

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

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Background:

- Australia is the largest exporter of chickpea (27%) with the sixth largest production (2%) in the world.
- Chickpea being a pulse crop, able to meet its own nitrogen requirements and provide a residue of nitrogen for succeeding cereal crops.
- Chickpea exports increased up to 300% in the past five years and the crop is becoming an important part of many farmers' rotational systems.

Bottlenecks in chickpea production:

- Chickpea seedlings are slow to emerge and develop.
- Poor competitors with weeds because of their open canopy structure and this slow growth.
- Moderate weed infestations- severe yield losses and harvesting problems.
- Lack of effective broadleaf weed control options- major hindrance to the expansion of chickpea industry in the northern grain region.

Herbicide options:

- Two very effective herbicides available for post-plant, pre-emergence use: Balance[®] (75% a.i. isoxaflutole) and Gesatop[®] (simazine).
- The efficacy of simazine is dependent on receiving rainfall (20-30 mm) within 2-3 weeks of application and weed control is often poor under drier conditions.
- Isoxaflutole remains stable on the soil even after a prolonged dry period. Isoxaflutole has unique properties that allow the product to “recharge” when rainfall occurs, due to limited leaching. This allows isoxaflutole to remain active for much longer periods than other herbicides.

Isoxaflutole and chickpea injury:

- Isoxaflutole provides more consistent and reliable control of a wide range of broadleaf weeds including some difficult-to-control, problematic species.
- Widespread adoption of this herbicide in chickpea production systems.
- However there have been records of chickpea crop damage due to the application of isoxaflutole.

Project Aims:

- To assess the sensitivity of different genotypes of chickpea to isoxaflutole.
- To examine the effects of different soil and environmental factors on chickpea tolerance to isoxaflutole.
- To assess the effects of different soil nitrate levels on the degree of isoxaflutole injury to chickpea.
- To determine the effects of isoxaflutole on growth, nodulation and nitrogen fixation of chickpea.

Results (genotype screening):

- Two polyhouse and one field experiments were conducted to assess the sensitivity of a wide range of chickpea genotypes to isoxaflutole.
- Visual injury symptoms, plant height and shoot and root dry weight reduction were used to measure herbicide phytotoxicity.
- In general, there was less herbicide injury to the kabuli genotypes compared with the desi chickpea genotypes.

Grouping of chickpea genotypes according to tolerance level:

Tolerance level	Genotypes
Tolerant type	Kyabra, 97039-1275
Moderate type	Gully, Jimbour, Amethyst, Flipper, ICLL 87322, Bumper, FLIP 94-90C, GCN 133-2, IG 9337, IG 96220, Kaniva, Macarena, S 95342
Susceptible type	Yorker, Howzat, 91025-3021, FLIP 94-92C, S 95425



91025-3021 (0 g a.i. ha⁻¹)



91025-3021 (75 g a.i. ha⁻¹)





Yorker (0 g a.i. ha⁻¹)

Yorker (75 g a.i. ha⁻¹)





Kyabra (0 g a.i. ha⁻¹)



Kyabra (75 g a.i. ha⁻¹)





97039-1275 (0 g a.i. ha⁻¹)



97039-1275 (75 g a.i. ha⁻¹)



Results (Soil pH and organic matter):

- Two glasshouse experiments were conducted to evaluate the sensitivity of chickpea genotypes to isoxaflutole across a range of soil pH and organic matter levels.
- The results of these experiments showed that chickpea genotypes differ in their sensitivity to isoxaflutole.
- Soil pH had a major effect on the injury of chickpea genotypes in response to the application rate of isoxaflutole. Organic matter also influenced the degree of injury.



Sensitive line (0 g a.i. ha⁻¹)

pH 5.1

Sensitive line (75 g a.i. ha⁻¹)





Sensitive line (0 g a.i. ha⁻¹)

pH 6.9

Sensitive line (75 g a.i. ha⁻¹)





Sensitive line (0 g a.i. ha⁻¹)

pH 8.1

Sensitive line (75 g a.i. ha⁻¹)





Sensitive line (0 g a.i. ha⁻¹)

pH 8.9

Sensitive line (75 g a.i. ha⁻¹)



- Injury symptoms of chickpea generally increased and plant dry weight decreased as herbicide rate and pH increased irrespective of the genotype.
- The more tolerant genotype showed symptoms of injury at high pH levels at the recommended rate of isoxaflutole and the symptoms translated into reductions in plant height and dry weights of shoots and roots.
- The herbicide injury symptoms were significantly greater in chickpea in the lower organic matter soil compared with the higher organic matter soil.

Results (Soil moisture and temperature):

- Two controlled environment experiments were conducted to evaluate the sensitivity of chickpea genotypes to isoxaflutole under a range of temperature and soil moisture levels.
- Increasing temperature and soil moisture content made the susceptible chickpea genotype more vulnerable to isoxaflutole damage in terms of increased leaf chlorosis and reduction in shoot height and dry matter production.

Results (Nitrate experiment):

- An experiment was carried out to examine the growth and nodulation response of one isoxaflutole tolerant and one sensitive chickpea cultivar under a range of soil nitrate (NO_3^-) concentrations and herbicide rates.
- The results of this study suggested that higher nitrate levels coupled with isoxaflutole had a detrimental effects on the general growth and nodulation of both chickpea cultivars. But the response of the isoxaflutole tolerant cultivar was better than the sensitive one for at least some growth parameters.

Results (Nitrogen fixation experiment):

- A controlled environment experiment was carried out to examine the growth, nodulation response and nitrogen (N) fixation of one isoxaflutole tolerant and one sensitive chickpea cultivar.
- At the recommended rate of isoxaflutole, the chemical reduced the amount of fixed N by both the tolerant (37%) and sensitive cultivars (42%) while the intensity of reduction was greater in the sensitive cultivar.

Conclusions:

- Plant breeding programmes should take into account the relative susceptibility of new chickpea genotypes to isoxaflutole. Farmers should avoid the most sensitive genotypes and instead use the most tolerant genotypes when they are using isoxaflutole as a weed control option in chickpea.
- In order to achieve effective weed control in chickpea using isoxaflutole care is needed in selecting tolerant genotypes, and in avoiding high pH and low organic matter soils. This could be important since some soils used for chickpea production (e.g. south eastern Australia) may have high pH levels (in excess of pH 8.5) and relatively low levels of organic matter.

Conclusions (Cont'd):

- Isoxaflutole may cause crop damage in situations with high temperatures and where rainfall is likely soon after herbicide spraying. These factors also need to be considered in making recommendations about the use of this herbicide.
- Tolerant genotypes of chickpea will need to be selected when using the herbicide isoxaflutole under variable soil nitrate levels to incur less crop injury and have better nitrogen economy for the succeeding cereal crops.
- This research project improved our understanding of the factors that affect the sensitivity of chickpea varieties to isoxaflutole and its effects on nodulation and nitrogen fixation.

Conclusions (Cont'd):

- The research findings will increase farmers' awareness regarding chickpea tolerance to isoxaflutole and provide guidelines for adjustment of rates for minimisation of crop injury and maximisation of the benefits of pulses in the rotation.
- By understanding the effects of soil characteristics on chickpea isoxaflutole tolerance, guidelines for the control of troublesome weeds in chickpea in particular situations may be improved.
- The study is also the precursor to understanding the effects of herbicides such as isoxaflutole on the competitive ability against weeds of apparently tolerant crops.

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