Evaluating bird-tolerance traits in sunflower

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ABSTRACT

- In Argentina, bird damage produced by eared doves (*Zenaida auriculata* Des Murs) and monk parakeets (*Myiopsitta monachus* Boddaert) is one of the main restrictions for sunflower production. Historically, in birds risky zones, only striped hybrids with downturned heads were cultivated due to a supposed tolerance. Purple-hulled genotypes have been reported to suffer less bird damage than oilseed types, possibly through taste aversion to anthocyanin pigment. The aim of our work was to evaluate yield looses produced by birds damage in sunflower genotypes with different combination of achene hull type and degree of head inclination (tolerance traits).
- We conducted four field tests in Entre Ríos province: three in 2008/09 growing season (Paraná 1, Rosario del Tala and Gualeguay) and one in 2010/11 (Paraná 2). The experiments were designed as randomized complete blocks with four replicates. Genotypes with different combinations of hull type (black, striped or purple) and degree of head inclination (downturned or upright) was evaluated. Purple-hulled hybrid only was evaluated in Paraná 2. Damage produced by doves and parakeets was not discriminated in the first experiments, while in Paraná 2 only parakeet damage was assessed. Rows were protected with plastic nets (0.7 x 1 cm mesh) and their yield was compared with unprotected adjacent rows. In Paraná 2 also were assessed seed size and oil concentration.
- In Rosario del Tala and Gualeguay, there were no significant differences among genotypes in yield loss. However, in Paraná 1 where the crop was exposed to a heavy bird depredation (70-90 %), the stripped hybrid with downturned head suffered less damage (p=0.021). In Paraná 2, the percentage of yield loss did not correlate with oil percentage, which may indicate that damage depends on the combination of tolerance traits like hull type and degree of head inclination at maturity instead of achene oil concentration. Between hybrids with downturned head, the striped or purple-hulled were less affected than the black-hulled (28 and 34 %, respectively) (p=0.0025). On the other hand, there were no significant differences in damage between the black or striped hulls within upright hybrids. Probably, a supposed less tolerant hybrid like the upright and black-hulled was not preferred to striped-hulled because a shorter time of exposition to parakeets. Since the experiment was fully protected before maturity and the upright and black-hulled hybrid was in bloom later than other genotypes, time of exposition was shorter. Yield loss by damage was mainly accounted by a decrease in seed number (r^2=0.92; n=30; p<0.0001). Even though the damage produced by parakeet began early during grain filling, there was no compensation process through remaining seeds size. Furthermore, there was a negative correlation between damage and relative seed size (p=0.0044). In addition, damage accounted for 70 % of relative decrease in seed oil concentration (p<0.0001). Considering that sunflower head damage produced by parakeet was peripheral and occurred from the end of blooming, morphological and physiological restrictions of central seeds within the head may explain these results. Also, the damage in head bracts may have contributed further to the decrease in seed oil concentration.
- Combination of classical bird tolerance traits, such as hull type and degree of head inclination, appears as a still effective tool to reduce sunflower bird damage. These traits should be considered in the genotype selection process. The inclusion of purple-hull trait may provide another source of tolerance.
- This strategy collaborates with the integrated pest Management necessary to reduce conflict between agricultural intensification and environmental protection.

Key words: birds - hull type - purple-hulled - sunflower - tolerance traits

INTRODUCTION

The sunflower crop has been virtually displaced by soybean in some areas of Agentina, probably due to a lower profitability and unstable yield. Bird damage produced by eared doves (*Zenaida auriculata* Des Murs) and monk parakeets (*Myiopsitta monachus* Boddaert) is one cause related with low sunflower yields. However, there are few studies that address the problem to quantify both field and regional scale (Canavelli, 2010).

Traditionally, in birds risky zones, only striped hybrids with down turned heads were cultivated due to a supposed tolerance (Zacagnini, 1985). These traits might confer tolerance because some birds may select their food according to the energy content (Mason et al. 1991), and on the other hand, head orientation of sunflower may complicate the access to the seeds (Parfitt, 1984; Canavelli, 2010). However, the differences in oil concentration between older striped-hulled and black-hulled hybrids, nowadays were reduced due to sunflower breeding process in Argentina (de la Vega et al., 2007).

In addition to morphological traits, a few studies have suggested that chemical traits like anthocyanin pigment in purple-hulled sunflower genotypes confer bird damage tolerance (Fox and Linz, 1983; Mason et al. 1986). Nonetheless, some controversy exists about if the lower damage is due to anthocyanin repellence or a lower seed oil concentration in the purple-hulled variety evaluated (Bullard et al., 1989).

The lack of traits that may confer complete bird resistance creates the need to combine traits to add different sources of tolerance (Mah et al., 1990).

The aim of our work was to evaluate yield looses produced by birds damage in sunflower genotypes with different combination of achene hull type and degree of head inclination (tolerance traits).

MATERIALS AND METHODS

Four experiments were conducted in Entre Ríos province to assess bird damage in sunflower genotypes with different tolerance traits. Three were conducted in 2008/09 growing season (Paraná 1, Rosario del Tala and Gualeguay) and one in 2010/11 (Paraná 2). Genotypes with different combination of achene hull type (striped, black or purple) and degree of head inclination (downturned or upright) was evaluated. The sunflower genotypes were planted in a randomized complete block with four and six replicates each season.

Rows from each genotype, 5 m long and 0.52 m apart, were protected with plastic nets (0.007 m x 0.010 m mesh) from blooming to maturity and their yield was compared with unprotected adjacent rows. Bird feeding damage was estimated based on the ratio between unprotected yield and the yield protected with plastic net. In Paraná 2 also were assessed seed size and oil concentration by Nuclear Magnetic Resonance (Oxford 4000 NMR, Oxfordshire, UK).

Since bird species relative abundance were no estimated, in the experiments conducted in 2008/09 growing season the damage was not discriminated. In Paraná 1 damage was caused by eared dove and parakeet, whereas in Rosario del Tala eared dove was the main cause of damage. Besides doves and parakeets, in Gualeguay also were observed house sparrows (*Passer domesticus* L.) consuming sunflower, probably due to the proximity (<5 km) with Gualeguay City. On the other hand, in 2010/2011 growing season only parakeet damage was assessed since the experiment was entirely protected whit nets before physiological maturity, preventing dove predation.

The Gualeguay and Rosario del Tala experiments were situated in commercial sunflower fields close to an eucalyptus grove and native forest, respectively. In contrast, in Paraná 1 and Paraná 2 the trials were located at the Paraná Experimental Station of INTA, virtually isolated from sunflower crops and close to diverse groves.

Data were analyzed by means of ANOVA procedures and means were compared by LSD test. Associations between variables were assessed by linear regression and correlation analysis.

RESULTS AND DISCUSSION

In 2008/09 growing season, we found that damage differed significantly among locations ($p<0.0001$). In particular, Paraná 1 had the highest mean yield loss (88 %), whereas Gualeguay and Rosario del Tala showed lower losses (37 % and 28 %, respectively). Probably the bird pressure was greater in Paraná 1 because this experiment was virtually isolated and there were no close sunflower crops. This aggravated bird pressure may cause greater damage level and the lower variability that enabled us to find significant differences between genotypes in this trial. Thus, the stripped hybrid with downturned head suffered less damage (Table 1).

Table 1. Mean yield loss damage (%) in sunflower genotypes with different combinations of hull type (black, striped or purple) and degree of head inclination (downturned or upright) in 2008/09 and 2010/11 growing seasons in Entre Ríos, Argentina. Means followed by the same letter within a column are not significantly different at P < 0: 05 as determined by LSD test.

	Damage (%)			
Genotype	Paraná 1	Gualeguay	Rosario del Tala	Paraná 2
Black-hulled/downturned	98.9 a	31.8 a	41.0 a	58.2 b
Black-hulled/upright	91.0 a	21.1 a	52.3 a	31.0 a
Striped-hulled/downturned	70.4 b	29.9 a	27.2 a	41.8 a
Striped-hulled/upright	91.6 a	28.3 a	27.1 a	32.7 a
Purple-hulled/downturned				37.8 a
CV (%)	10.9	74.5	57.5	32.5
p-value	0.021	0.758	0.618	< 0.003

Contrasting with results reported in other species (Bullard et al., 1989; Manson et al., 1991), our analysis about the relation between damage produced by parakeet and oil seed concentration in undamaged sunflower genotypes (protected with net) revealed that there was no correlation (p=0.62).

Among downturned genotypes, damage in the black-hulled was greater than striped or purple-hulled sunflower (Table 1).

In contrast, there were no significant differences in damage between upright genotypes related to hull type. Probably the supposed less tolerant hybrid like the upright and black-hulled was not preferred to striped-hulled because a shorter time of exposition to depredation by parakeet. Since the experiment was fully protected before maturity and the upright and black-hulled hybrid was in bloom 6 days later than other genotypes, time of exposition was shorter. This may explain the observed contrast in the hull type effect between downturned or upright genotypes.

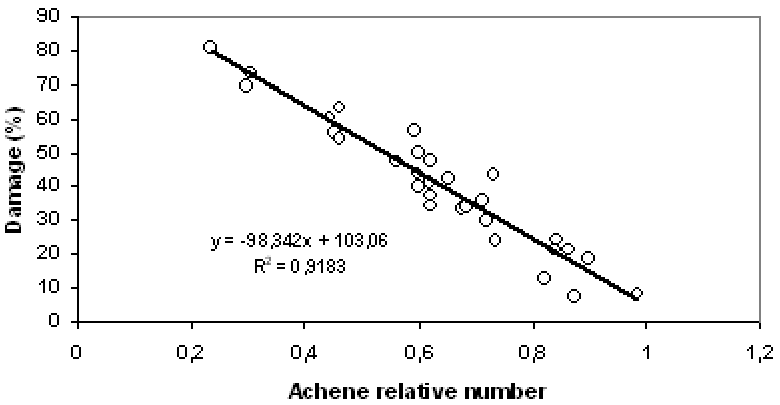

Fig. 1. Relation between sunflower achene number relative to undamaged controls and damage produced by parakeet in Paraná, Entre Ríos, Argentina (2010/11).

Sunflower yield loss by damage was mainly accounted by a decrease in seed number (r^2=0.92; n=30; p<0.0001; Fig. 1). Even though the damage produced by parakeet began early during grain filling, there was no compensation process through remaining seeds size in response to a source-sink relationship more favourable as those found by Sedgwick et al. (1986). Furthermore, there was a negative correlation between damage and relative seed size (r=-0.43; n=30; p=0.0044). In addition, damage accounted for 70 % of relative decrease in seed oil concentration (p<0.0001; Fig. 2). Considering that sunflower head damage produced by parakeet was peripheral and occurred from the end of blooming, morphological and physiological restrictions of central seeds within the head may explain these results. Connor and Hall (1997) suggest that although seed retain an important capacity to respond to improved conditions after anthesis, restriction of seed size imposed by stresses before anthesis are likely to be translated into smaller seed at harvest. Thus, competition with peripheral seeds during initial seed filling might limit the central seeds response to a better source-sink ratio during the rest of the filling, after peripheral seeds depredation. Also, the damage in head bracts by parakeet may reduce photo-assimilates supply and contribute further to the decrease in seed oil concentration.

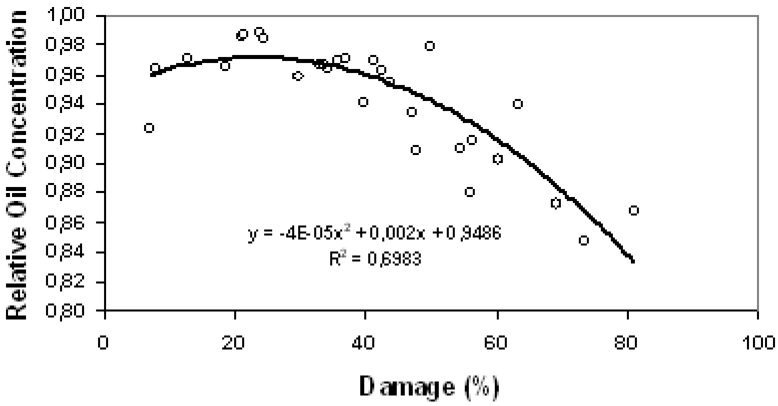

Fig. 1. Relation between damage produced by parakeet and seed oil concentration relative to undamaged controls in Paraná, Entre Ríos, Argentina (2010/11).

Combination of classical bird tolerance traits, such as hull type and degree of head inclination, appears as a still effective tool to reduce sunflower bird damage. In zones with high probability of bird damage not only yield potential but these traits should be considered in the genotype selection process. Also, considering that tolerance traits may differ between bird species (Parfitt, 1984; Manson et al., 1989), further studies are needed to investigate the specific efficiency of these traits in eared dove and parakeet separately. In addition, the inclusion of purple-hull trait may provide another source of tolerance. These strategies collaborate with the integrated pest management necessary for the equilibrium between agricultural intensification and environmental protection.

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