POLLINATION STUDIES IN HYBRID SUNFLOWER SEED PRODUCTION.

D. DRANE, R. MACPHERSON, and K. WHITE
Arthur Yates & Co. Pty. Ltd., Narromine, N.S.W. 2821 Australia.

ABSTRACT

Successful seed production of hybrid sunflowers relies on the satisfactory transfer of pollen by vector insects, especially bees, from male-restorer (R) lines to cytoplasmic male-sterile (A) lines. A common dilemma is the potential increase in seed yield which may result from introducing bee hives into seed production crops. Bee activity was monitored in a range of hybrid sunflower seed production crops in the Macquarie Valley region in central-western N.S.W. Bee activity was related to stage of flowering, female row distance from male, ratio of male-sterile (A) lines to male-restorer (R) lines, actual size of the crossing block and apparent attractiveness of the three female lines used in the study. The effect of the addition of bee hives into several crops on bee activity and seed yield was also observed.

INTRODUCTION

Seed production of hybrid sunflowers based on the use of cytoplasmic male-sterility and fertility restoration, essentially relies on the physical transfer of pollen by insects from the fertility-restoring parental male line (R-line) to the cytoplasmic male-sterile female line (A-line). Radford and Rhodes (1978) and Furgala *et al.*, (1976) have indicated that cytoplasmic male-sterile lines may be less attractive to bees than pollen-bearing sunflowers. Since a major objective of hybrid sunflower seed production must be to maximise yields from the crossing block, it is important to understand the activity of pollinating insects and their interaction with the parental lines, and also to determine levels of insect activity above which pollination and seed set will be sufficient to allow the full yield potential of the crop to be realised.

For commercial sunflower crops in Australia, Langridge and Goodman (1974) and Radford and Rhodes (1978) have found domestic honey bees to be the only significant pollinators. In hybrid seed production blocks in France, Delaude and Rollier (1977), found domestic bees usually comprise over 95% of the pollinating fauna, except in several instances where the female line was less attractive. The present study has only considered the role of domestic honey bees as pollinating fauna.

The objectives of the present study were

- To observe patterns of bee activity in hybrid sunflower crossing blocks at different times during the day, at three stages of flowering.
- To relate this bee activity to the overall ratio of male-sterile (A) lines to male-restore (R) lines, and also to the actual number of successive rows of A-lines and R-lines at a constant ratio.
- To determine the degree to which bee activity, as influenced by the overall female-male ratio and by the size of the crossing block, affects the productivity of seed production crops.
- To compare a number of A-lines and R-lines in terms of attractiveness to bees, and productivity.
- To assess the need to introduce bees to supplement indigenous populations.

METHODS

The study was commenced in September 1980 and involved eleven (11) hybrid sunflower seed production crops located in the Macquarie Valley region of central-western N.S.W.

The eleven crossing blocks were planted from September to December 1980 at different numbers of female (F) and male (M) rows, including 10F:2M, 12F:4M, 14F:4M, 16F:4M, 18F:6M and 30F:10M. The overall female to male ratios represented in these crops were 3:1, 3.5:1, 4:1 and 5:1. The crossing blocks were planted to three different combinations of three female and two male lines. The three female lines in the study were designated SX52F, SX51F and SX150F.

Before flowering, three (3) samplings sites comprising a group of male and female rows were selected and marked out in each crossing block. During flowering, daily counts of bee activity were performed on twenty (20) heads per alternate row at three (3) flowering stages (25%, 50% and 75% flowering) and at four (4) time periods during the day (10.00h, 12.00h, 14.00h, 16.00h). By definition, 25% flowering was reached when half of the flowering heads in a row sample had three circles of disc flowers open. At 50% flowering two-thirds of the florets were open in at least half of the flowering heads, 75% flowering was reached when the innermost one-third of the disc flowers were opening in a majority of heads.

After flowering, ten (10) heads in each row were bagged to protect them from possible bird damage. After physiological maturity (backs of heads turned yellow and involucral bracts brown), the bagged heads were harvested and air dried on trays.

Heads were later assessed subjectively for percentage seed set, then hand threshed and seed weight per head and 100 seed weight recorded. Oil content was determined using a Newport Mark III Analyser.

RESULTS AND DISCUSSION

Bee activity versus flowering stage and time of day. The levels of bee activity during flowering and at different times of the day averaged over all sites are indicated in Figure 1. Bee activity was highest during the early to mid stages of flowering and decreased to a low level at 75% flowering (Table 1). Delaude and Rollier (1977) similarly found that the capitulum of male-sterile and male-fertile heads in hybrid sunflower crossing blocks in France were most attractive to bees at around the 50% flowering stage. The peak levels of bee activity at 50% flowering in the present study were probably due to a peak in nectar production and crop attractiveness, since at this stage all heads in the crop were open and visible producing nectar.

Table 1. Mean bee activity and seed yield per female head averaged over all crossing blocks in relation to flowering stage.

Flowering Stage	Mean Bee Activity Per Head ± SE	Mean Seed Yield Per Head ± SE	Correlation
25%	0.56 ± 0.04a	41.63 ± 1.24a	r = 0.90(P<0.01)
50%	0.62 ± 0.03a	42.84 ± 0.92a	r = 0.81(P<0.05)
75%	0.26 ± 0.02b	32.48 ± 0.83b	r = 0.76(P<0.05)
mean	0.48 ± 0.03	39.00 ± 0.97	r = 0.86(P<0.01)

P a,b < 0.01

From Table 1, it can be seen that mean bee activity per head was highly correlated with mean seed yield per head for all flowering stages. This relationship suggests that for any male-sterile head in the crossing blocks, the amount of bee activity was the main determinant of the seed yield from that head. It also may suggest that the saturation point for bee numbers in the crops may not have been reached, i.e. that bee numbers may have been limiting.

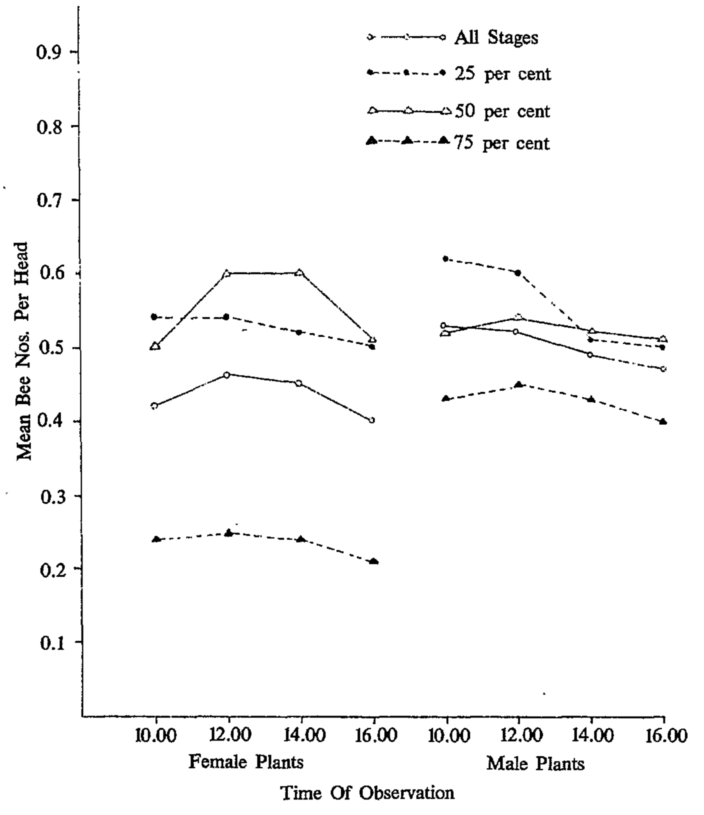

Figure 1. Daily bee activity according to flowering stage, averaged over all crops.

In terms of the flowering process, the relationship between mean bee activity per head at 75% flowering and mean seed yield per head is considered to be particularly important, since at this stage bee numbers are most likely to be limiting in some crossing blocks. The use of branched males in which secondary branches enable a spread of the pollen period could well be important in ensuring pollination and subsequently maximum seed yields in hybrid production crops, as was evident in the study of Delaude and Rollier (1977).

Bee activity and seed yield across male-sterile rows. The distribution of bee activity across the female rows in the crossing blocks averaged over all sites and flowering times is illustrated in Figure 2. As can be seen, bee activity in the female rows increased slightly with increasing distance from male rows. Even though it is not shown, this increased in activity was similar at all flowering stages (25%, 50%, 75%). This result is similar to that of Delaude and Rollier (1977) who found that the frequenting by pollinating insects in a 8 Female: 2 Male crossing block were similar in both border and medium rows of the female. It might have been expected that bee activity might have decreased with increasing distance from the male rows, but this was not the case. To a degree, this might be accounted for by the fact that most pollination of male-sterile lines is done by nectar collectors; Langridge and Goodman (1974) found nectar collectors accounted for 97.3% of honey bees in a commercial sunflower crop in Australia, whilst Free (1964) observed that pollen collectors in sunflower crops kept their bodies more free of pollen than nectar collectors and so made a lesser contribution to pollination.

Mean seed yield per head for each row averaged over all sites followed a similar trend to bee activity (Figure 2), and was comparable to the high correlation between these two parameters seen in Table 1. Bee activity and seed yield per head only dropped off after 9 to 11 rows distance from male rows. This indicates that numbers of female rows in crossing blocks up to 18 to 20 rows may not reduce yields per female row even when bee numbers are limiting.

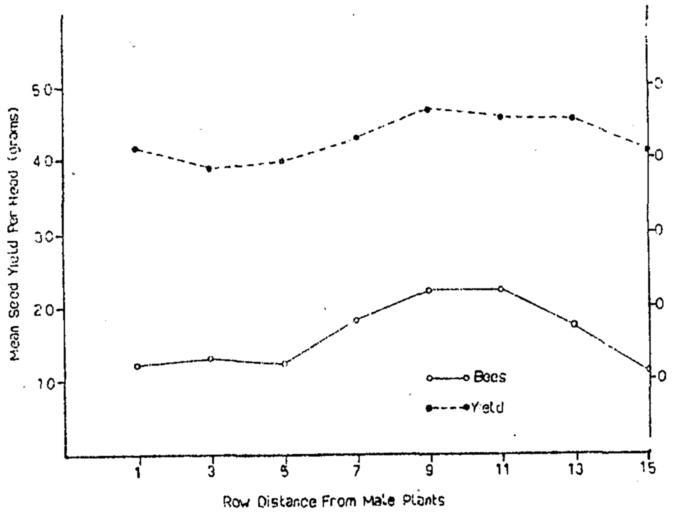

Figure 2. Distribution of mean seed yield per head and mean bee activity per head averaged over all sites and flowering times, on a row basis.

Delaude and Rollier (1977) similarly found that pollinating insects were just as efficient in terms of both activity and seed yields on a ratio of 8F:2M as on 4F:2M and 6F:2M. As a result in their study seed yield per overall ha increased from 4F:2M to 6F:2M to 8F:2M with the 8F:2M ratio having an average increase in productivity per overall ha of 26% over the 4F:2M ratio.

Bee activity versus size of crossing block and female to male ratio. There was no significant differences between ratios of female to male rows in terms of bee activity in the female rows, with the exception of crossing blocks sown at a ratio of 3.5F:1M (Figure 3; Table 2, columns B,F). The reduced activity of the two crossing blocks sown on 3.5:1 ratio (actually 14F:4M) may have been due to a reduced attractiveness of the female lines sown at these sites and may not reflect the overall trend.

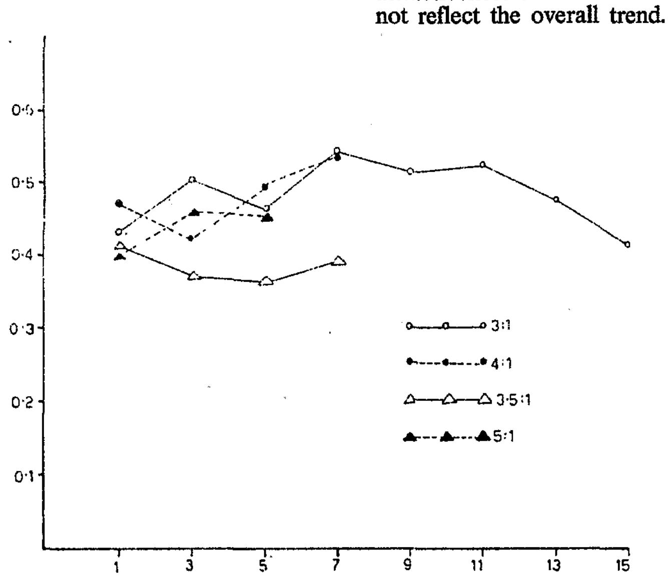

Figure 3. Mean bee activity per female head according to row distance from male plants for different ratio of female: male rows.

Table 2. Bee activity and seed yield per head for different female to male ratios and crossing block sizes.

A Crossing Block Size (Number of F:M rows)	B Female to Male Ratio	C Number of Observations	D Mean Bee Activity per Head ± S.E. Crossing Block Male	E Female	F Mean F:M Ratio Female	G Mean Seed Yield Per Female Head ± S.E. Crossing Block	 F:M Ratio
12F:4M	3:1	6	0.79 ± 0.02a	0.37 ± 0.01b		31.45 ± 0.67c	
18F:6M		6	0.38 ± 0.02c	0.53 ± 0.02a		55.12 ± 2.05a	
30F:10M		3	0.35 ± 0.06c	0.49 ± 0.06a	0.48 ± 0.03a	45.42 ± 1.30b	46.78 ± 1.52a
14F:4M	3.5:1	6	0.47 ± 0.02b	0.38 ± 0.01b	0.38 ± 0.01b	32.22 ± 0.79c	32.22 ± 0.79b
16F:4M	4:1	6	0.86 ± 0.02a	0.48 ± 0.01a	0.48 ± 0.01a	34.25 ± 0.61c	34.25 ± 0.61b
10F:2M	5:1	6	0.40 ± 0.03c	0.44 ± 0.02ab	0.44 ± 0.02ab	45.10 ± 3.67b	45.10 ± 3.67a

Means with different superscript within columns differ significantly $P < 0.01$

The mean seed yield per female head at the different ratios again closely followed that of bee activity per head (Table 2, columns F, H) although ratios of 3:1 and 5:1 had significantly higher seed yields than ratios of 3.5:1 and 4:1. Crops of SX52 hybrid sunflower were mainly produced at ratios of 3:1 and 5:1, and it is considered that the higher average seed yields at these ratios is mainly a reflection of the greater female attractiveness of its female parent line. In fact for crops of the same hybrid grown at different ratios of F:M, there were almost no differences in terms of bee activity or seed yield per head.

There were some differences when bee activity and seed yield per head were compared for different crossing block sizes (Table 2, columns A, D, E, G). However again these differences mainly reflected the female line used and showed no consistent trend with block size. The only visible decline in bee activity with row distance from male occurred after 11 rows.

Bee activity in different parental lines/female attractiveness. Figure 4 illustrates the daily distribution of bee activity, averaged for their respective sites, for the various male and female parents of the three hybrids whose seed was produced. Bee activity per female head differed significantly for the three females used (Table 3) with the female of SX52 having the highest activity and the female of SX150 having the least. The female of SX52 also had the highest mean seed yield per head (Table 3). It is suggested that the higher bee activity and seed yield for the female of SX52 is due to higher bee attractiveness for this female than for the other two females.

Table 3. Mean bee activity and seed yield per head averaged according to hybrid being produced.

Hybrid	Number of Blocks	% Crude Protein of Male Pollen	Mean Bee Number Male	Per Head ± S.E. Female	Ratio of Bee Activity Female/Male	Mean Seed Yield Per Female Head ± S.E.
SX52	5	25.6%	0.40 ± 0.02a	0.48 ± 0.02a	1.20a	46.63 ± 0.98a
SX51	4	25.6%	0.65 ± 0.01b	0.38 ± 0.01b	0.58b	26.87 ± 0.97b
SX150	4	26.1%	0.68 ± 0.02b	0.34 ± 0.01c	0.50b	27.78 ± 1.34b

Means with different superscripts within columns differ significantly $P < 0.01$

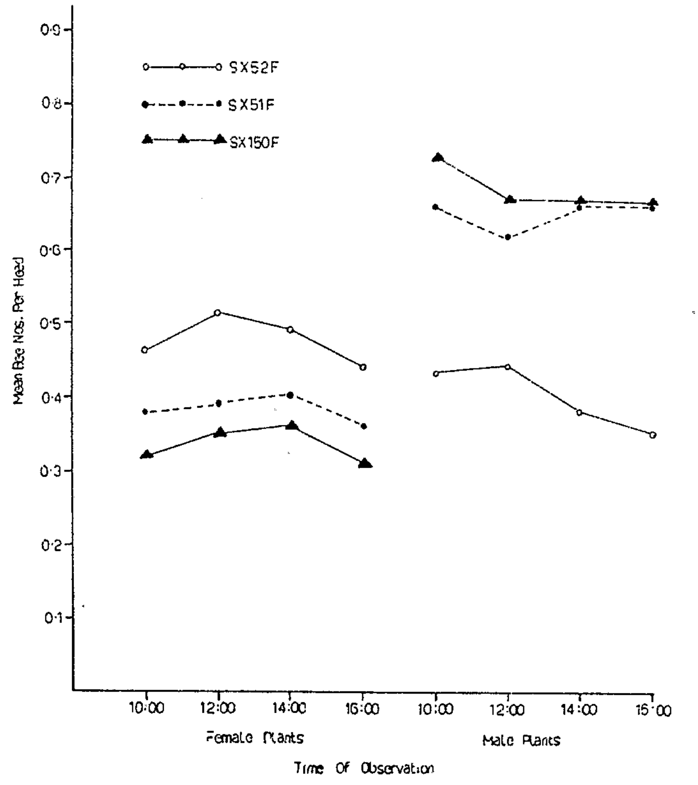

Figure 4. Daily distribution of bee activity according to variety.

There were also considerable differences between the male parents of SX150 and SX51 with SX150. It is interesting to note that the order of activity among the three females is completely reversed in the male parent. it is suggested that this is due to the female parents exhibiting a differential attractiveness for a limited number of bees — if the female has good attractiveness, bee numbers on the male heads are reduced.

No differences were found in protein quality of the pollen from the male lines used (Table 3).

Effect of introducing bee hives. A comparison of crossing blocks of SX51 and SX150 which received bee hives to those which relied on an indigenous population of bees is shown in Table 4 and Figure 5. For both comparisons it was found that introducing bee hives significantly increased mean bee activity in both male and female rows.

Table 4. Effect of introducing bee hives on bee activity per head and seed yield per female head.

Hybrid	Number of Observations (n)	Mean Bee Numbers per Head ± S.E. Male	Female	Ratio of Bee Activity Female/Male	Mean Seed Yield Per Female head (gm) ± S.E.
SX51 Without Hives	6	0.86 ± 0.03	0.28 ± 0.03	0.33	17.85 ± 1.29
With Hives	6	0.44 ± 0.01**	0.48 ± 0.01**	1.09**	34.25 ± 0.61**
SX150 Without Hives	6	0.57 ± 0.02	0.30 ± 0.01	0.53	25.90 ± 1.80
With Hives	6	0.79 ± 0.02**	0.37 ± 0.01*	0.47	31.45 ± 0.67

*P < 0.05 **P < 0.01

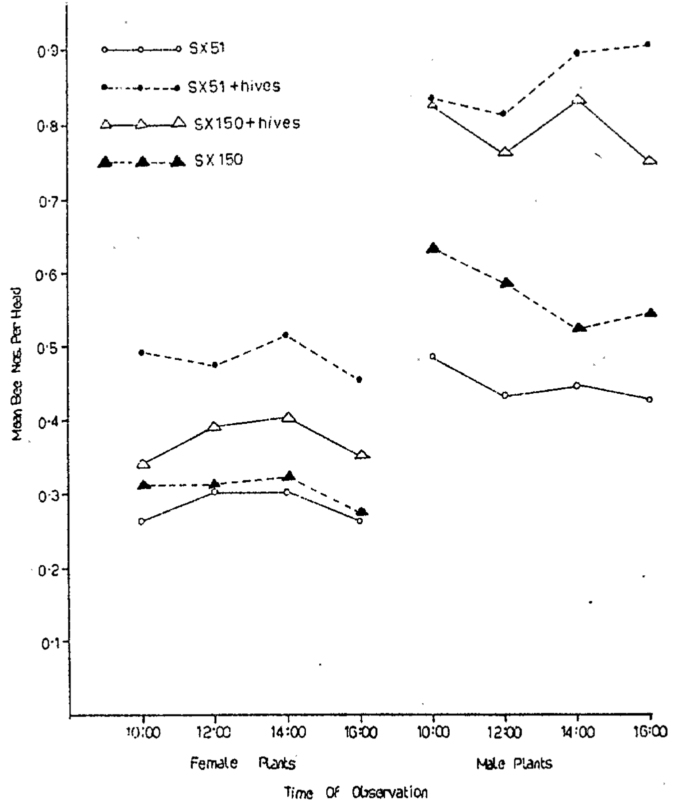

Figure 5. Effect of introducing bee hives on mean bee activity per head in crossing blocks of two hybrids.

With SX51, the addition of bee hives resulted in a significant yield increase over the crossing blocks which received no added hives (Table 4). However there was no significant increase in mean seed yield per head fo SX150. This lack of increase with SX150 may have been partly due to site problems with the crop to which bees were added.

100 Seed weight and oil content. There was no significant differences between mean bee activity per head and 100 seed weight or seed oil % for any of the crossing blocks or treatments (Figure 3). Although there was no significant difference between mean bee activity in the 30F:10M crossing block and the smaller 18F:6M unit, it is suggested that the safe limit of crossing block size was exceeded in the 30F:10M block.

CONCLUSIONS

For the eleven hybrid sunflower seed crossing blocks studied, there was a significant correlation between mean bee activity in the female rows and the subsequent yield of hybrid seed from the female parent. There were also consistent differences between the overall female to male ratios examined from 3F:1M up to 5F:1M, particularly within the one hybrid. These two relationships indicate that increasing the ratio of female to male rows, up to at least 5F:1M may be used to increase yields in hybrid sunflower seed crops, without causing any loss in bee activity or productivity in the female rows. In addition actual block sizes of up to 18 female rows did not cause any decrease in bee visits and subsequent seed yields. There was in fact a slight trend towards increasing bee activity and seed yield as the number of female rows increased up to at least 9 rows from the nearest male row.

Female attractiveness appears to be an important factor in increasing seed yields in hybrid crossing blocks of sunflowers. It is suggested that the higher bee activity and seed yields in crossing blocks of SX52 than in two other hybrids were mainly due to a greater bee attractiveness of the female parent of SX52. Where bee numbers in the female line were high, bee numbers in the corresponding male rows were low, and vice-versa, and it is suggested that this effect is mainly due to variable success of the different female lines in competing for a limited number of bees.

The addition of bee hives into two hybrids resulted in significant increases in bee activity in both females, but only gave significant increases in seed yield with the female of SX51. However in view of the increase in bee activity in the crops into which bees were introduced together with the high correlation averaged over all sites between mean bee activity per female head and seed yield per head, it appeared that in most of, if not all, the crossing blocks studied the numbers of bees were limiting.

From the above findings, it is suggested that where bee numbers are likely to be limiting in hybrid sunflower seed production crops, restriction on the number or ratio of female rows to male rows is unlikely to lead to an increase in seed yield per female row. The introduction of bee hives into hybrid sunflower seed production crops, together with the use of females with better attractiveness and/or the use of branched male restorer lines would appear to offer more chance of increasing seed yields, both in the female rows and per overall area.

LITERATURE CITED

DELAUDE, A and ROLLIER, M. 1977. *Information Techniques — Cetiom* 56: 15 — 24.

FREE, J.B. 1964. *Journal of Applied Ecology* 1: 19 — 27.

FURGALA, B., NOETZEL, D.M. and ROBINSON, R.G. 1979. *Proceedings 4th International Symposium on Pollination, Maryland.* 1978. 45 — 48.

LANGRIDGE, D.F. and GOODMAN, R.D. 1974. *Australian Journal of Experimental Agriculture and Animal Husbandry* 14(67); 201 — 204.

RADFORD, B.J. and RHODES, J.W. 1978. *Queensland Journal of Animal Sciences* 35(2): 149 — 157.

T1982AGR37

SUNFLOWER HOLLOW SEEDEDNESS AND NITROGEN FERTILIZATION IN RELATION TO HARVESTING TIME.

E.A. OGUNREMI

Institute of Agricultural Research and Training, University of IFE, P.M.B. 5029, Moor Plantation, Ibadan, Nigeria.

ABSTRACT

Field trials were conducted for three years at Ibadan to investigate the effects of harvesting time on hollow seededness in relation to nitrogen fertilization. Treatments consisted of six nitrogen levels — 0, 30, 60, 90, 120 and 150 kg/ha and five harvesting times — 3, 4, 5, 6 and 7 weeks after 'spearing'.

Results showed that hollow seededness was significantly influenced by harvesting time. Up to 50% of the seeds were unfilled when harvesting was done before five weeks after spearing. The percentage of unfilled seeds was significantly reduced five weeks after spearing. Hollow seededness was not affected by application of up to 90 kg/ha N. Increasing added nitrogen beyond 90 kg/ha significantly reduced seed and oil yields by increasing the proportion of unfilled seeds.

Complete paper not received at time of printing.

T1982AGR38

EFFECT OF ACHENE (SEED) SIZE ON SUBSEQUENT GROWTH AND DEVELOPMENT OF HYBRID SUNFLOWER (*HELIANTHUS ANNUUS* L.).

EFECTOS DEL TAMAÑO DE AQUENIO (SEMILLA) SOBRE EL CRECIMIENTO Y DESARROLLO DE GIRASOL HIBRIDO (*HELIANTHUS ANNUUS* L.)

LEONIDAS CHOLAKY, OSCAR GIAYETTO Y EDGAR C. NEUMANN.

Facultad de Agronomía y Veterinaria-Universidad Nacional de Río Cuarto, 5800-Río Cuarto, Argentina.

ABSTRACT

Achenes of sunflower (*H. annuus*) were graded into four size classes (2 large, 3 and 4 intermediate and 5 small) and were compared in relation to germination, emergence, growth and development, plant morphological characteristics, yield components achenes and oil production/ha., pericarp, embryo and protein percentage and quality of harvested achenes for seed. The test was carried out under field conditions at two sowing depths (5 and 10 cm). Sunflower seedlings from small achenes were found to emerge more rapidly at both sowing depths and to have a smaller area of cotyledons. The latter were found to contain a low percentage of oil and higher germination energy, power and coefficient rate index. The mean emergence rate for the four degrees of achenes was higher at the 10 cm sowing depth. Size of achene and sowing depth had no effect on hypocotyl and taproot length and weight, sunflower growth and development, height and number of leaves per plant, ratio of plant height to number of leaves, stem diameter, head and unproductive head area, weight of achene per head, and 1,000 achenes weight, achene and oil production/ha., and pericarp, embryo and protein percentage of harvested achenes.

INTRODUCCIÓN

Con la incorporación de cultivares híbridos al gran cultivo del girasol (*Helianthus annuus* L.), se están comercializando aquenios de diferente calibración como semilla para un mismo cultivar. Ello ha originado inquietudes entre los productores de esta oleáginosa con respecto a la conveniencia de sembrar uno u otro tamaño de aquenio de determinado cultivar híbrido, dado que los antecedentes existentes en la literatura para esta especie no son suficientes y completamente concordantes entre ellos. De allí, que este estudio tenga por finalidad evaluar bajo condicioes de secanó, los efectos de diferentes tamaños de aquenios sembrados a dos profundidades sobre el crecimiento, desarrollo, morfología, componentes del rendimiento y producciones de aquenios y