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Factors affecting the sensitivity of chickpea (*Cicer arietinum*) to isoxaflutole and its effect on nitrogen fixation

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Abstract

One of the major obstacles in growing chickpea (*Cicer arietinum*) successfully is its poor ability to compete with weeds. Heavy crop losses are possible in weedy situations and the lack of registered post-emergence herbicides for broadleaf weeds reduces the options for weed management. In Australia, isoxaflutole at 75 g a.i. ha^{-1} is registered for the control of several difficult-to-control broadleaf weeds [e.g. Indian hedge mustard (*Sisymbrium orientale*), sowthistle (*Sonchus oleraceus*), capeweed (*Arctotheca calendula*), prickly lettuce (*Lactuca serriola*), wild radish (*Raphanus raphanistrum*), turnip weed (*Rapistrum rugosum*), crassula (*Crasulla* spp.), medic (*Medicago* spp.), deadnettle (*Lamium amplexicaule*), and slender celery (*Ciclospermum leptophyllum*)] in chickpea. However, there have been records of chickpea crop damage due to the application of isoxaflutole at the recommended rate. The main objectives of this study were to identify genotypes tolerant or sensitive to this herbicide, to determine the soil and environmental factors affecting the herbicide sensitivity of the genotypes and to examine the effect this herbicide has on nodulation and nitrogen fixation.

Variety screening trials with a range of isoxaflutole rates have found that the chickpea genotypes Howzat, Yorker, 91025-3021 (desi types), FLIP 94-92C and S 95425 (kabuli tyopes) were more susceptible to isoxaflutole damage. In comparison, the desi genotypes 97039-1275 and Kyabra recorded very minor injury and can be regarded as the most tolerant. Other genotypes - Gully, Jimbour, Amethyst, Flipper, ICLL 87322 (desi types) and Bumper, FLIP 94-90C, GCN 133-2, IG 9337, IG 96220, Kaniva, Macarena, S 95342 (kabuli types) – are intermediate in their response to isoxaflutole.

Soil pH and organic matter were the soil factors most likely to affect differential sensitivity of chickpea genotypes to isoxaflutole. Isoxaflutole applied pre-emergence resulted in increased phytotoxicity with increases in soil pH and herbicide rate. Even the most tolerant chickpea genotype was damaged when exposed to higher pH and herbicide rates, as indicated by increased leaf chlorosis and significant reductions in plant height, and shoot and root dry weight. The effects were more severe with the sensitive genotype. Root dry weight reductions and phytotoxic symptoms were most acute when grown on a low organic matter soil compared with a high organic matter soil. Chickpea cultivar

performed comparatively well (produced more root dry matter) in the higher organic matter soil compared with the lower organic matter soil having the same pH.

Among the environmental factors, temperature and soil moisture (rainfall) were also likely to affect differential tolerances among chickpea genotypes. Increasing temperature and moisture content made the susceptible chickpea genotype more vulnerable to isoxaflutole damage. With increasing moisture content, isoxaflutole caused more damage to chickpea in terms of increased leaf chlorosis and reduction in shoot height and dry matter production.

The interaction effects of isoxaflutole on the growth and nodulation of chickpea at various nitrate levels suggested that the sensitive chickpea cultivar was more susceptible to isoxaflutole damage with increasing herbicide rate and nitrate levels. Some damage was observed with the tolerant cultivar at the highest herbicide rate and nitrate levels. In general, isoxaflutole decreased shoot height, shoot dry weight, root dry weight, nodule number, nodule dry weight and average nodule weight of the sensitive cultivar. Herbicide applied at the recommended rate reduced nodule dry weight of chickpea by 51% at 6 mM nitrate level. Nodule number of the tolerant cultivar was decreased by 30% at the recommended rate of herbicide. Nodule dry weight and average nodule weight were decreased with increasing nitrate levels without herbicide application; the addition of herbicide further reduced nodule dry weight and average nodule weight.

Nitrogen (N) fixation of chickpea with the recommended rate of the herbicide indicated that total N of both the tolerant and sensitive cultivars was increased with the addition of nitrate with or without isoxaflutole compared with plants grown without nitrate. But isoxaflutole only reduced total N of the sensitive cultivar when nitrate was added. The recommended rate of isoxaflutole reduced the amount of fixed N by both the tolerant and sensitive cultivars, while the reduction was greater in the sensitive cultivar. The amount of fixed N was also reduced in the sensitive cultivar when nitrate was added.

These findings are discussed in relation to chickpea agronomy and breeding future chickpeas tolerant to this valuable herbicide.

Thesis structure

This thesis is composed of a General introduction, Literature review, five research chapters and General conclusions. The first three research chapters have been submitted for publication in scientific journals and the manuscripts of the last two research chapters are in preparation to send to scientific journals.

Publications from this thesis

Journals

Datta, A., Sindel, B. M., Jessop, R. S., Birchall, C., and Felton, W. L. (2006). Differential response of chickpea (*Cicer arietinum*) genotypes to isoxaflutole. *Communications in Agricultural and Applied Biological Sciences* **71 (3a)**, 733-742.

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