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SUNFLOWER CULTIVAR RESPONSES TO NON-UNIFORMITY OF THE STAND: EFFECTS ON YIELD PER PLANT AND AT THE CROP LEVEL

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SUMMARY

Non-uniformity of the sunflower stands at crop establishment is commonly observed on farms and is often associated with reduced yields. We hypothesized that cultivars with plasticity of response in capitulum size have a greater capacity to acclimate to the non-uniformity of the stand in terms of flower number and grain yield.

Crops of two cultivars of putative different plasticity were conducted under non limiting conditions of water and nutrients at FAUBA during 1998-99 season. Desired crop non-uniformity was established by removing plants in the target row at the two leaf-stage. Treatments with non-uniform border rows were also included. Crop developmental stages were recorded and grain yield was determined at physiological maturity.

Cultivars did not differ significantly in response to treatments. Yield per plant was directly related to distance between plants in the row. Spacing of plants in the border row affected yield to a lesser extent. The relationship between yield per plant and the distance between plants in the row allowed us to estimate the potential yield (plants protected from lodging, insects and diseases) of crops with a degree of non-uniformity characteristic of Argentine sunflower crop areas. The results indicate that yield of non-uniform crops are equal or higher than yields of uniform crops of the same density because of the higher contribution to crop yield of the proportion of plants at low distances in the row.

Provided non limiting conditions are supplied to the crops (i.e. in the absence of biotic, water, and nutrient stresses, and protecting plants from lodging) the "crowded" plants in the row compensate, more than proportionally, the unused space of the sparse plants in the crop.

INTRODUCTION

The non-uniformity of sunflower crop stands at establishment is a problem even among good farmers. Although many of these non-uniform crops reach full cover in anthesis, crop yield is impaired (AACREA, 1998). Sunflower cultivars exhibit variability for capitulum size. We hypothesized that those cultivars with greater plasticity for capitulum size have a greater capacity to acclimate to the non-uniformity of the stand in terms of flower number and grain yield and compared the effects of non-uniformity on the yield of two cultivar of reputedly contrasting plasticity.

The effects of suboptimal plant density and non uniformity in plant spacing on sunflower grain yield was studied by Wade et al. (1988) using regression techniques in order to predict yield reductions due to those factors. Their equations were developed for the very low yield conditions of Australian rainfed areas and they are not applicable to areas of higher sunflower yield potential. In this research we have attempted a different approach to this issue. This involves combining i) an analysis of cultivar responses to non-uniform distributions under protection from biotic and abiotic stresses with ii) on-farm records of crop uniformity.

MATERIALS AND METHODS

Crops of Aguará (AG) and Contiflor 9 (C9), hybrids of putative contrasting plasticity of capitulum size, were grown under non limiting conditions of water and nutrients at the experimental field of the Facultad de Agronomía, Universidad de Buenos Aires (34° 35′ S., 58° 29′W.) during 1998-99 season. Diseases, insects and lodging were controlled. The distance between rows was 0.70 m (the commercial norm in Argentina) and desired crop non-uniformity was established by removing plants from the oversown crop in the target row and/or the border rows at the two-leaf stage. Treatments consisted in widely spaced, normal and crowded stands in the target row, combined with a range of densities in the border rows (Table 1). Harvest plot size was 0.60 m^2 for both crowded and normally spaced stands and 0.78 m^2 for widely spaced ones. A split plot design with three replications was used. Yield per plant was determined at physiological maturity on 3 plants per replication in the target row.

Table 1: Definition of treatments which combined wide, normal and crowded spacing in the target row, with normal, wide and crowded spacing in the border rows at 0.70 m to each side of the target row.

Treatment	Distance between plants in the target row (m)	Distance between plants in the two border rows (m)
T1 (commercial density)	0.28	0.28
T2	0.14	0.28
T3	0.56	0.28
T4	0.56	No border
T5	0.14	No border
T6	0.14	0.14
T7	0.56	0.14
T8	0.14	0.56
T9	0.56	0.56

A survey of commercial crops in the main sunflower crop zones of Argentina was performed by AACREA (1998) and non-uniformity evaluated. Measurements of the distances between plants in the row at the establishment stage were made on plots of 10 m^2 with six replications per field. Number of evaluated fields was 110. The data from these surveys were used to develop frequency distributions of distances between plants in the row and to establish ranges of non-uniformity typical of on-farm conditions.

RESULTS

Duration of pre-anthesis phase in C9 was 62 days from emergence and took a week longer in AG. Both hybrids completed the post-anthesis phase in 45 days. Yield per plant (Y, g $plant^{-1}$) showed a significant (P=0.05) relationship with distance between plants (D, cm) in the row which did not differ among hybrids (Figure 1) the relationships being:

$$Y = (35.4 \pm 7.15) + (1.2 \pm 0.22)\,D \text{ for C9} \quad (1)$$

$$Y = (44.6 \pm 9.50) + (1.3 \pm 0.24)\,D \text{ for AG} \quad (2)$$

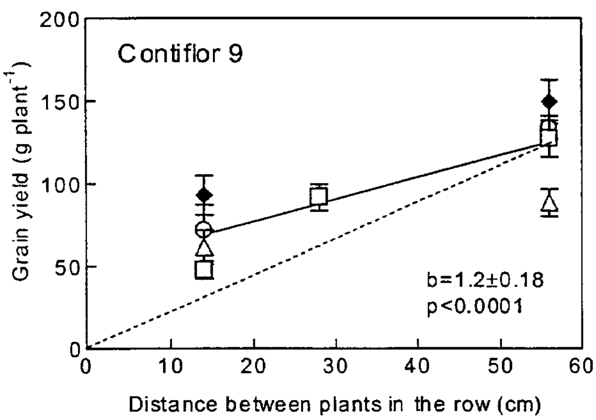

Figure 1: Grain yield per plant as a function of the distance between plants in the target row of C9 sunflower crops and response to density in the neighboring border rows. Dotted line: see text for explanation. Symbols: Treatments T1, T2 and T3 (squares); T4 and T5 (closed diamonds); T6 and T7 (triangles); T8 and T9 (open circles). See Table 1 for further details.

The density of plants in the neighboring border rows only had significant effects on yield per plant when the border row was lacking (i.e. treatments T4 and T5) (Figure 1). Nevertheless, there was a consistent trend for target rows surrounded by dense and sparse neighboring rows to yield less or more, respectively, than target rows flanked by normal density border plots. There was no effect of cultivar on yield per plant in any treatment, although AG did form a significantly larger number of florets per head in non-uniform crops (data not shown). However, this greater number did not translate into variations in grain number or yield. Due to the lack of cultivar effects a single yield-distance relationship was developed using data from both hybrids:

$$Y = (40.0 \pm 6.1) + (1.3 \pm 0.16)\,D \quad (3)$$

The frequency distribution of the distance among plants in on-farm crop rows found in the AACREA survey (1998) varied from quite uniform (e.g. Figure 2a) to very non-uniform (e.g. Figure 2d). However, even in uniform crops, the frequency of plants at the planned interval (ca. 28 cm) seldom reached 75 %. Mean crop densities (d) tended to decrease as mean spacing (D) and variance (V) increased. Equation 3 was used in combination with observed frequency distributions, to estimate crop yield over a range of mean densities (Figure 3, solid line). These estimates were compared with hypothetical uniform crops (i.e. with V= 0) of equivalent densities (Figure 3, dotted line). This exercise gave an unexpected result: non-uniform crops had equal or higher yields than the equivalent hypothetical uniform crop. Within the range of distances between plants explored in our experiment, plants at low distances (e.g. 14 cm) contribute more than proportionally to the yield of a non-uniform crop because the association Y/D had a positive Y intercept (Equation 3 and Figure 1) as compared with a linear relationship Y/D, with Y= 0 intercept (Figure 1, dotted line). When, as a result of non-uniformity, mean crop density was low, yield compensation among the proportions of dense and sparse plants diminished and yield of uniform and non-uniform crops became similar (Figure 3). We emphasize that the plots of highest density in the target row (i.e. Treatments T2, T6 and T8) were protected from lodging during grain growth, protection that is not possible in on-farm crops.

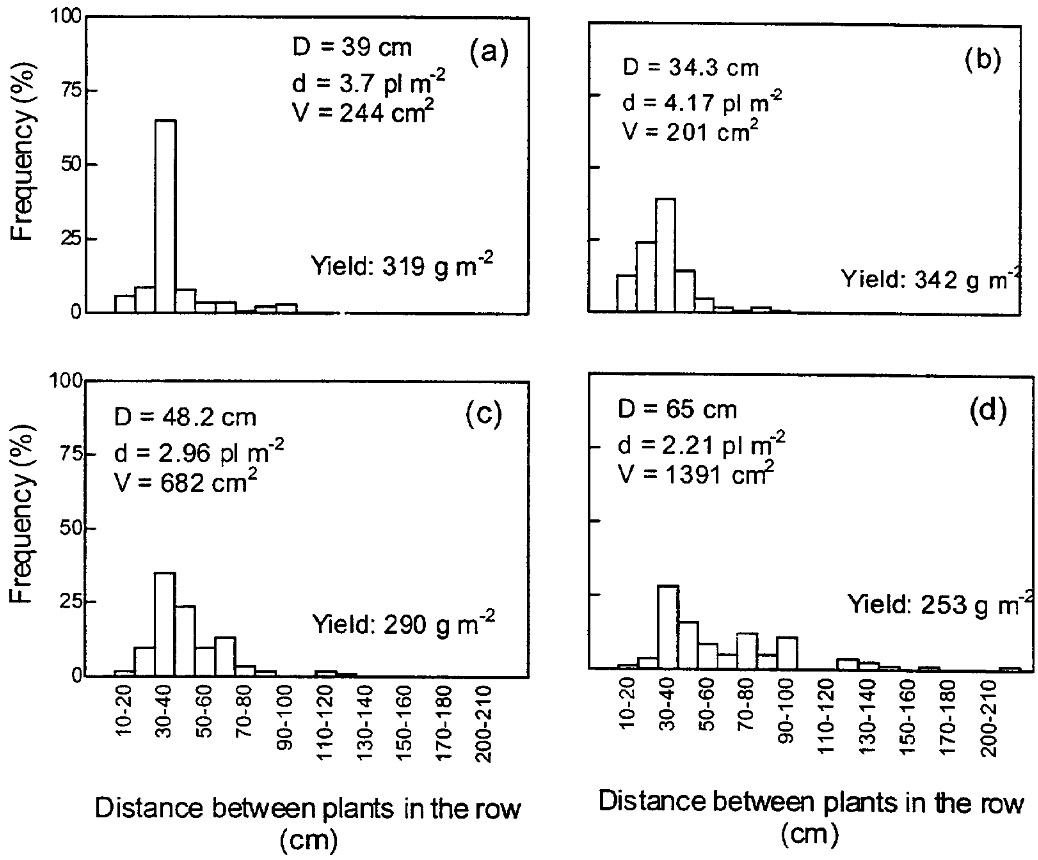

Figure 2: Examples of frequency distribution of distances between plants in the row of four sunflower crops, part of a survey performed by AACREA (1998) on farms of the sunflower cropping area of Argentina. D = mean distance between plants; d = mean crop density; V = variance.

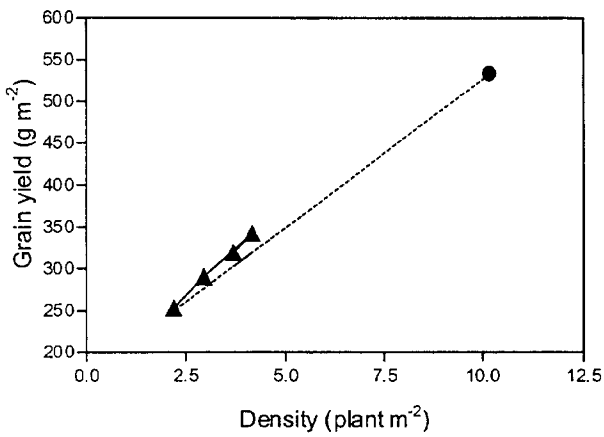

Figure 3: Grain yield as a function of crop density for the crops whose frequency distribution of distances between plants is presented in Figure 2 (solid line, triangles) and for hypothetical uniform crops of equivalent density (dotted line). Circle illustrates yield of an hypothetical uniform crop at 10.1 plants m^{-2}. Yield per plant was estimated using Equation 3 for each class of the frequency distributions shown in Figure 2 and converted to yield per unit area using the same distributions

DISCUSSION

Our results show that sunflower yield potential is not impaired by non-uniformity within the range of mean densities used in our conditions. No cultivar differences in acclimation to non-uniformity were found when measured in terms of yield. AG did, however, show responses to treatments in terms of number of florets per head.

The results also show that sunflower crop density can be higher than usually recommended for commercial crops. Actual recommended density ranges are determined by factors other than the capacity of the plant to adjust to space availability. The results are not in accordance with the estimations of Wade et al. (1988) which indicated reductions in yield with increased non-uniformity and density in low potential yield environments.

Effects on yield of plants having dense border rows were low in extent and did not impaired the yield of non-uniform crops, but merit to be explored in future experiments. The two-dimension approach (i.e. non-uniformity evaluated through distances between plants in the row) would require improvement to a three-dimension approach considering the array formed by the target row and the two neighboring border rows.

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