# Invasive *helianthus* interference in an imi sunflower crop

## Mauricio Casquero, Ana Julia Luisoni, Karen Kiehr and Miguel Cantamutto.

Agronomy Department, Universidad Nacional del Sur, (8000) Bahía Blanca, Argentina. mauricio\_casquero@hotmail.com

## ABSTRACT

• *Helianthus annuus* is a non-native plant invader recently introduced in Argentina, naturalized in an extended region strongly overlapped with the sunflower crop area. Wild species and volunteers are frequently observed within sunflower crops as *Helianthus* weeds (HelW).

• Morphological and reproductive changes of DK3880, an IMI tolerant sunflower commercial hybrid, were evaluated under four densities of three HelW biotypes; a ruderal (DIA), an agrestal (BRW) and a volunteer (VOL). During the 2009/2010 crop season HelW plants were grown in the same row as DK3880 sunflower. In the field, crop stand was adjusted to 7.1 plants m<sup>-2</sup> and HelW to 0 (control), 0.2, 2.4, 7.1 and 10.7 plants m<sup>-2</sup>. Field was kept clean by hand weeding and water was supplied by drip irrigation, according to crop requirements. At R6 stage (Schneiter and Miller, 1981) plant height, number of dead and green leaves and leaf width was gathered on four plants of the central row. At harvest head diameter, grain number and yield per plant were determined. The design was a randomized complete block, four replications and experimental units of 3.4 m<sup>2</sup>. Data were analyzed by ANOVA and means were compared using the LSD Fisher test (p <0.05).

• DK3880 plant height was reduced 7.5 cm by DIA interference at medium density. Head diameter was reduced by BRW and DIA interference at medium and high densities. While low densities of DIA and VOL did not affect DK 3880 weight, number and grain biomass, high densities of BRW reduced crop yield by 76%. Leaf surface per plant was reduced by all HelW crop interference, except VOL at 0.2 plants m<sup>-2</sup>. More than 7 plants m<sup>-2</sup> of BRW reduced 57% the leaf area per plant.

• Interference of the three weeds produced morphological changes in DK3880 sunflower plants, but did not have a considerable impact on crop yield at low densities. The magnitude of morphological changes was greater when the interference was exerted by BRW, which reduced yield even at low densities.

Key words: wild relatives - competition - ferality.

#### **INTRODUCTION**

Human activity moves plant propagules across the entire world, but only a few species become abundant in a non-native habitat (Inderjit et al., 2005). A successful invader must compete with well adapted natural flora or crops in the new environment. To do so, some invaders escape from predators or parasites, others find unoccupied niches and some are aided by human disturbance (Mashhadi and Radosevich, 2004). *Helianthus annuus* is an annual invader recently spread in Argentina (Poverene et al., 2002). This species' invasive ability is observed in wild biotypes, but also volunteers and natural wild-crop hybrids are sometimes found interferring crops. These *Helianthus* weeds (HelW) can interbreed with the crop and originate hybrid plants with good reproductive fitness (Ureta et al., 2008).

HelW plants are sometimes found as isolated weeds into crops, but with the advance of the weediness stage, reaches high densities. Wild *H. annuus* biotypes have been a source of variability in the sunflower domestication process, but they are also noxious weeds in several crops (Gillespie and Miller, 1984; Geier et al., 1996; Villaseñor and Espinosa, 1998; Allen et al., 2000; Rosales-Robles et al., 2002; Deines et al., 2004; Mesbah et al., 2004).

Volunteer plants may originate from fallen seeds before or during harvest operations (Marzocca, 1994). Sunflower volunteers might be weeds with a great ability for interference on wheat (Blamey et al. 1997). While no till practices would decrease emergence of these plants the year after sunflower crop (Robinson, 1978), one can also expect high population levels due to the high crop losses, often exceeding 200 seeds  $m^{-2}$  (Bragachini et al., 2004; Pomsár y Reisinger, 2004).

Sunflower crop reached a wide geographic distribution around the word. In Argentina, crop production is 3.6 million tons, distributed over 1.94 million ha in Buenos Aires, Chaco, La Pampa, Santa Fe, Santiago del Estero, Cordoba, Entre Rios, and San Luis provinces. It represents the fourth world production, 12% of total. Exports from Argentina reach 699 million dollars (MinAgri, 2011). Due to the increasing adoption of herbicide tolerant sunflower varieties, there is a concern about the possible increase of HelW agrestal biotypes.

In the initial phase of the invasive process, low densities of HelW cause small reductions in sunflower yield (Casquero et. al, 2010). Interference and sunflower crop yield losses at high HelW densities are unknown. The objective of this work was to evaluate morphological and reproductive changes of a sunflower commercial hybrid under a wide range of densities of HelW biotype invasion.

## MATERIALS AND METHODS

An experiment was conducted during the 2009/2010 summer to assess morphological and reproductive changes on sunflower plants caused by a wide range of HelW biotype densities. It was done in the Agronomy Department, Universidad Nacional del Sur, Argentina, experimental field  $(38^{\circ}41'46''S, 62^{\circ}14'55''W)$ . The sunflower crop was the hybrid DK3880 (IMI tolerant) planted at 7.1 plants m<sup>-2</sup> stand (0.7 m between rows and 0.2 m between plants in the row). HelW was a ruderal *H. annuus* biotype from Entre Ríos (DIA), an agrestal *H. annuus* biotype collected in an invaded sunflower field at Tres Arroyos district (BRW), both under open pollination, and a volunteer (VOL) biotype generated under controlled conditions in the experimental field as a DK3880 F2 during the previous season.

Seed dormancy was overcome by stratification during one week over wet paper at 5°C. The crop and the HelW biotypes were sown at high densities at the same time in a 10 cm width row. Crop and weed density was adjusted before V4 stage by thinning at 0 (control), 0.2, 2.4, 7.1 and 10.7 weeds m<sup>-2</sup>. The experiment was maintained free of other weeds by hand-weeding throughout the growing season. Water was supplied by drip irrigation, according to crop requirements.

Weed interference was evaluated at R6 stage on four sunflower plants in the central row of each plot. Data included total plant height, leaf number and leaf width, head diameter, grain number and weight per plant. Foliar area was estimated according Aguirrezábal et al. (1996). Total foliar area per plant was estimated as the sum of all the plant leaf areas. At crop harvest maturity (R9), 15cm of HelW stem were cut from the basal part of the plant, to determine stem humidity. This trait estimated the harvest difficulties due to the differential maturity between crop and weeds. Each stem section was weighed before and after driving at 60°C in a forced air chamber to constant weight.

The design was a randomized complete block with four replications and experimental units of 3.4 m<sup>2</sup>. To facilitate data analysis weed densities were grouped as low (0.2 weeds m<sup>-2</sup>), medium (2.4 weeds m<sup>-2</sup>) and high (> 7 weeds m<sup>-2</sup>) according to our observations in field conditions. Data were analyzed by ANOVA, and means were compared through LSD Fisher test (p <0.05) with InfoStat (2010).

## **RESULTS AND DISCUSSION**

More than 7 plants m<sup>-2</sup> of BRW reduced foliar area by 59%, mainly due to the decrease of leaf expansion (32%) (Figure 1A). To a lesser extent, high HelM density caused a small reduction of the total leaf number differenced per plant (8%) and senescence increase (10%). The crop developed  $25 \pm 2$  leaves per plant without interference. BRW biotype only did not reduce the crop total foliar number per plant at medium density, but DIA reduced two leaves per plant. Under competition with low HelW densities, DK 3880 had more leaves than the remaining treatments, therefore green leaves differences were found only within BRW at low and high density. Actually weed-free plants had in average more total leaves and green leaves per plant, and less dead leaves. Overall, DK3880 foliar area per plant was reduced by the interference of all HelW biotypes at medium or high densities, but VOL did not cause any reduction under low densities (Figure 1B).



**Figure 1:** A- Width and leaf number (green, dead and total) per plant at DK3880 R6 stage. Black letters into each column section or above show differences (p<0.05, LSD Fisher) between treatments. White letters show differences in leaves width (p<0.05, LSD Fisher) between treatments.

B- Foliar area per plant, estimated according to Aguirrezábal et al. (1996). Letters represent differences (p<0.05, LSD Fisher) between treatments.

At R6 stage height in weed-free DK3880 plants was 143 cm  $\pm$  18.5. Only DIA at medium density reduced significantly 7.5 cm of crop height. Head diameter was reduced by medium and high densities of BRW and DIA weed biotypes but VOL did not cause the same effect (Figure 2). High densities of BRW reduced 5.4 cm of head diameter of the sunflower. While low densities of DIA and VOL did not affect DK3880 reproductive parameters, under high densities BRW reduced 58%, 44% and 76%, grain number per plant, grain biomass and yield per plant respectively.

There are no previous references to weedy sunflower interference in cultivated sunflower in the literature. Four weedy *Helianthus* plants  $m^{-2}$  predicted 56% sunflower yield loss in average (Cantamutto et al., 2011). Deines et al. (2004) found in Kansas similar yield losses in corn (46%), however soybean was more affected, causing 4.6 plants  $m^{-2}$  between 95 and 97% yield loss (Geier et al., 1996) and 47 to 72% with 3 plants  $m^{-2}$  in Missouri (Allen et al., 2000). In the present experiment, both weeds and crop belong to *Helianthus annuus* species and constitute a particular case of intraspecific interference.

Previous studies have found that increasing sunflower densities decrease head diameter, seed per head and seed weight (Holt and Campbell, 1984; Holman et. al, 2004).

When crop reach the R6 stage, agrestal BRW plant mean height was 187 cm, 33 and 51 cm taller than DIA and VOL. BRW and VOL biotypes had both full and apical branching, meanwhile DIA had only full branched plants. At crop maturity, BRW and DIA had more than 80% shattering, allowing seed dispersion before sunflower harvest, however, VOL seeds in same crop stage remained attached to the receptacle.

Despite VOL could contribute to crop yield (21g plant<sup>-1</sup>), it represented only around a half of the estimated yield reduction under interference of more than 2.4 weeds m<sup>-2</sup> (100 g m<sup>-2</sup>). Under agroecological conditions, volunteer plants represent an additional risk due to their ability as conduits for gene exchange between cultivated and wild sunflower (Reagon, 2006). At crop harvest, the crop, BRW and VOL show statistically the same moisture degree in the basal stem segment (15 to 18%). At the same crop stage, DIA plants showed 62% (\*\*) moisture in the same segment of the stem. This difference was associated to determinate growth observed in the crop, BRW and VOL, in contrast to the ruderal DIA biotype, which exhibits indeterminate growth and continued flowering at harvest time.

**Figure 2:** Traits assessed on the four central DK3880 plants of a plot in competition with three HelW biotypes. HelW biotype and density (weeds  $m^{-2}$ ) in competition with crop are shown. The same letter above the column indicates that means for each treatment are not different (p<0.05 according to LSD Fisher test).



## CONCLUSIONS

The magnitude of sunflower reproductive changes was remarkable in plants under competition with high weed density, especially when the interference was exerted by BRW.

Although yield losses caused by the ruderal DIA *Helianthus annuus* were not as great as those caused by the agrestal BRW biotype, the ruderal biotype was still growing at crop harvest stage. This biotype shows indeterminate growth, which might difficult harvest operations.

As the initial *H. annuus* invasive process is associated with low weed densities, yield losses are insignificant. This masks the threat caused by their presence, therefore producers allow HelW to reproduce and this could facilitate invasion. However, it would be extremely important to prevent the HelW biotypes expansion to avoid the potential yield losses caused at high weed densities.

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