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BEE POLLINATION OF SUNFLOWER.

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Summary

Although high African honey bee (Aphis mellifera adansonii) populations were considered to occur naturally in the Springbuck Flats where poor seed set devastated the yield of certain sunflower fields, it was purported that insufficient pollinators may occur at certain times such as after an unfavourable bee period or from the application of toxic chemicals. Furthermore inadequate bee numbers would be accentuated by the planting of a large area almost exclusively to sunflower at one time as this would result in the crop flowering almost simultaneously. Bee proof cages were erected over sunflower just prior to flowering in the centre of an area where over 1000 ha had been established to the crop at one time and where poor seed set had occurred in previous years. One side of the cage of one treatment was left open to allow pollinating insects to enter; the cages of the second treatment were sealed to exclude pollinating insects after removal of all visible insects. A small bee colony was enclosed for the duration of the flowering period in the cages of the third treatment. Information was also recorded on uncaged open-pollinated plots. Less than three bees per 100 flowering heads and virtually no other pollinating insects were observed during the flowering period in the trial area. The four treatments produced hollow achene percentages of 79, 88, 18 and 66 and seed yields of 525, 558, 1066 and 578 kg/ha respectively. This investigation revealed that low numbers of pollinating insects, mainly bees, markedly reduced seedset and yield. This response also indicates that the autogamy or self-pollinating ability in the absence of pollinating insects of even this highly self compatible hybrid may be inadequate under certain conditions in the Springbuck Flats.

Resumé

LAPOLLINISATION DU TOURNESOL PAR L'ABEILLE

Bein qu'on considère que de grandes populations d'abeilles africaines (Aphis mellifera adasonii) existent dans les Springbuck Flats, une faible fecondation des fleurs a considérablement reduit le rendement de certains champs de tournesol. On a invoqué qu'il y avait un nombre insuffisant dë pollinisateurs á certains moments comme par exemple après une période défavorable aux abeilles ou après l'application de produits chimiques toxiques. En outre l'insuffisance numérique des abeilles serait accentuée par la plantation d'une grande surface presque exclusivement en tournesols simulatanémént ce qui aurait pour résultat une floraison presque simultanée de la culture. Des cages inaccessibles aux abeilles furent installées audessus du tournesol juste avant la floraison et au centre d'une région où plus de 1000 ha avaient été plantés en même temps et où une faible fécondation des fleurs avait été constatée au cours des années précédentes. Un côté de la cage d'un traitement fur laissé ouvert pour permettre aux insectes pollinisateurs d'entrer; les cages du second traitement furent scellées pour exclure les insectes pollinisateurs après y avoir enlever tous les insectes visibles. Une petite colonie d'abeilles fut enfermée pour la durée de la période de floraison dans les cages du troisième traitement. Des renseignements furent aussi enrégistrés sur les parcelles sans cage et ouvertes à la pollinisation. On a observé moins de trois abeilles pour 100 têtes en fleur et pratiquement aucun autre insecte pollinisateur pendant la période de floraison dans le champs d'expérience. Les 4 traitements produisirent respectivement des pourcentages d'achènes creux de 79, 88, 18 et 66 et donnèrent des rendements respectifs en graines de 525, 558, 1066 et 578 kg/ha. Cette recherche révéla que de faibles nombres d'insectes pollinisateurs, principalement les abeilles rèduisaient fortement la fecondation des fleurs et le rendement. Des résultate indiquent aussi que l'autogamie ou l'aptitude á l'auto-pollinisation en l'absence d'insectes pollinisateurs même avec un hybride hautement auto-compatible peut être insuffisante dans certaines conditions sur les Springbuck Flats.

Introduction

Poor seed set of the cultivated sunflower adversely affected the seed yield in various parts of the Springbuck Flats over the past 4 years. The hollow seededness varied from slight, which did not affect the yield, to severe which in some instance reduced the crop from an expected seed yield of over 2,5 t/ha to less than 800 kg/ha. In 1979/80 poor seed set near Settlers, 100 km north of Pretoria, caused a loss etimated at almost R2 million. In most cases poor seed set occurred when the crop made very good vegetative growth and produced large heads. It also appeared to be associated with large scale plantings at specific times in localised areas though both planting time and area varied from year to year. Marked variation occurred between fields planted at one time as well as within fields and between individual plants.

Severe sunflower yield losses from poor seed set has occurred in many countries and may be caused by a large number of factors. In some instances this has been associated with high levels of self incompatibility of the cultivar (Jain et al., 1978; Furgala et al., 1979). Sunflower seed producers consider local hybrids to be highly self compatible. Covered heads of local hybrids produced 62 to 80% of the seed yield of uncovered heads (Herring, 1980).

Insects, mainly bees, are the primary pollinators of sunflower (George and Shein,1980). Wind is of little importance in the interplant transfer of pollen (Robinson, 1978). Bagging sunflower heads or caging to exclude pollinating insects during flowering reduces the seed set of hybrids (Furgala et al., 1979; George et al., 1980). When insect pollinators are absent some hybrids are able to self-pollinate better than others and thus are less dependent on insect pollination to produce good seed set (George and Shein,1980).

An Australian survey of 42 fields in the Central Darling Downs, a well known cropping and beekeeping area, showed that the natural bee numbers (>22/100 flowering heads) were adequate for good pollination (Radford et al., 1979). Areas of the Springbuck Flats where seed set problems occurred were considered by farmers to be well supplied with wild honeybees from colonies in adjacent bushveld, headlands and farmsteads. Indeed excessive bee numbers were considered a serious farming hazard.

A deficiency of boron can devastate seed set and markedly reduce yields (Blamey, 1976). Various environmental factors also affect seed set (George *et al.*, 1980; Roath and Miller *et al.*, 1982) while other factors like 2,4-D weedkiller drift may induce a similar effect (Knudson, 1977). Several studies reported a negative correlation between large head sizes and the percentage filled seeds (Khanna, 1972; Jain *et al.*, 1978; Nur, 1978).

Research and investigations of production lands having poor seed set indicates that hollow seededness in the Settlers area was not caused by a deficiency of boron, disease or adverse weather. Simulated picloram- 2,4,5-T weedkiller drift investigations at the Towoomba Research Station correspond with those of Reinhardt and Nel (1983) and indicate that the hollow seededness was not caused by the direct effect of weedkiller drift from large areas of bush that were aerial sprayed when sunflower was in bloom.

Although high bee populations were thought to occur naturally in the area it was purported that insufficient pollinators may occur at certain times such as after an unfavourable bee period or from the application of toxic chemicals. Furthermore inadequate bee numbers would be accentuated by the planting of a large area almost exclusively to sunflower at one time as this would result in the crop flowering almost simultaneously. It was therefore considered necessary to investigate whether such conditions could reduce the natural insect pollinator population to a level that would reduce seed set and yield.

Materials and Methods

The experiment was conducted near Settlers (27°57S, 28°32E) in the centre of an area where over 1000 ha had been planted at almost the same time to sunflower in late January 1983 and where poor seed set had occurred in previous years. Severe drought had prevented earlier planting in the area. Bee-proof cages were erected over sunflower just prior to flowering. One side of the cage of one treatment was left open to allow pollinating insects to enter. The cages of the second treatment were sealed to exclude pollinating insects after the removal of all visible insects. A small bee colony containing approximately four brood frames of bees and three frames of brood was enclosed for the duration of the flowering period in the cages of the third treatment. The bee proof cages were 4,4 m long by 3,6 m wide by 2,3 m high and covered four rows and approximately 50 plants. They were made from slotted angle iron and covered with fibreglass reinforced plastic mosquito netting. Two replicates were used. The cages were retained until harvesting to prevent bird damage. Information was also recorded on the uncaged commercial sunflower field.

The field was planted on 1983-01-29 using the sunflower hybrid SO 209. A final stand of approximately 30 000 plants per hectare was achieved. The relatively fertile heavy black clay soil (vertisol) of the Arcadia soil series was not fertilised. Bee counts were made during midmorning on four occasions during the main flowering period on the production land and on the caged with bees treatment. Information was recorded on the final stand, seed yield and the number and mass of the filled en unfilled achenes from two heads per plot. Colour and X-ray photographs were used to record seed set.

The rainfall was low and only 35, 26, 48, 25 and 25 mm were recorded for the months January to May respectively and included 34 mm that fell in the late bud stage. The flowering period was generally cloudless except on one day when light rain fell. Little wind occurred during flowering.

Results and Discussion

Exceptionally low bee numbers of less than one per 100 flowering heads at commencement of flowering to three per 100 flowering heads at the end of the main flowering period on the production field indicated that insect pollination was likely to be less than optimum. Hardly any other pollinating insects such as the spotted maize beetle (Astylus atromaculatus) were present. The bee numbers only reached 21 per 100 flowering heads some 3 weeks after the commencement of flowering on the few plants that flowered appreciably later. Even then the bee numbers were relatively low when the sparcity of flowering heads is taken into account. Very high bee counts of over two per flowering head were made during the bloom period in the cages containing bee colonies.

The very low bee population in the field is thought to be due mainly to the long and severe drought that kept the bee colonies at a very low level and the almost simultaneously flowering of a large area of sunflower. Bee colonies usually take at least 6 weeks to build up adequate numbers of foraging worker bees once conditions become favourable. Other factors contributing to the low bee population are the marked reduction of the area under bushveld, the increased area under annual crops coupled with the widespread aerial application of chemicals toxic to bees.

The critical number of bees required for optimum pollination is difficult to determine as it is influenced by many factors. It has been expressed as bee visits per floret, bee per 100 flowering heads, bees per row or hectare or even colonies per hectare. Lecomte (1962) recorded 92% seed set with 15 bees per 100 flowering heads, while Radford et al., (1979) consider 24 bees per 100 flowering heads to be satisfactory. Langridge and Goodman (1974) consider 30 bees per 100 flowering heads to be less than optimum, while some bee specialists advocate as high as one bee per flowering head (McGregor, 1976).

The high percentage of hollow achenes, 79 and 88% in terms of number, produced on sunflower heads in the cages with one open side and in those cages to exclude insects and the 66% of the production land adversely effected the seed yield (Table 1). The 18% hollow achenes of the caged with bees treatment was representative of the 15 to 20% hollow achenes normally attained under open pollination when conditions were favourable for pollination. The 18% would probably have been even lower had the larvae of the American bollworm (Heliothus armigera) not caused severe damage to the face of the head. Hollow achene mass is a less sensitive measure of seed set as filled seeds compensate for hollow seeds by increasing in mass. This compensation is reflected by the highest 1 000 seed mass (56 g) being produced by the caged to exclude pollinating insects treatment which had the highest hollow achene percentage. The lowest 1 000 seed mass (47 g) was produced by the caged with bees treatment that had the best seed set (Table 1).

The inclusion of bees in the cage virtually doubled the seed yield achieved without bees as well as where one side of the cage was left open and on the production land (Table 1). This very marked improvement in seed set and yield with bees differs from most similar studies conducted with the hybrids in the USA. In such trials the open-pollinated uncaged control usually gave the highest yield while cages without bees produced the lowest yield (Furgala, et al., 1979; Roath and Miller, 1982). These studies showed that the yield reduction was greater the higher the level of self incompatibility of the cultivar.

Local sunflower breeders generally consider that most hybrids have more than adequate self compatibility. However, as indicated by George, et al., (1980) it is necessary to differentiate between self compatibility and autogamous pollination which is pollination that occurs naturally in the absence of any pollinators. Hybrids that exhibit high levels of autogamous pollination are less dependent upon insect pollination to produce normal yields. The very marked response to bees may indicate that the autogamous pollinating ability of the hybrid was much lower than its self compatibility.

Environmental conditions on the Springbuck Flats may have reduced the autogamy and orself compatibility of the hybrid as marked environmental effects have been reported (George, et al., 1980; Roath and Miller, 1982). The probable effect of the environment in markedly reducing the autogamy level of the cultivar on the Springbuck Flats may be supported by the hybrid IS 894 only producing 52% of the seed yield in cages without bees compared with that achieved when caged with bees near Johannesburg (GF Pretorius, personal communication, 1983). This cultivar is considered to have a high autogamy level in the USA and investigations in Minnesota showed that it produced indentical yields when caged with or without bees (Furgala, et al., 1979). This investigation also showed that the yield of cultivars having lower self compatibility levels were markedly reduced in the absence of bees.

Conclusions

This investigation revealed that low bee numbers of less than three bees per 100 flowering heads coupled with virtually no other pollinating insects during the main flowering period markedly reduced seed set and yield. The low bee numbers are thought to be due to the severe drought and other factors reducing the natural bee population to a very low level. The absence of another strong nectar flow prior to sunflower flowering also prevented the natural bee population from building up to an adequate level prior to the sunflower coming into bloom. The large area that flowered at one time accentuated the low bee population. This strong response to bees may also indicate that the autogamous pollination level of the cultivar was much lower than expected amd shows the important role of honeybees as pollinators irrespective of the degree of self compatibility of the cultivar. Environmental conditions may have reduced the autogamy level of the cultivar.

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TABLE 1 The influence of various caging treatment on the stand, hollow achene percentage, seed yield and 1000 seed mass

Treatment	Final stand (1000 /ha)	Hollow achene percentage		Seed yield (kg/ha)	1000 seed mass (g)
		Number	Mass		
Uncgaed	29	66	9	587	57
Caged, open side	28	79	25	525	56
Caged, no insects	32	88	40	558	56
Caged with bees	33	18	3	1086	47