville, Ohio) and 12 lb of dolomitic limestone per cubic yard (0.9 and 7.1 $kg \cdot m^{-3}$, respectively) . Eight replicate containers were assigned to each of the following treatments: 1. Control (received N, P, and K), 2. No P (received only N and K), 3. No P or K (received only N), 4. No K (received only N and P). Treatments 1 and 2 received 0.025 oz (0.7 g) K_2SO_4 and treatments 1 and 4 received 0.025 oz (0.5 g) of triple superphosphate (0N–20P–0K) per pot monthly. All pots received 0.085 oz (2.4 g) $(NH_4)_2SO_4$ per month. Pots were placed in a full sun (maximum photosynthetic photon flux =2175 $\mu E \cdot m^{-2} \cdot s^{-1}$) nursery and received about 3⁄4 inch (2 cm) of water daily from overhead irrigation.

Foliar symptoms began to appear after about 1 year of treatment. Two months later plant visual symptoms were recorded, and three replicate leaf samples per treatment consisting of the second oldest and the youngest mature leaf pairs on each shoot were collected for nutrient analysis. Samples of similar-aged leaves were also collected from symptomatic and asymptomatic ixoras growing in a nearby landscape. Leaf samples were dried at 140 °F (60 °C), digested using a modified H_2SO_4-H_2O_2 method (Hach et al., 1987) and analyzed for K using atomic absorption spectroscopy and P using the ascorbic acid method (Greenberg et al., 1985). The number of leaves retained on each shoot was

Fig. 2. Experimentally induced K deficiency in *Ixora* 'Nora Grant' (right) with control plant on left.

Table 1. Potassium and P concentrations in most recently matured and second oldest leaves of *Ixora* 'Nora Grant' subjected to deficiencies of K, P, or both K and P. Concentrations presented are percentage of dry weight.

Treatment	Young leaves K	Young leaves P	Old leaves K	Old leaves P	No. of leaves
	(% dry wt)				
Control	1.18 b[z]	0.20 b	1.15 b	0.26 b	10.9 a
No K	0.35 d	0.34 a	0.30 d	0.43 a	4.0 d
No K or P	0.48 d	0.13 c	0.43 d	0.17 d	6.3 c
No P	1.82 a	0.09 d	1.44 a	0.07 e	9.6 b
Landscape symptomatic	0.81 c	0.16 c	0.82 c	0.16 d	
Landscape asymptomatic	0.85 c	0.18 b	1.11 b	0.20 c	

[z]Mean separations within columns by the Waller-Duncan k ratio method.

also counted since this variable appeared to vary systematically among treatments. All data were analyzed by analysis of variance with mean separation by the Waller-Duncan k ratio method (SAS Inst., Cary, NC).

Results and discussion

After 14 months ixoras grown without K produced young leaves that were dark green and symptom-free. Slightly older leaves showed a mild diffuse interveinal chlorosis that was more intense in older leaves (Fig. 2). Midshoot leaves also had sharply delimited necrotic spots ranging from 0.04 to 0.24 inch (1 to 6 mm) across. Spots larger than 0.12 inch (3 mm) across had light brown necrotic centers. Leaf margins of older leaves showed irregular patterns of necrosis. Leaves were reduced in size and were often distorted and puckered. Plants were stunted in overall size and retained an average of four leaves per shoot compared to nearly 11 for control plants (Table 1).

Ixoras grown without P were slightly stunted in overall size, but leaf size was not reduced as in K-deficient plants. Youngest leaves were yellow-green, hardening off to olive-green. Middle-aged leaves had a uniform brown-red blush restricted primarily to the outer 2/3 of each leaf, the central 1/3 remaining olive green in color. Older leaves were uniformly brown-red in color (Fig. 3). No spotting, blotches, or necrosis were observed on any leaves and the number of leaves retained per shoot was only slightly lower than on control plants (Table 1).

Ixoras grown without K and P exhibited a unique set of symptoms that closely matched those observed on landscape plants (Figs. 1 and 4). Youngest leaves were uniformly yellow-green in color, but middle- and older-aged leaves showed irregular brown-red blotches. The margins of these blotches were diffuse and often appeared as brown-red stippling. The centers of some blotches contained necrotic spots 0.04 to 0.4 inch (1 to 10 mm) across, with the centers of larger necrotic areas having lighter brown centers. Some new leaves were also cupped or puckered. Shoots from K- and P-deficient plants retained an average of 6.3 leaves per shoot compared to nearly 11 for controls. Symptoms of K- and P-deficient ixoras, as well as those observed in the landscape, are thus intermediate between K-deficient and P-deficient plants, yet are unique to this particular combination of deficiencies.

Analysis of leaf tissue for K and P content shows that symptomatic ixoras growing in a landscape generally had lower levels of K and P than asymptomatic plants (Table 1). These differences were not significant for K content in young leaves, but since both K and P are considered mobile within plants, older leaves should be better indicators of K and P status than younger leaves. Potassium concentrations of 0.8% to 1.0% and P concentrations of 0.1% to 0.14% are considered to be low for recently matured leaves of *Ixora coccinea* L. (Jones et al., 1991). Leaf concentrations for both elements in symptomatic experimental and landscape ixoras were generally within this range.

In experimental plants, P-deficient ixoras actually had elevated concentrations of K in both young and old foliage (Table 1). Since P deficiency generally causes a marked reduction in growth rate, and K was applied regularly despite little growth demand, K would be expected to accumulate in the foliage. Similarly, P concentrations in both young and old leaves were much higher in K-deficient plants than in control plants.

Casual observations of symptomatic landscape plants fertilized with either K or P fertilizers indicated that neither element alone could correct this problem, although symptoms may shift slightly towards those of either K deficiency or P deficiency, depending on which element was applied. Application of both elements in landscape situations at least temporarily improves this condition, but since these calcare-

Fig. 3. Experimentally induced P deficiency in *Ixora* 'Nora Grant' (right) with control plant on left.

Fig. 4. Experimentally induced K and P deficiency in *Ixora* 'Nora Grant' (right) with control plant on left.

ous sandy soils have very low cation exchange capacities (<3 meq/100 g), K is readily leached through them and P is rapidly fixed due to high pH (Dickey, 1977). Frequent applications of water-soluble, or less frequent use of controlled-release K and P fertilizers should prevent this problem from occurring.

Conclusions

The reddish leaf blotch disorder so frequently observed on ixoras growing in calcareous sandy soils appears to be caused by a combination of K and P deficiencies. Neither of these elements by themselves can cause this type of symptom and application of either of these elements by themselves will not correct the problem. Since sand soils are unable to retain nutrients against leaching, application of controlled release K and P sources should help alleviate this problem.

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