

Simulated Drift of Glyphosate and Imazamox on Winter Wheat

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Abstract

Off-target movement of many herbicides can have a significant influence on the growth and development of winter wheat. Glyphosate and imazamox are common pre-plant burndown and postemergence herbicides that may be applied to fields in close proximity to wheat in the spring. Consequently, drift of these herbicides onto wheat at critical stages of growth and development can cause serious injury and yield reductions. Field research was conducted at Manhattan, Kansas in 2002 and 2003, to determine the effects of simulated drift of glyphosate and imazamox on winter wheat. Glyphosate and imazamox at 1/100X, 1/33X, 1/10X, and 1/3X of typical field use rates were applied individually to wheat in the early jointing or the early flower stages of growth. The 1X use rates of glyphosate and imazamox were 840 g ae/ha and 35 g ai/ha, respectively. Crop injury was evaluated at 1, 2, and 4 weeks after treatment, and wheat was harvested at the end of the season. Wheat injury and yield loss increased as herbicide rate increased, with minimal effect from either herbicide at the 1/100X rate, and near complete kill and yield loss of wheat from both herbicides applied at the 1/3X rate, regardless of application stage. The greatest differences between herbicides and treatment stages occurred at the 1/33 and 1/10X rates. In general, wheat injury and yield reduction was greater from glyphosate than imazamox. Wheat injury and yield loss generally was greater from herbicide treatment at the jointing stage than at the heading stage of wheat development. Correlation analysis suggest that visual injury is an accurate indicator of future yield reductions.

Introduction

In many parts of the United States, herbicides are frequently used to control growing plants in the fields prior to no-till planting summer crops (Peterson 1997). Fields are often in close proximity to the summer crop fields, and thus herbicides used to control weeds prior to summer crop planting may contact wheat by either drift or accidental application. This time period often occurs at the time when wheat is in jointing or heading stages. Herbicide drift injury is usually greater when drift occurs in early reproductive growth stages (Ghosheh et al. 1994; Hurst 1982; Snipes et al. 1991).

Currently, glyphosate is the standard treatment for burndown weed control prior to summer planting. Glyphosate is a nonselective, postemergence herbicide that is translocated rapidly from foliage to roots and causes death of many annual and perennial grass and broadleaf weeds (Padgett et al. 1995; Franz 1985). In addition, accidental application or drift of glyphosate may cause severe injury on crops, including wheat (Fernandez et al. 1994; Nalewaja et al. 1992; Yenish and Young 2000).

Imazamox is frequently used as a postemergence herbicide to control broadleaf and grass weeds in alfalfa, edible legumes, soybean, and some imidiazolinone-resistant (Clearfied) crops such as sunflower, wheat, corn, rice, and rapeseeds. These crops are frequently planted in close proximity of conventional wheat that is susceptible to imazamox. The application of imazamox on these crops may coincide with wheat at early vegetative or reproductive growth stages when it is very susceptible to herbicides (Regehr et al. 2004).

The objectives of this research were to determine the effects of simulated drift rates of glyphosate and imazamox applied at the jointing and heading stages of winter wheat on growth, yield and seed germination, and determine the correlation between early injury symptoms and grain yield.

Materials and Methods

Field experiments were conducted in the spring of 2002 and 2003 at the Kansas State University Department of Agronomy–Ashland Bottoms Research Farm at Manhattan, Kansas. The soil was a Reading silt loam in 2002 and Wymore silty clay loam in 2003 with 2.5 and 2.8% organic matter and a pH of 6.0 and 6.3 in 2002 and 2003, respectively.

Wheat varieties of ‘Karl 92’ and ‘2137’ were planted on October 1, 2001 and October 2, 2002, respectively. Wheat were seeded in rows 20 cm apart at rates of 78 and 50 kg/ha at Manhattan and Hays, respectively. Plots were 3.0 m by 7.6 m.

The experiments were established as a randomized complete block design with a split-split plot arrangement. The main plots were two application times, jointing and flowering stages. Jointing was defined as the first wheat internode at a length of 2.5 cm and flowering was defined as the first appearance of anthers. The subplot consisted of two herbicides, glyphosate and imazamox. The sub-subplots were 1/100, 1/33, 1/10, and 1/3X the recommended herbicide use rate and a control. The 1X rate of glyphosate and imazamox were 840 g ae/ha and 35 g ai/ha, respectively. Experiments had four replications.

Herbicides were applied using a backpack sprayer delivering 187 L/ha at 138 kPa through XR8002 nozzles. All glyphosate treatments included 2% ammonium sulfate by weight whereas imazamox treatments included 28% urea-ammonium nitrate at 4.7 L/ha and nonionic surfactant at 0.25% (volume by volume). To eliminate off-target drift, plots were sprayed when wind was less than 5 km/h.

Wheat plants were observed for injury symptoms and recovery during the entire growing season, and visible injury ratings were determined 1, 2, and 4 weeks after treatment (WAT) utilizing a scale of 0 to 100, with 0 equal to no wheat injury and 100 equal to plant mortality. Wheat was machine-harvested from 1.8 X 7.6 m strip in the center of each plot when wheat reached physiological maturity. Grain moisture was recorded and yields were adjusted to 12.5% moisture. Visible injury ratings and grain yield data were analyzed by using regression analysis. Regression slope and y intercepts were compared using t ratios (Draper and Smith 1998).

Results and Discussion

Glyphosate injury symptoms were noticeable on wheat plants within 4 to 7 days after treatment (DAT) and peaked at 3 to 4 WAT. However, symptom intensity varied depending on glyphosate rate and environmental conditions. Glyphosate symptoms were more severe at higher rates, especially when glyphosate was applied at the jointing stage. Initial glyphosate injury symptoms were leaf chlorosis and bleaching at lower rates and severe chlorosis and plant death at the highest rate. When glyphosate was applied at the flowering stage, however, wheat heads were initially bleached and turn necrotic within 1 WAT. In addition, flag leaves and wheat heads were the first to show symptoms, followed by other leaves. At the highest glyphosate rate, all wheat plants were killed.

Imazamox caused slight to severe injury symptoms 6 to 9 DAT and symptom intensity peaked by 4 WAT. The lowest rate of imazamox did not cause any injury symptoms, but 1/33 of the use rate caused slight chlorosis, however, plants recovered and appeared normal at the end of the growing season. The two highest rates of imazamox caused moderate to severe chlorosis, plant stunting, and eventually death at the highest rate. Symptoms of imazamox drift were similar when applied at jointing and flowering stages.

In 2002, glyphosate injury increased with increasing rate at both growth stages (Figure 1). Wheat was killed by 4 WAT with glyphosate at the 1/3X rate at both application timings. Glyphosate applied at the jointing stage injured wheat more than the heading stage at the 1/33 and 1/10X rates. These results are not surprising since young, rapidly growing plants would be expected to absorb more herbicide than mature plants (Devine 1989; Wanamarta and Penner 1989). In 2003, however, wheat injury was minimal from glyphosate application at either application stage at the 1/100 or the 1/33X rates. The low injury in 2003 may be attributed to more favorable weather conditions for wheat growth that resulted in greater recovery from glyphosate injury. The threshold rate for glyphosate injury in 2003 for both application timings was between the 1/33 and 1/10X rates. At the 1/10X rate, glyphosate generally caused more injury at 4 WAT when applied at jointing compared to the heading applications.

Imazamox generally caused less injury to wheat than glyphosate (Figure 2). In general, imazamox injured wheat more when applied at jointing compared to the flowering stage. In addition, wheat injury after imazamox application was minimal at either application stage at the 1/100 or the 1/33X rates. At 4 WAT, the imazamox threshold rate for injury for both application timings was between the 1/33 and 1/10X rates. At the 1/3X rate, injury ratings ranged between at 33 and 98% 4 WAT.

Wheat yield was more affected by glyphosate than imazamox treatments; however, both herbicides can significantly reduce yields at 1/10 and 1/3X of the recommended herbicide use rate (Figure 3 and 4). Yield reduction was rarely over 10% for wheat treated with the 1/100X rate of either herbicide. In general, glyphosate or imazamox exposure at the jointing stage of wheat caused greater yield loss than exposure at the flowering stage. Wheat yield was reduced by more than 90 and 95% by imazamox and glyphosate applications at the 1/3X use rate, respectively.

Wheat injury ratings were highly correlated with yield reduction ($r = 0.99$). Therefore, glyphosate and imazamox visual injury to wheat at 4 WAT is a strong indicator of yield reduction and can be used to predict yield reduction from glyphosate and imazamox drift. Consequently, management decision about whether to save or terminate the crop can be made at this time.

This study clearly showed that visual injury to wheat is a strong indicator of yield reduction and may be a factor in management decisions, particularly in years of optimal growth and development. In addition, wheat is more susceptible to glyphosate than imazamox, but both herbicides reduced yield at 1/10 and 1/3X of the use rate.

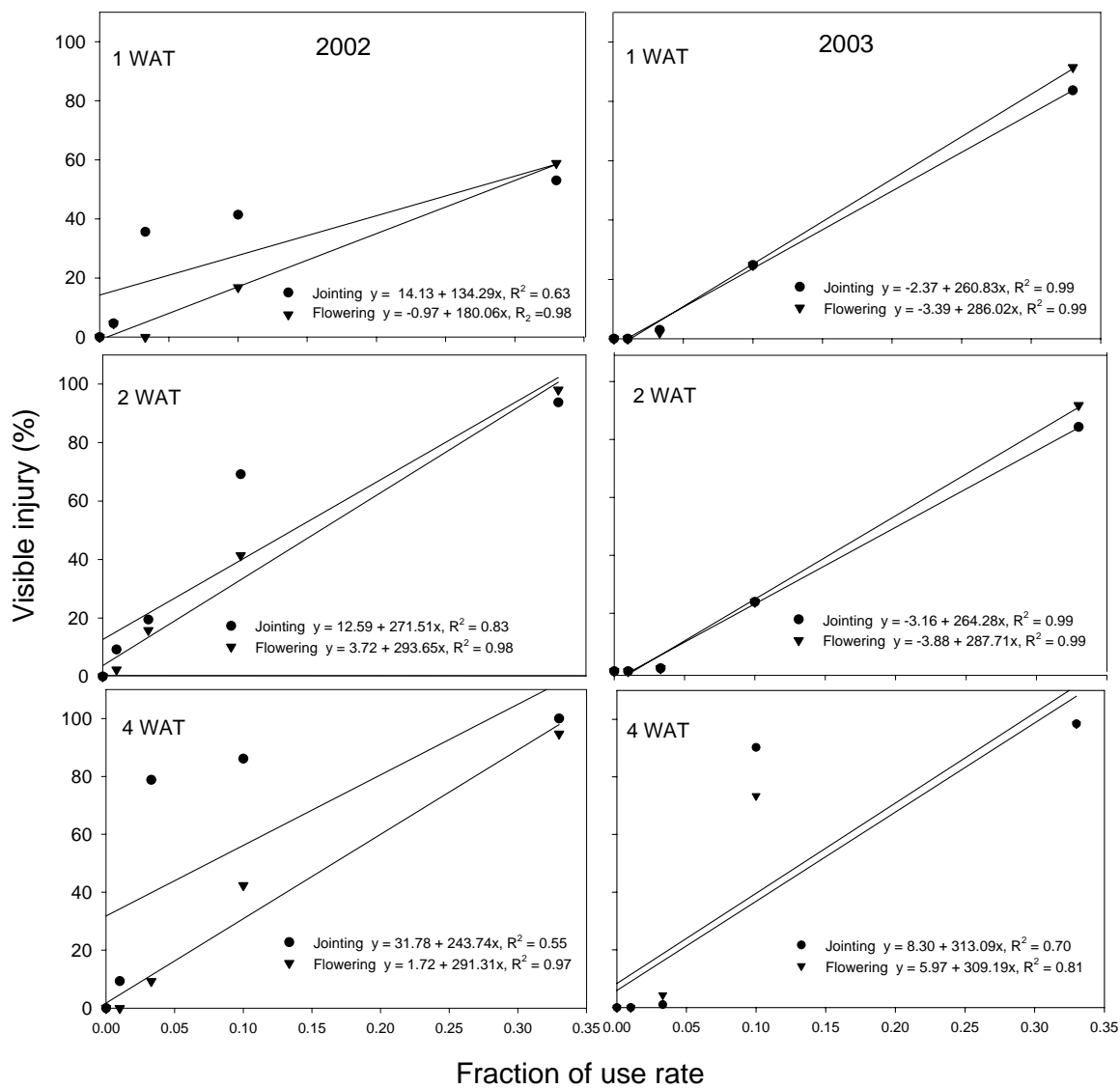


Figure 1. Wheat visible injury ratings as affected by glyphosate applied at jointing and flowering stages at Manhattan, Kansas in 2002 and 2003.

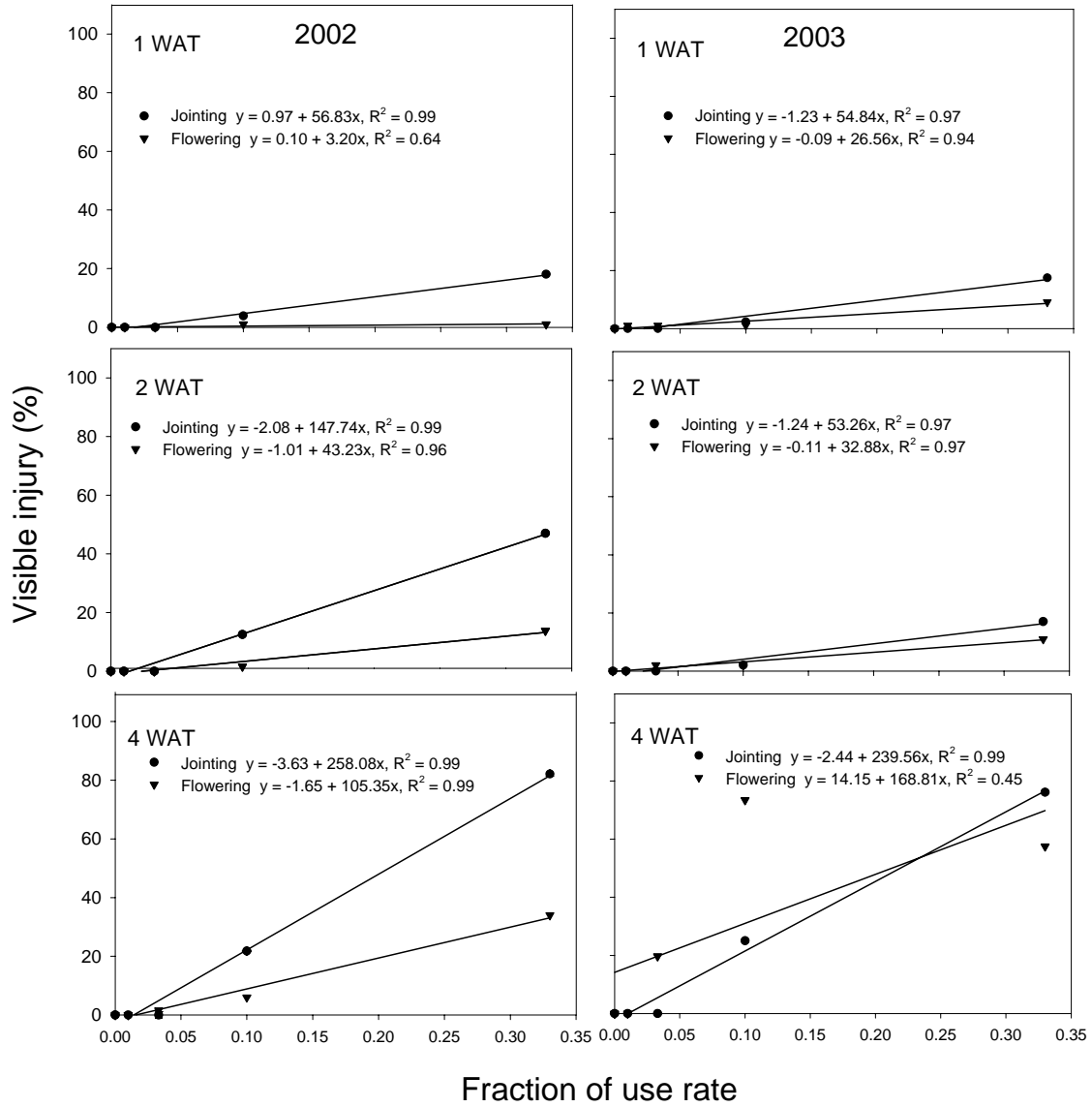


Figure 2. Wheat visible injury ratings as affected by imazamox applied at jointing and flowering stages at Manhattan, Kansas in 2002 and 2003.

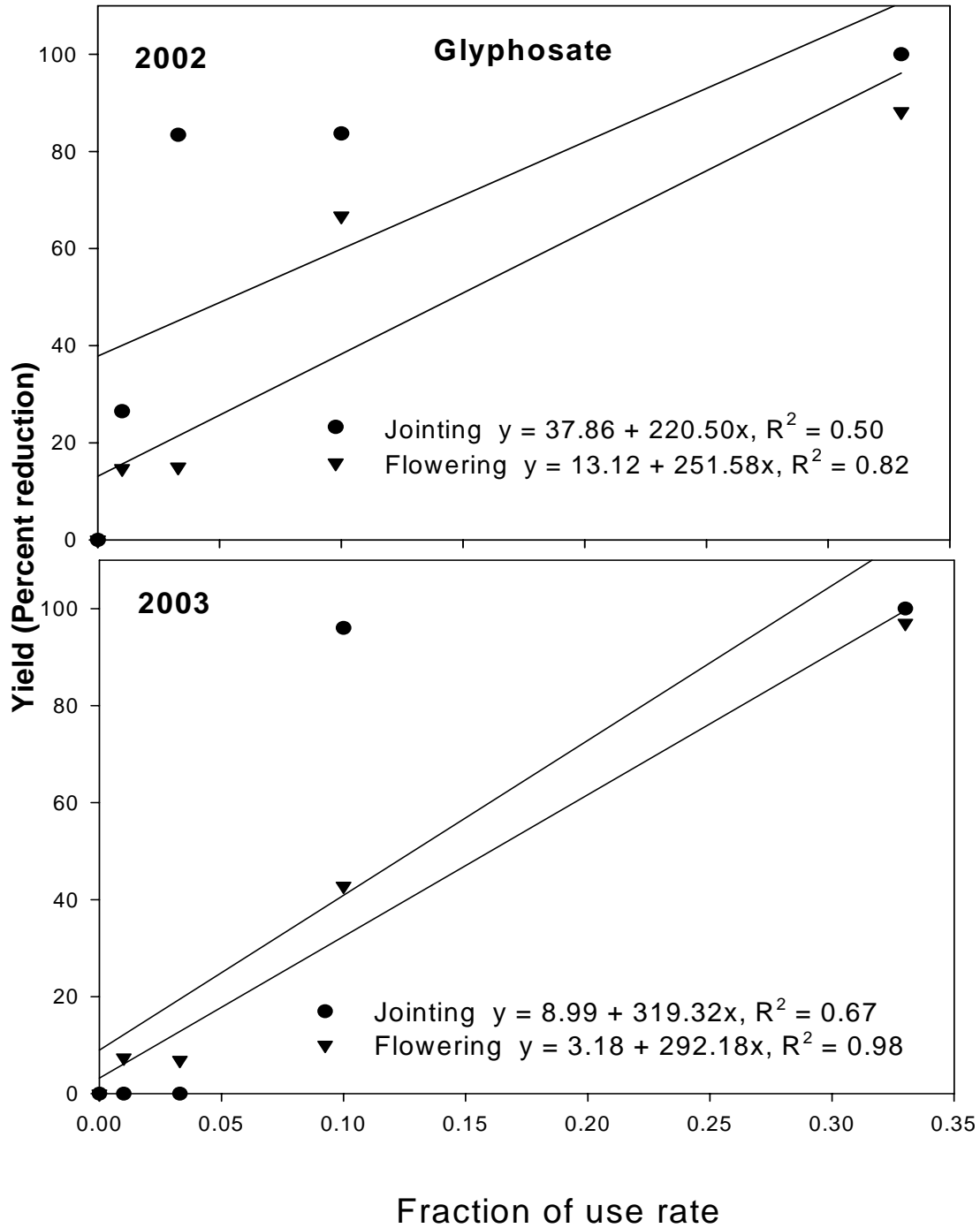


Figure 3. Wheat yields as affected by glyphosate applied at jointing and flowering stages at Manhattan, Kansas in 2002 and 2003.

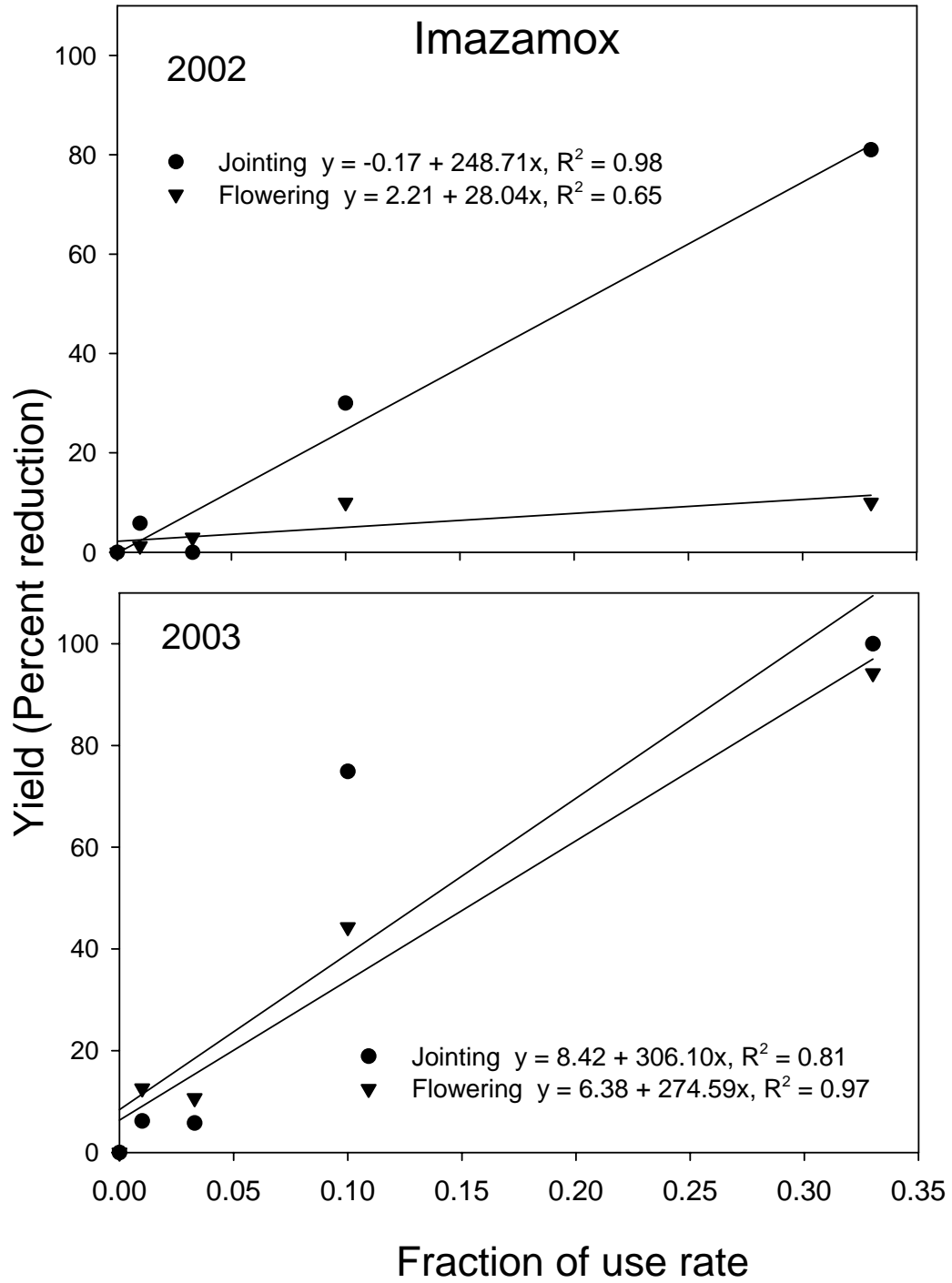


Figure 4. Wheat yields as affected by imazamox applied at jointing and flowering stages at Manhattan, Kansas in 2002 and 2003.

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