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SEED SET IN SUNFLOWER CROPS ON THE CENTRAL DARLING DOWNS, QUEENSLAND

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SUMMARY

Seed set was measured in sunflower crops on the central Darling Downs in 1974-75 and 1975-76.

In generally fine weather in 1974-75, seed set in heads open to pollination (79 to 97%) was positively correlated with seed set in bagged heads at the same site (0 to 48%). Seed set in the open heads was not significantly correlated with percentage commercially usable achenes (40 to 84%). Seed set in open heads was independent of number of beehives within 3 km and area of crop, indicating that pollinators were adequate.

In 1975-76, heads which flowered during five wet days had lower seed set than heads which flowered in fine weather. Achene yield per head was also lower. This is attributed to reduced honeybee activity during the wet weather and low self-compatibility in the cultivars studied.

I. INTRODUCTION

Sunflowers have become an important crop in the economy of the Darling Downs, and growers and researchers are keen to identify factors limiting achene yields. One such factor may be level of seed set.

Cultivars currently grown have low self-compatibility and seed set is dependent on the transfer of compatible pollen from other flowering heads by external agents (Free and Simpson 1964). Of these, large insects such as honeybees are more effective than wind and small insects (Putt 1940). Honeybees are by far the most abundant insect visitors to sunflower crops on the central Darling Downs (Radford *et al.*, unpublished data), but whether there are always enough for crop requirements is not known. Reduction in seed set could be expected when prolonged wet weather coincides with flowering, since honeybees do not forage in heavy rain and fly only short distances in light rain (Ribbands 1953) and sunflower stigmas remain receptive for only five days (Putt 1941). Jensma (1973) suggested that reduced seed set may also occur under hot conditions, which limit insect activity.

The aim of this work was to find whether seed set problems exist in sunflower crops on the central Darling Downs, to determine the reasons for any such problems and to suggest appropriate solutions. Surveys of seed set in sunflower crops were conducted in 1974-75 and 1975-76.

II. MATERIALS AND METHODS

In the 1974-75 season, a survey was conducted on 28 sunflower crops on the central Darling Downs. Heads were sampled at a single site in the centre of each crop (where they would be least accessible to pollinators). At each site, 12 heads were enclosed in water-resistant paper bags prior to flowering. At maturity, eight intact bagged heads and eight open (unbagged) heads at each site were collected for determination of percentage seed set. The following data were recorded for each of the 28 crops: cultivar, date of flowering (50% of plants with open ray florets), area of crop, and number of known honeybee colonies (feral and domestic) within 3 km. Crops were divided according to cultivar and month of flowering, and "between and within" analysis of variance of seed set was carried out using the inverse sine transformation.

In the 1975–76 season when there was a period of prolonged wet weather, seed set was measured in open heads flowering during wet and fine weather. Five successive days of wet or overcast weather occurred from 19 to 23 December when sunflower crops were flowering in the Nobby-Pilton-Clifton area. Rainfall records at Nobby, Pilton and Clifton during the period are shown in table 1. Six crops of open-pollinated cultivars (Polestar and Sunfola 68-2) each had some heads flowering during the wet period and others flowering during completely fine weather. (Individual heads take approximately eight days to flower.) Eight heads which flowered during the five wet days were compared with eight which flowered in fine weather before the rain (two sites) and with eight which flowered in fine weather after the rain (four sites). At one site, numbers of pollinators were counted during light rain, overcast conditions and fine weather within a period of three days. Ten counts of pollinators on 100 flowering heads were recorded for each set of weather conditions.

In both seasons, a 180° sector of each head sampled was hand-threshed so that all achenes were collected. The achenes were separated into two groups in a "General" Seed Blower (Model ER) set at full capacity. Achenes blown over

TABLE 1

RAINFALL RECORDS AT NOBBY, PILTON AND CLIFTON, 17 TO 26 DECEMBER 1975

Date (Dec 1975)	Rainfall (mm)		
	Nobby	Pilton	Clifton
17	0	0	0
18	0	0	1
19	41	29	14
20	34	42	46
21	0	61	30
22	77	26	19
23	39	27	28
24	27	6	39
25	2	0	0
26	0	0	0

the inverted U-tube were considered commercially unusable (termed "unusable") because they would also blow away during winnowing; achenes retained were considered commercially usable (termed "usable"). All the usable achenes contained seed. Some unusable achenes contained small seeds (figure 1) and some were seedless (figure 2). Percentage seed set in each 180° sector was determined by dissecting a subsample of 50 unusable achenes to find the proportion containing small seeds.

III. RESULTS

SEED SET IN BAGGED AND OPEN HEADS. Mean seed set percentages in bagged and open heads in 1974–75 are presented in table 2, in which the 28 crops are ranked according to mean percentage seed set in bags. Mean percentage seed set in bags was positively correlated with mean percentage seed set in open heads ($r = +0{\cdot}51$; $P < 0{\cdot}01$; $n = 28$), indicating that level of self-compatibility may influence level of seed set in a crop.

EFFECT OF CULTIVAR ON SEED SET IN BAGGED AND OPEN HEADS. Hysun 30 had significantly higher seed set in bags than Polestar, Hysun 20 and Sunfola 68-2 (table 3). Hysun 30 also had the highest percentage seed set in open heads, but differences were non-significant (table 3).

TABLE 2

MEAN PERCENTAGE SEED SET AND MEAN PERCENTAGE USABLE ACHENES IN BAGGED AND OPEN HEADS, 1974–75

Crop No.	Bagged Heads		Open Heads	
	Mean % Seed Set	Mean % Usable Achenes	Mean % Seed Set	Mean % Usable Achenes
1	48·3	41·8	93·4	66·2
2	40·5	40·0	95·1	73·5
3	36·3	34·3	94·5	83·2
4	29·3	25·3	85·6	76·6
5	18·9	15·7	91·5	69·9
6	18·6	12·5	95·0	70·4
7	16·4	11·9	89·1	77·4
8	14·3	13·9	85·8	76·2
9	13·4	11·7	91·3	61·4
10	12·6	12·6	84·8	81·4
11	8·8	8·6	92·1	63·8
12	6·4	6·4	88·1	74·7
13	6·2	6·2	83·7	71·9
14	6·0	5·7	92·4	70·5
15	5·8	5·6	86·9	41·6
16	5·1	5·1	86·2	70·6
17	4·5	4·3	86·1	64·4
18	4·2	4·2	81·4	40·0
19	2·7	2·7	90·4	66·3
20	2·3	1·6	86·2	62·3
21	2·2	2·2	89·6	64·5
22	1·0	1·0	83·5	58·6
23	0·7	0·7	87·9	63·8
24	0·7	0·7	77·6	67·6
25	0·5	0·5	88·0	50·7
26	0·4	0·4	87·9	76·0
27	0·2	0·2	89·0	84·0
28	0·1	0·1	91·9	80·5
Average S.E.	4·0	3·2	3·5	4·5

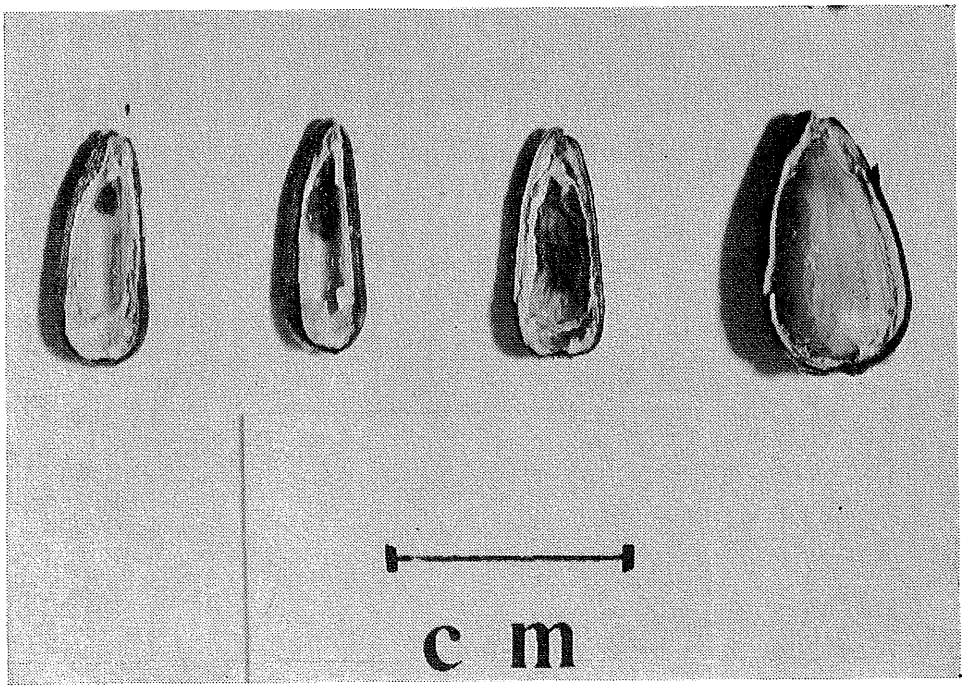

Figure 1. Achenes containing seeds, showing the range of seed sizes observed.

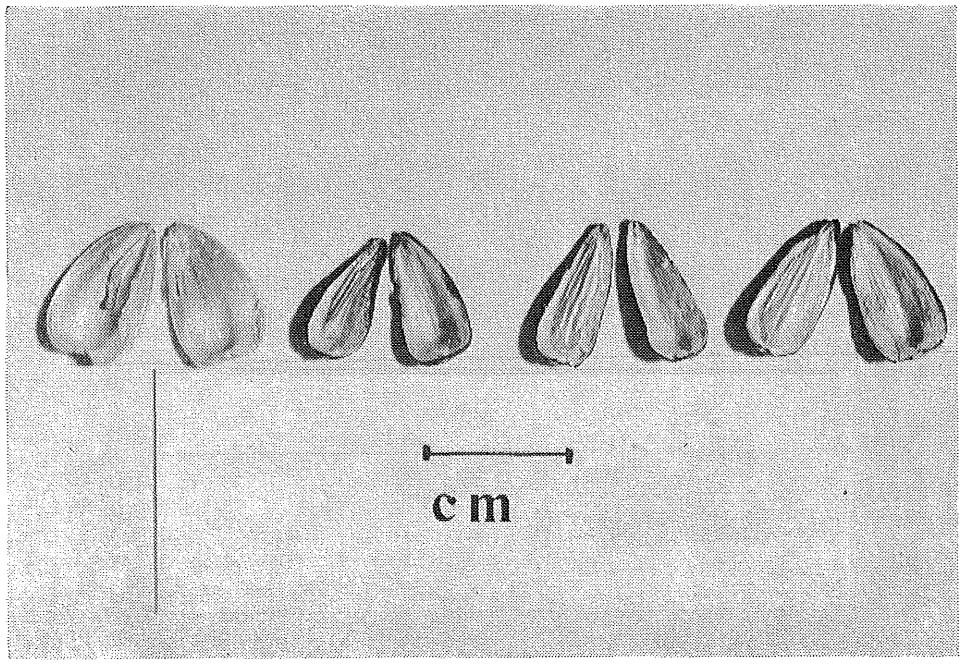

Figure 2. Seedless achenes showing the range of ovule sizes observed.

TABLE 3

EFFECT OF CULTIVAR ON SEED SET IN BAGGED AND OPEN HEADS, 1974–75

Cultivar	No. of Crops	Mean Percentage* Seed Set in Bagged Heads	Mean Percentage* Seed Set in Open Heads
Hysun 30	5	31·4 a†	91·7 a†
Polestar	5	6·1 b	90·7 a
Hysun 20	3	3·3 b	85·7 a
Sunfola 68–2 ..	11	1·4 b	90·6 a

† Values followed by the same letter are not significantly different ($P < 0.05$).

* Percentage equivalent to mean inverse sine.

TABLE 4

EFFECT OF MONTH OF FLOWERING ON SEED SET IN OPEN HEADS, 1974–75

Month of Flowering	No. of Crops	Mean Percentage* Seed Set in Open Heads
December	8	92·6 a†
January	11	87·9 b
February	2	91·4 ab
March	6	87·8 b

† Values followed by the same letter are not significantly different ($P < 0.05$).

* Percentage equivalent to mean inverse sine.

EFFECT OF HONEYBEE HIVES ON SEED SET IN OPEN HEADS. Number of hives of honeybees within 3 km of the crop was not significantly correlated with percentage seed set in open heads. Thus six crops with 24 to 130 hives within 3 km averaged 87·3% seed set while 22 crops with no more than six hives within 3 km averaged 88·7% seed set. Numbers of feral colonies within 3 km could not be determined precisely.

EFFECT OF AREA OF SUNFLOWER CROP ON SEED SET IN OPEN HEADS. Area of sunflower crop over a range of 0·5 to 56 ha was not significantly correlated with percentage seed set in open heads. This applied for all 28 crops and also for the 22 crops with no more than six hives within 3 km.

EFFECT OF MONTH OF FLOWERING ON SEED SET IN BAGGED AND OPEN HEADS. Month of flowering had no significant effect on seed set in bagged heads, but open heads flowering in December had slightly but significantly higher mean percentage seed set than open heads flowering in January and March (table 4). No explanation for this was apparent.

EFFECT OF FLOWERING DURING WET WEATHER ON SEED SET. Heads which flowered during the five wet days had significantly lower seed set than heads which flowered in fine weather (either before or after the rain) (table 5). Achene yield per head was also significantly lower (table 5). Yield reductions were attributed to reduced honeybee activity during wet and overcast weather (table 6) and low self-compatibility in Polestar and Sunfola 68-2 (table 3).

TABLE 5

EFFECT OF WET WEATHER FLOWERING ON PERCENTAGE SEED SET AND PERCENTAGE AND WEIGHT OF USABLE ACHENES, 1975–76

Measurement	Weather at Flowering	
	Fine	Wet
Mean percentage * seed set ..	†84·4 a	67·0 b
Mean percentage* usable achenes	†63·9 a	50·5 a
Mean weight of usable achenes in a 180° sector (g)	†21·7 a	12·5 b

† Values followed by the same letter are not significantly different ($P < 0.05$).

* Percentage equivalent to mean inverse sine.

TABLE 6

SUNFLOWER POLLINATOR COUNTS IN FINE, OVERCAST AND WET CONDITIONS AT A SINGLE SITE

Date	Time	Weather	Mean No. of Honeybees per 100 Flowering Heads (No Other Pollinators Present)
16 December, 1975 ..	10·00 am	Fine	47·1 a
19 December, 1975 ..	10·30 am	Overcast	14·2 b
19 December, 1975 ..	9·30 am	Light rain ..	0 c

Values followed by the same letter are not significantly different ($P < 0.05$). Values were compared with 0 using a one-sided t test.

EFFECT OF PERCENTAGE SEED ON PERCENTAGE USABLE ACHENES IN BAGGED AND OPEN HEADS. At the generally low levels of seed set recorded under bags in 1974–75 (0 to 48%), percentage seed set showed high positive correlation with percentage usable achenes ($r = +0.99$; $P < 0.01$; $n = 28$). Percentage usable achenes (0 to 42%) was usually equal to or only slightly less than percentage seed set (table 2), since nearly every seed formed underwent limited competition and produced a usable achene.

At the intermediate levels of seed set recorded in 1975–76 (37 to 90%), percentage seed set was still positively correlated with percentage usable achenes (29 to 84%) ($r = +0.67$; $P < 0.05$; $n = 12$).

At the high levels of seed set recorded in open heads in 1974–75 (79 to 97%), percentage seed set was not significantly correlated with percentage usable achenes (40 to 84%).

IV. DISCUSSION

Level of self-compatibility (measured by seed set in bags) was positively correlated with level of seed set in open heads. This indicates that higher seed set may be obtained with self-compatible cultivars. Such higher seed set may not increase achene yields, however, due to compensatory reductions in achene size. Thus in 1974–75 when mean seed set was 79 to 97% there was no association between seed set and numbers of usable achenes. In 1975–76 when mean seed set

was 37 to 90%, however, higher seed set resulted in more usable achenes ($P < 0 \cdot 1$) and greater yields per head. Yield reductions due to low seed set occurred in heads which flowered during five successive days of wet and overcast weather. These conditions apparently resulted in a lack of honeybee pollinators.

Variation in seed set in crops which flowered in generally fine weather cannot be attributed to a lack of pollinators. The presence of beehives near such crops failed to increase level of seed set. If pollinators were lacking, larger crops could be expected to set fewer seeds, but this did not occur in crops from 0·5 to 56 ha in area.

Seedless achenes (figure 2) were characteristic of sunflower heads open to all pollinating agents. They were observed most commonly in the centres of heads, as reported by Free and Simpson (1964). Achenes containing very small seeds (figure 1) were also characteristic. They too were observed most commonly in the centres of heads. Level of seed set in the centres of heads could vary without affecting achene yield, since both seedless and seeded achenes in the centres of heads are light enough to blow away during winnowing. The very small seeds apparently ceased growth soon after fertilization, due to failure of the plant to supply growth requirements. Such failure is most likely in the centres of heads where the florets are last to open and seeds must compete with earlier-formed ones.

It is concluded that achene yields on the central Darling Downs are normally limited by factors controlling plant growth and development and not by level of seed set. When wet weather occurs at flowering, however, level of seed set may limit yield. In such circumstances, highly self-compatible cultivars could increase yield by setting more seed; cultivars of low self-compatibility could benefit from beehives if additional bees after the rain can compensate for lost pollinating time while stigmas remain receptive.

Spray irrigation of flowering sunflowers may deter pollinating honeybees and should therefore be avoided during daylight hours when bees are active.

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