MORPHOLOGY AND DISTRIBUTION OF INCOMPLETELY DEVELOPED FRUITS IN SUNFLOWER (*HELIANTHUS ANNUUS*) CAPITULA

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Abstract

Incompletely developed fruits (IDF) produced by two sunflower genotypes (Dekasol [DK] 4030 and DK3900) grown in two different locations were categorized at three levels (Category [Cat] I, II and III) according to their color and dimensions. The percentage of total IDF and the relative proportion and distribution within the capitula of the three IDF categories were determined. The presence and degree of development reached by the embryos in each category were also observed. In both locations, DK3900 presented a lower percentage of total IDF, a higher proportion of Cat III (black IDF, > 4 mm width) and a lower embryo frequency than DK4030, that presented mainly fruits of Cat II (brown IDF, 3 to 4 mm width). The importance of this study to ascertain the incidence of IDF production on sunflower yield is proposed.

Introduction

At maturity, sunflower capitula usually show a set of fruits with a different degree of pericarp and embryo development. In most of them, the embryo reaches its full size filling the internal cavity of the mature ovary. These are usually defined as fully developed fruits (FDF). In many others, because of physiological and anatomical reasons, the grain filling and growth processes stop at different moments, leaving the fruit with an incompletely developed pericarp and seed (incompletely developed fruits or IDF). Some IDF are easily identified in the head because the pericarp development is arrested, showing an abnormal external appearance. Others show an external normal appearance. IDF generally tend to be considered as "seedless" or "empty", though in some of them the embryo can reach a certain level of development (Lindström et al., 2001, Alkio et al., 2003).

In a preliminary study (Lindström et al., 2001), IDF were categorized according to their color and dimensions: Cat I, light gray fruits, < 3 mm width (resembling the ovary appearance at anthesis); Cat II, brown fruits, 3 to 4 mm width (intermediate in color and dimensions between Cat I and III) and Cat III, black fruits, > 4 mm width (similar to a FDF).

We found this definition helpful to go further in studying the variability in the IDF generation in the sunflower capitulum. So, in order to explain the differences in IDF produced

by different genotypes, it would be not enough to consider the total number of IDF but also the relative proportion of the different categories.

In this work, using two sunflower hybrids grown in two different locations, we determined the percentage of total IDF per capitulum and the relative proportion and distribution of each category within the capitulum. The frequency and embryo dimensions were also measured.

Materials and Methods

Two sunflower genotypes, DK3900 and DK4030, were grown during the growth season 2001-2002 at a density of 5.6 plants/m sq. in two different locations: Villalonga (furrow irrigated crop, 39º 55' S Lat.; 62º 40' W Long.) and Palihue (partially rain fed crop, 38 º 45' S Lat. S; 62º 11' W Long).

At physiological maturity (R9 stage; Schneiter and Miller, 1981), 15 capitula were harvested per hybrid and location. From each capitulum, the fruits of four opposite parastichies were extracted, determining, in each of them, the category of IDF (Lindström et al., 2001) and their position within the parastichy: external, intermediate and internal third. Of each capitulum, 1/4 was manually threshed, counting the total number of FDF and determining the number of IDF for each category (I, II and III). The percentage of total IDF was calculated from the number of IDF and FDF accumulated from the 15 capitula:

$$\text{Total IDF (\%)} = [\text{total IDF}/(\text{total FDF} + \text{total IDF})] \times 100$$

The IDF of each category were expressed as a percentage of total IDF. In each category, the frequency and the dimensions of embryos were determined. The embryos were observed and drawn with a stereomicroscope provided with a drawing tube. Photographs of IDF were taken with a Nikon Lapophot-2 microscope.

Results and Discussion

No differences were found for each genotype between locations, in the percentage of total IDF and the proportion and distribution of IDF categories within the capitula, nor between the evaluation made as from the four parastichies and the quarter of the capitulum ($p>0.05$). So, results are presented as from the parastichies for each hybrid in both locations.

The percentage of IDF was higher for DK4030 as compared to DK3900 (Figure 1). Most of the IDF in DK3900 belong to Cat III, with a higher proportion in Cat II than in Cat I (Figure 1). In DK4030, approximately 50% of the IDF belong to Cat II, with almost the same proportion of IDF in Cat I and III (Figure 1).

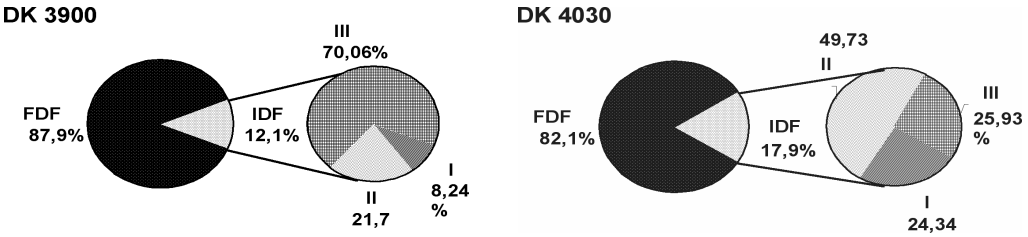

Figure 1. Average distribution for both locations of the 3 categories of IDF in DK3900 and DK4030, calculated as from the number of IDF and FDF accumulated from 4 parastichies and 15 capitula.

Regarding the distribution of IDF per category within the parastichies, in DK3900, fruits of Cat I were restricted to the internal third of the capitulum (Figure 2). Those of **Cat II**, though they appeared throughout the parastichy, were also more conspicuous in the internal third. IDF of Cat III, were found homogeneously distributed in the three thirds (Figure 2). In DK4030, IDF belonging to Cat I were found mainly in the internal third while those of Cat II prevailed both in the medium and internal thirds. IDF of Cat III were distributed homogeneously in the three thirds (Figure 2).

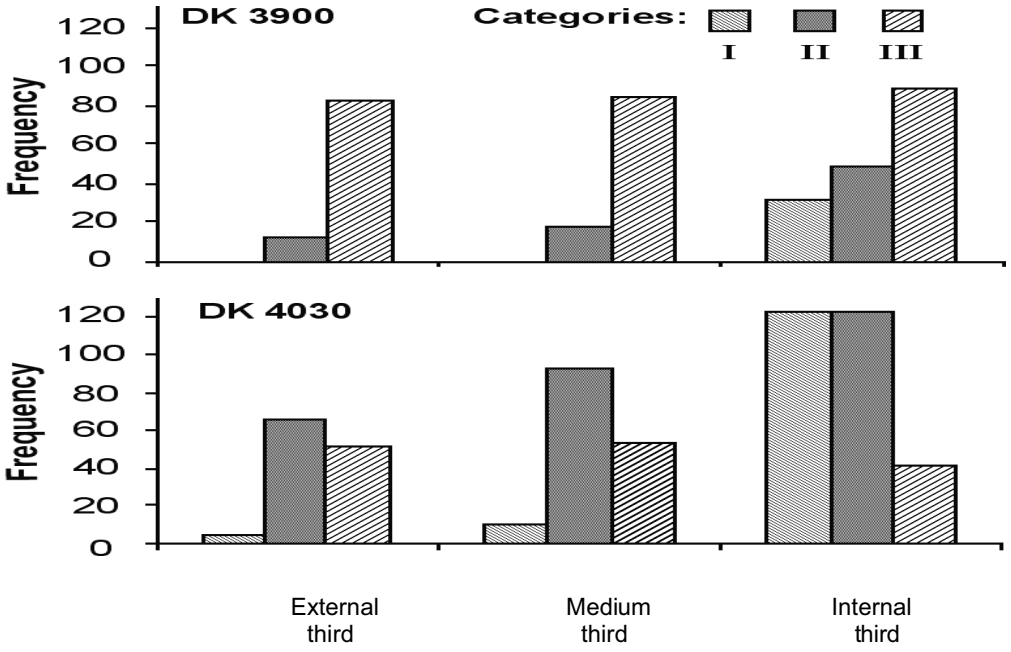

Figure 2**.** Average distribution for both locations of IDF in each third of the parastichies in capitula of DK3900 and DK4030.

DK4030 showed a higher ($p<0.01$) frequency of embryos than DK3900 for both locations (Table 1). No embryos were observed in IDF of **Cat I** in DK3900 for both locations nor in IDF of **Cat II** for Villalonga (Table 1). DK4030 presented embryos in the three categories of IDF in both locations (Table 1).

Table 1. Relative frequency of embryo in each category for both genotypes and locations.

Genotypes	Villalonga			Palihue		
	Categories					
	I	**II**	**III**	**I**	**II**	**III**
DK3900	0	0	0.21	0	0.11	0.29
DK4030	0.33	0.25	0.36	0.42	0.39	0.80

No differences were found in average dimensions of IDF embryos of Cat II and III in each genotype and location ($p>0.05$). In DK3900 IDF embryos of Cat III from Palihue were smaller than those from Villalonga ($p<0.01$). In DK4030 IDF embryos average dimensions of each category were similar ($p>0.05$) between locations while those of Cat I were smaller ($p<0.01$) than those of Cat II and III (Figure 3).

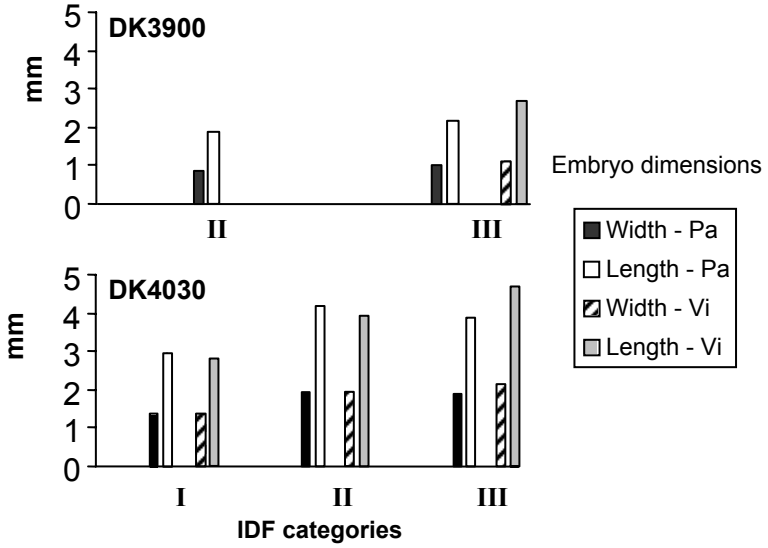

Figure 3. Dimensions (width and length in mm) for embryos observed in each category of IDF in both genotypes and locations. Pa: Palihue; Vi: Villalonga.

The average embryo shape ranged from small heart-shaped (Figure 4B) with approximately 1.1 mm width and 2.2 mm length to embryos with 2.2 mm width and 4.7 mm length (Figure 4C) in all categories. So, the three categories differed in the development achieved by the fruit pericarp but this morphological character was associated neither with the presence nor with the developmental status reached by its seed embryo (Figures 3 and 4).

The results presented herein suggest that the energetic cost of each DK3900 plant producing a lower percentage of IDF per capitulum with a higher proportion of Cat III and a lower embryo frequency (Figure 1, Figure 4D), would be the same as that in DK4030 expressed by higher percentage of total IDF, mainly of Cat II, with a higher embryo frequency (Figure 1, Figure 4B).

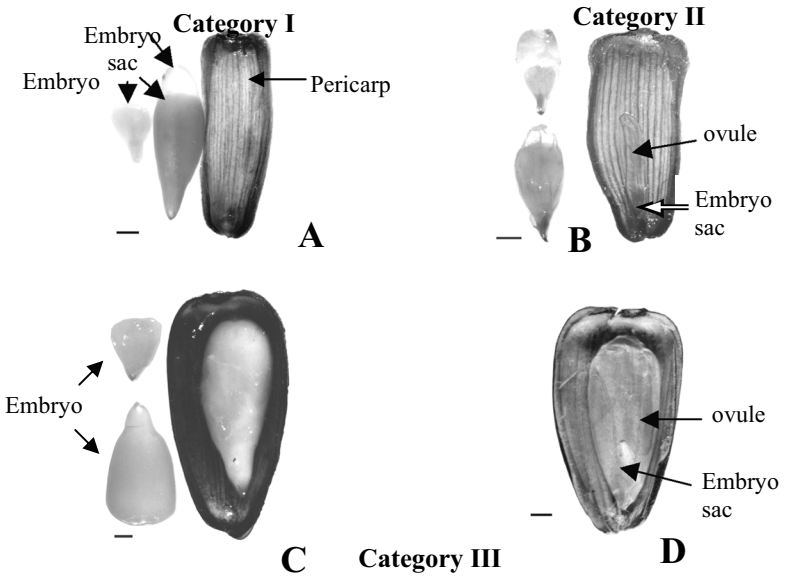

Figure 4. A–D. Pericarp and degree of development reached by the corresponding embryo in IDF of the three categories. (Genotype DK3900) **A.** Heart-shaped embryo and a more developed embryo. **B**. Two embryo sacs with heart-shaped embryos and an open fruit showing its ovule and embryo sac without a visible embryo. **C**. Different size of embryos observed in IDF of Cat III**. D**. Dissected fruit of Cat III showing its ovule and embryo sac without visible embryo. Bar= 1mm.

Conclusions

We conclude that the presence of IDF in a mature sunflower capitulum is not just a quantitative phenomenon but also qualitative. Therefore, to evaluate accurately its incidence in the yield, the relative proportion in which the different categories of IDF appear in different genotypes should be considered.

Acknowledgements

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