Field Crops Research 184 (2015) 104–111

Contents lists available at ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

Cropping systems and the prevalence of giant ragweed (*Ambrosia trifida*): From the 1950's to present

Eric R. Page*, Robert E. Nurse

Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, 2585 County Rd. 20, Harrow, N0R 1G0 ON, Canada

ARTICLE INFO

Article history:
Received 5 June 2015
Received in revised form
14 September 2015
Accepted 14 September 2015
Available online 27 September 2015

Keywords:
Yield loss
Competition
Height
Fecundity
Fractional intercepted photosynthetically active radiation
Giant ragweed
Ambrosia trifida L.
AMBTR
Maize
Zea mays L.
Soybean
Glycine max Merr. L.

ABSTRACT

Over the course of the past two decades, giant ragweed (*Ambrosia trifida* L.) has become an important weed of arable lands in many parts of the United States and Canada. Its shift from a primarily ruderal weed to one commonly found in row crop production has coincided with advancements in maize and soybean production practices and the associated fluctuations in the area seeded to each of these major crops. A field trial was conducted over three years to explore how cropping systems practices representative of distinct eras of maize and soybean production (i.e., the 1950s, 1980s and 2000s) influenced giant ragweed's ability to grow, develop and successfully reproduce within a crop field. Maize hybrids and soybean cultivars bred in each era were seeded in separate split plot designs with era of production practices as the whole plot and time of giant ragweed transplanting (i.e., at crop emergence or 14 days after) as the split plot. Results of this study indicate that historic changes brought about through maize breeding and shifts in cropping systems practices have increased the capacity of this crop to suppress the growth and reproduction of giant ragweed. Conversely, the phenotypic shift of soybean from a vine to a more upright row crop, coupled with the relative lack of change in production practices, has had little impact on its weed suppressive capacity. Giant ragweed's ability to overtop soybean, even when placed at a competitive disadvantage by delayed emergence, creates a situation where the control of giant ragweed seed production is almost exclusively dependent on the availability and efficacy of in-crop herbicide options. In contrast, there is a clear potential for the suppression of giant ragweed fecundity when modern maize hybrids, planted at high plant population densities, are provided a 14 d weed-free window following emergence.

1. Introduction

Over the past 75 years, significant yield improvements have been realized for both maize (*Zea mays* L.) and soybean (*Glycine max*(L.) Merr.) production in North America (Egli, 2008b). From the 1930–40s onward, the average yields of maize and soybean in Ontario have increased by 1.5 and 0.5% per year, respectively (Morrison et al., 2000; Tollenaar and Wu, 1999). Similar rates of yield increases have also been observed in the USA, Europe and South America (Derieux et al., 1987; Duvick, 1992; Luque et al., 2006; Specht and Williams, 1984). Yield increases coincided with the introduction of maize hybrids and improved soybean cultivars in the early 1940s and can be attributed to the interaction of genetic improvements and advancements in cultural practices (Duvick, 1992; Tollenaar and Wu,1999; Wilcox et al., 1979).

In maize, the greater stress tolerance of hybrids enabled the recommended plant population density (PPD) of a typical stand to increase from approximately 3 plants m^{-2} in the 1950s to nearly 9 plants m^{-2} in the early 2000s (Duvick et al., 2004; OMAFRA, 1960, 2009; Tollenaar and Lee, 2011). From the 1960s onward, the increased adoption of higher PPD among farmers resulted in greater use of nitrogen (N) fertilizer and this spurred on the development of maize hybrids with stiffer stalks and increased resistance to barrenness (Duvick et al., 2004; Tollenaar and Lee, 2011). Similarly in soybean, genetic improvement through breeding has resulted in higher yielding cultivars that are shorter, lodge less and produce more seeds per plant (Cober and Voldeng, 2012; Morrison et al., 1999, 2000; Wilcox et al., 1979). In contrast to maize, however, increases in PPD and N were not important contributors to the observed yield improvements in soybean (Egli, 2008a,b).

Both maize and soybean have benefited from new developments in crop management practices. Improvements in weed control options, mechanization, and shifts in tillage practices have all contributed to the yield improvements observed in these crops (Egli,

* Corresponding author.
E-mail address: eric.page@agr.gc.ca (E.R. Page).

http://dx.doi.org/10.1016/j.fcr.2015.09.013
0378-4290/

Table 1
Plant population densities and fertilization practices used to establish cropping systems ERAs representative of the year of release of the maize hybrids and soybean cultivarsutilized in this study.

Crop	Hybrid or Variety	Year of Release	Crop heat units[a]	Plant population density (kg ha^{-1}) (plants ha^{-1})	Actual Nitrogen
Maize	Pride 5	1959	2700	30,000	100
	Pioneer 3902	1988	2700	60,000	200
	Pioneer 8906	2009	2650	90,000	200
Soybean	Harosoy[b]	1955	3000–3300	4,30,000	0
	Harovinton[c]	1991	>3000	4,30,000	0
	Mersea[d]	2010	>3050	4,30,000	0

[a] Tollenaar et al. (1979).
[b] Weiss and Stevenson (1955).
[c] Buzzell et al. (1991).
[d] Poysa et al. (2010).

2008b). The adoption of conservation tillage, for example, has been cited as a significant factor contributing to the multidecadal trend of earlier maize planting dates, resulting in longer growing seasons and higher yields in the Corn Belt of the US (Kucharik, 2006). While changes in management practices are designed to be beneficial to the crops in production, they can often have important long term effects on non-target biotic and abiotic components of the cropping system. For instance, it is well established that changes in cropping systems practices can cause notable shifts in the frequency and abundance of weed species or weed functional groups (i.e., grasses vs. broadleaves, annuals vs perennials, etc; Clements et al., 1996; Derksen et al., 1993; Froud-Williams et al., 1983a,b). In a study of the impact of cultivation practices on weed species abundance Froud-Williams et al. (1983a) noted the tendency for perennial and wind born weed species to increase in abundance in uncultivated fields, whereas annual dicotelydenous weed species occurred more frequently in tilled fields.

Since 1990, giant ragweed (*Ambrosia trifida* L.) has become an increasingly important weed of arable lands in many parts of the USA and Canada (Gibson et al., 2005; Johnson et al., 2009; Stoltenberg, 2011). Although it has historically been considered a weed of roadsides, fence rows and ditches (Bassett and Crompton, 1982; OMAFRA, 1992; Schutte, 2007), it is now frequently described by farmers as one of the most difficult weeds to control. Numerous factors have likely contributed to the increase in giant ragweed abundance in these regions, including the development of resistance to Group 2 (i.e., Inhibitors of acetolactate synthase (ALS)/acetohydroxyacid synthase (AHAS))and 9 herbicides (i.e., Inhibitors of EPSP synthase; Dinelli et al., 2013; Follings et al., 2013; Patzoldt and Tranel, 2002; Stachler 2008; Vink et al., 2012), the selection for delayed emergence in agricultural biotypes of giant ragweed (Schutte et al., 2012), the adoption of conservation tillage practices (Stoltenberg et al., 2011) and earthworm mediated seed dispersal (Regnier et al., 2008).

While herbicide resistance is often viewed as the primary factor underlying an increase in the abundance of a problem weed, giant ragweed has often appeared on farmer surveys as an important weed at a county and state level well before resistance to Group 9 herbicides was been documented in that region (Nice and Johnson, 2005; Gibson et al., 2005; Heap, 2015). For example, in Indiana, giant ragweed was consistently listed as the number one problem weed in farmer surveys from 1996 onward (Nice and Johnson, 2005), yet the first case of Group 9 resistance in that same state was not documented until 2005 (Heap, 2015). A similar increase in the frequency of giant ragweed occurrence has also been observed in south-western(SW) Ontario, prior to the discovery of the first Canadian case of Group 9 resistance in 2008 (Heap, 2015; Vink et al., 2012). Weed surveys conducted by the Ontario Ministry of Agriculture and Rural Affairs (OMAFRA) identified giant ragweed as one of the top 25 weeds in the province as a whole in 2005 and, more recently in 2014, as the 5th most frequent weed and 2nd most difficult weed to control in SW Ontario (Cowbrough, Personal communication). Past weed surveys of this same SW Ontario region conducted in the 1960s, 70s and 80s did not identify giant ragweed as a significant problem weed (Alex, 1964; Frick et al., 1990; Frick and Thomas, 1992; Hamill et al., 1983; Thomas and Frick, 1993); in fact Alex (1964) only mentions giant ragweed in an addendum to note its presence in rare instances.

Giant ragweed's shift from a primarily ruderal species to one of the most widespread and hard to control weeds in the corn belt of the United States and Canada presents a unique opportunity to examine the factors driving invasion and adaptation in arable lands. While there are many climatic and agricultural factors that may have contributed to this shift, the primary changes in maize and soybean cropping systems from the 1950s to present have been crop genetic improvement, fertility and PPD (Duvick et al., 2004; Egli, 2008a,b). The objective of this research was to examine how changes in these factors of maize and soybean cropping systems have influenced giant ragweed's ability to grow, develop and successfully reproduce in crop fields.

2. Materials and methods

2.1. Cultural practices

Field trials were initiated in the spring of 2012, 2013 and 2014 at the Greenhouse and Processing Crop Research Centre, Harrow, ON. The soil type was a Harrow sandy loam (66% sand, 23% silt, and 11% clay) with a pH of 5.4 and 5.6% organic matter. A split-plot experimental design was used to evaluate the impact of giant ragweed emergence timing on maize and soybean yield from three representative eras of cropping systems practices (i.e., the 1950s, the 1980s and the 2000s). Separate split-plot designs were established for each crop and consisted of cropping systems era (hereafter referred to as ERA) as the whole plot and timing of giant ragweed emergence as the subplot. Historic maize hybrids and soybean cultivars were assigned to each ERA and were seeded and fertilized based on the cropping practices in use in Ontario at the time each hybrid or cultivar was first released commercially (Table 1). The PPDs and fertility levels assigned to each ERA were based on information obtained from historic recommendation guides for SW Ontario (OMAFRA, 1960, 2009), peer reviewed literature (Egli, 2008b; Tollenaar and Lee, 2011) and informal discussions with researchers and OMAFRA staff knowledgeable in the production practices representative of this region. Although this study did not address several important cropping practices that have changed from 1950 to present, such as tillage (Heatherly and Elmore, 2004), row width (Heatherly and Elmore, 2004) and planting date (Kucharik, 2006, 2008), the factors of crop genetics, PPD and N fertility represented in our ERAs have been consistently identified as the primary elements of maize and soybean cropping systems associated with the observed yield increases during this period of time (Duvick et al., 2004; Egli, 2008b; Tollenaar and Lee, 2011).