Research Application Summary

Effect of temperature on maize sensitivity to acetochlor

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Abstract

This greenhouse study determined the effect of temperature on the herbicide acetochlor. The herbicide was applied a day after planting at the rates of 0.74, 1.47, 2.94 and 5.85 kg ha^{-1}. Plants were kept at three temperature: supra-optimal (35/28 ^{0}C), optimal (28/18 ^{0}C) and sub-optimal (15/08 ^{0}C). Significant interactions were observed for herbicide rate x temperature x cultivars. Generally seedlings at the optimal and supra-optimal temperatures grew faster and passed the seedling stage rapidly.

Key words: Acetochlor, herbicide, maize, seedling growth, temperature

Résumé

Cette étude effectuée dans la serre a déterminé l'effet de la température sur l'acétochlore herbicide. L'herbicide a été appliqué un jour après la plantation au taux de 0.74, 1.47, 2.94 et 5.85 kg ha^{-1}. Les plantes ont été gardées à trois températures: supra-optimale (35/28 ^{o}C), optimale (28/18 ^{o}C) et sous-optimale (15/08 ^{o}C). Des interactions significatives ont été observées pour les taux d'herbicide x température x cultivars. En général les semis à la température optimale et supra-optimale ont augmenté plus rapidement et ont dépassé le stade des semis rapidement.

Mots clés: Acétochlore, herbicide, maïs, croissance des plantules, température

Background

Temperature influences plant growth and development through its effect on the rate of physiological and biochemical reactions. Temperature also affects herbicide activity in such a way that it affects its solubility, volatility, sorption and desorption. An increase in temperature within the range of 10-30^{o}C enhances the phytotoxicity of herbicides. This is because an increase in temperature increases the absorption and translocation rate of herbicides. In some cases a decrease in temperature results in an increase in toxicity. It appears therefore that the influence of temperature on herbicide phytotoxicity is dependent on the herbicide and the target crop. Since no literature on the effect of temperature to acetochlor activity on maize was found for

Malawi, this study determined the effect of temperature on acetochlor activity in maize.

Literature Summary

When temperature exceeds the optimum for biological processes, crops often respond negatively with a reduction in net growth. This was observed in maize where an increase in temperature from the optimum (25 - 30°C) to 35°C resulted in a reduction in seedling growth (Karim *et al.*, 2000; Medany *et al*., 2007). Wolfe (1991) found that the relative growth rate of maize was decreased by 10% when temperature was reduced from 28/18°C to 18/13°C. In other cases an increase in temperature was reported to accelerate seed germination and growth (Pearson, 1975; Milford and Riley, 1980).

Temperature affects some processes which contribute to herbicide activity, such as solubility, volatility, and sorption and desorption (Bowen, 1967; Mulder and Nalewaja, 1978; Rao, 2000; Bayer, 2002). An increase in temperature to 26°C was reported to result in an increase in plant sensitivity to 2,4-D more than at 10°C and 5°C (Muzik and Mauldin,1964).This increase in phytotoxicity was attributed to increases in absorption and translocation of the herbicides (Vostral *et al.*, 1970; Lambrev, 1999). In a review done by Hammerton (1967), it was stated that high temperatures generally increased the susceptibility of plants to herbicides. However, Xie *et al.* (1996) found that Fenoxaprop-ethyl phytotoxicity was reduced by high temperatures (30/20°C).

The activity of some herbicides from the chloroacetanalide group is also affected by temperature. For example Le Court de Billot and Nel (1977) found that metolachlor toxicity in maize increased with a decrease in temperature, a result that was confirmed by Viger *et al.* (1991). Similar results have been reported by Belote and Monaco (1977), Rice and Putman (1980) and Kanyomeka (2002). Similarly, Allemann (1993) reported that alachlor phytotoxicity to sunflower was increased with an increase in temperature.

Study Description

The experiment was carried out in three controlled environment cabinets on the Bloemfontein campus of the University of Free State, each set at a different temperature regime with a 12 hour photoperiod. The first temperature regime [15/8°C (day/night)] was selected to be below the optimum temperature for maize germination and seedling growth; the second temperature regime of 25/18°C (day/night) was within the optimal temperature range; and the third temperature regime [35/28°C (day/night)] was higher than the optimal temperature range. The trial was laid out in a completely randomized block design in each growth chamber, with each treatment replicated six times.

Polyethelene pots, 150 mm in diameter and 120 mm high were lined with polyethelene bags in order to prevent leaching and contamination from the sides of the pot, and filled with 1.5 kg of sandy loam soil (pH_{KCl} = 4.9 and 15% Clay). Two maize cultivars were used, one tolerant (PAN6Q521R) and one sensitive (DKC 73-76R) to acetochlor. Five maize seeds were planted at a depth of 25 mm in each pot.

Acetochlor was applied at five rates, viz. 0 (control), 0.74, 1.47, 2.94, and 5.88 kg ai ha^{-1}, being 0, 0.5, 1, 2, and 4 times the recommended application rate for the soil that was used. The herbicide was applied to the soil surface the day after planting and the control pots were sprayed with RO water.

The soil water content at field capacity was determined gravimetrically. Prior to herbicide treatment all pots were watered with RO water to within 130 mm of the volume of water required to wet the dry soil to field capacity. Following herbicide application the remaining 130 mm of water (approximating a rain shower of 6 mm) was applied evenly over the surface of each pot in order to leach the herbicide into the soil and bring the soil to field capacity.

Two weeks after planting, plants were thinned out so that three plants remained in each pot. Two replicates were used to adjust the water application for growth of the maize plants. This was done by harvesting the plants at 14 and 21 days after planting, weighing them, and then adding the average mass to the pot mass when weighing pots in order to adjust the soil water content.

Plants were harvested 30 days after treatment and plant height as well as above ground fresh mass determined. Plants were then dried to constant mass in an oven at 70 °C and dry mass determined. Data were analysed using the SAS Ver.9.1 for windows statistical package (SAS Institute, 2003). The data were expressed as a percentage of the control treatment prior to statistical analysis in order to negate inherent growth differences between cultivars. Significant results were analysed using Tukey's Least Significant Difference test.

Research Application

Time to emergence was significantly affected by temperature, acetochlor application rate and the interaction of temperature x acetochlor application rate (P<0.01) level. This indicated that germination was affected differently by acetochlor rate at the different temperature regimes. The first seedlings to emerge were from supra-optimal temperature regime (35/28°C), followed by those from optimal temperature regime (28/18°C), lastly those from sub-optimal temperature regime (15/8°C) (Fig. 1).

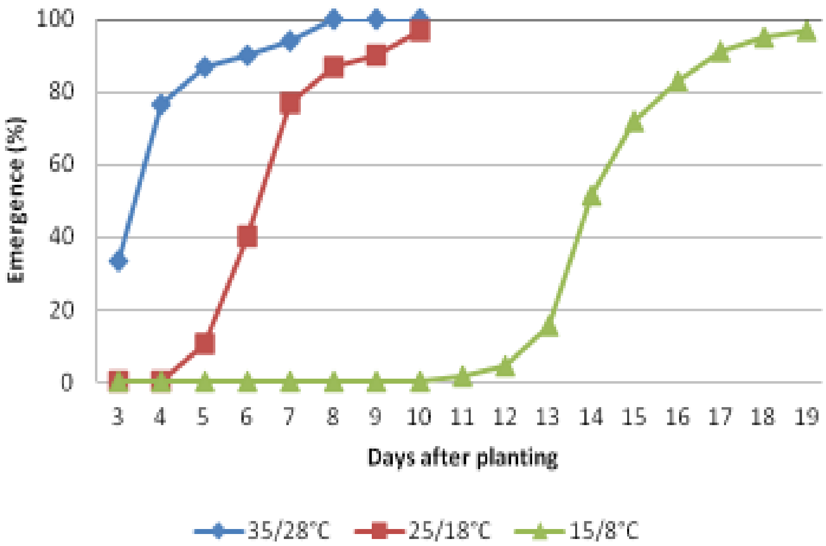

Figure 1. Seedling emergence pattern at the different temperature regimes

The dry mass of seedlings was significantly affected by cultivar (P=0.0291), acetochlor application rate (P=0.0001) and temperature regime (P=0.0001). Temperature x Cultivar, and Temperature x Acetochlor application rate interactions also had a significant effect, while no other interactions were significant at 5% level. The significant temperature x acetochlor application rate interaction indicated that both temperature regimes and acetochlor application rate played a role in determination of maize tolerance to acetochlor. The interaction between the temperature regimes and cultivar indicated that maize cultivars were affected differently at the different temperature regimes.

Seedlings from both cultivars had lower dry mass at the optimum temperature regime (25/18°C) compared with that at the other temperature regimes. The difference in seedling dry mass between these temperature regimes was not significant in PAN6Q521R, but in DKC 73–76R dry mass at optimum temperature regime was significantly reduced compared with that at sub-optimal temperature regime. Those grown under supra-optimal temperature conditions (35/28°C) had a greater percentage difference from the control than those at the sub-optimal temperature regime (15/8°C). This may be due to heat injury to seedlings at the high temperature, and the limitation in some metabolic processes, which resulted in a reduction in shoot dry mass. An increase in uptake of the herbicide could also have caused this, as the plants at the optimal (25/18°C) and supra-optimal (35/28°C) temperature regimes were growing fast and passed the seedling stage (2-4 leaves) rapidly.

Recommendation

It is recommended that this trial be repeated and include the element of the study of physiological processes of the plants, in order to check on the influence of temperature on plant water absorption and metabolism.

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