VERY EARLY COMBINE HARVESTING OF SUNFLOWER TO AVOID BIRD DEPREDATION.

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ABSTRACT

The devastating effect of bird depredation reducing sunflower seed yields by 30 to 60% is one of the main factors affecting the profitability of this crop in South West Africa. Desiccants did not reduce bird damage appreciably while bird scaring techniques were considered largely impractical. It was therefore considered necessary to develop a system that would enable sunflower to be harvested as soon as the seed became physiologically mature and contained 35% moisture and before birds had started to cause damage. A number of self propelled combines harvested this very high moisture crop remarkably well when suitably adjusted. Design improvements to increase the combining tempo as well as improved screening efficiency require investigation. A moveable batch drying system was developed to dry the seed harvested per combine per day. This system was used with success on a production scale in SWA in 1981. Bird depredation was completely eliminated and drying costs were similar to desiccant costs. It is probable that the additional benefits of this very early harvesting system more than covered the drying costs.

INTRODUCTION

Harvesting is one of the most critical operations in sunflower production as serious seed loss during this period can markedly reduce the profitability of the crop. Sunflower is more predisposed to severe harvest loss than most grain crops as in addition to the normal gathering and combine losses it is exceptionally prone to pre-harvest loss. This loss of seed before harvesting is due mainly to bird depredation in addition to shattering, lodging, head drop and rot. Yields can be devastated in a short period of less than 1 week before harvesting and this is a major risk factor over which the grower has very little control.

In South West Africa (SWA) sunflower is produced in a hot, low rainfall area where extensive beef ranching on heavily bushed savannah is the main enterprise. Relatively small areas are planted to crops, mainly maize and sunflower. The high bird population of the bush coupled with the isolated, usually relatively small (10 — 50 ha) sunflower fields and the fondness of birds for sunflower seed makes the crop subject to a high bird population per hectare during the pre-harvest drydown period. Rock pigeons *(Columba guinea)* and red eyed turtle-doves *(Streptopelia semitorquata)* are the most important birds depredating sunflower in this area though a wide range of other birds also damage the crop.

Chemical desiccants were applied in 1979 in an attempt to accelerate crop drydown to promote earlier harvesting and so reduce bird damage. The aerial application of diquat (2 l/ha) to physiologically mature sunflower only enabled the crop to be harvested a couple of days earlier than the untreated area. Similar results were achieved in Texas, (Allen, Wiese and Hudspeth, 1979), Poland (Dembinski, Musnicki and Ponikiewska, 1974) and Australia (Barrett, 1978) where diquat only hastened the drying of the seed to 10% seed moisture by from 1 to 7 days. The slightly earlier harvested desiccated sunflower in SWA did not noticeably reduce the bird damage and seed yields were usually reduced by 30 to 60%. In desperation some farmers even reverted to hand harvesting of heads near physiological maturity of the seed prior to using various simple and often impractical methods to dry the heads before threshing. It was obvious that unless a much more effective method of preventing bird damage was developed it would be impractical and uneconomical to grow sunflower in this area.

Various other methods of reducing bird damage of sunflower used in other countries were considered. Cultural practices, such as markedly increasing the area planted at the same time to sunflower in an area and the use of low value decoy crops were in most cases considered impractical. Scaring devices such as gas exploders or shooting usually had very limited effect unless done very intensively. Electronic amplification of bird alarm calls or other sounds although having promise was not considered reliable enough. Chemical control with a fright producing repellant was not effective.

After careful consideration of all factors it was decided that the only way to reliably prevent birds from depredating sunflower was to try to combine harvest the crop as soon as it became physiologically mature and before bird damage had started. No reference to such very early combine harvesting of sunflower seed was found in the literature. The moist seed would require artificial drying prior to storage and marketing.

PHYSIOLOGICAL MATURITY

Physiological maturity of sunflower seed is important as it is the earliest the crop can be harvested without adversely affecting the seed yield, quality or oil concentration in the seed. As this stage reflects the termination of yield increase and is of special significance with regard to harvesting, a number of methods based on head colour, floret abscission and seed moisture content have been used to describe it. Physiological maturity is frequently described as "when the back of the head has turned from green to yellow" (Schuler, Hirning, Hofman and Lundstrom, 1978) "and the bracts are turning brown" (Cobia and Zimmer, 1978) while complete floret abscession also reflects this stage (Browne, 1978).

Although such subjective descriptions are adequate for normal harvesting practices, the objective seed moisture content is considered a more reliable index of physiological maturity and is better suited to determining this stage for very early harvesting though is more laborious. Local investigations indicate that 35% moisture in the seed is indicative of physiological maturity in a wide range of sunflower cultivars (Loubser, 1981). In the USA, Whitehead (1980) also considers this stage to be reflected by 35% seed moisture content while Australian investigations indicate 38% (Barrett, 1978) and 40% (Anderson, 1975) seed moisture contents. This slight discrepancy is probably due to the accuracy with which the maximum seed mass is determined though climate and sampling procedures may be involved. As the dry seed mass and oil content increases by less than 5% as the moisture content in the seed decreases from 40 to 35% (Loubser, 1981) and the seed is hard enough to withstand combine harvesting at 40% moisture content, harvesting may be commenced at this stage should exceptionally early harvesting be required though 35% moisture is preferable. Sound moisture testing procedures and uniform maturity of the crop become increasingly important when harvesting at higher moisture contents.

When the seed contains 30 to 40% moisture the spongy receptacle (head), upper leaves and stems contain about 80% moisture. The moisture content of the seed drops much more rapidly as can be seen by seed containing only 8 to 10% moisture in Texas and Tennessee while the head and top leaves and stalk still contained 60 to 70% moisture. A further 2 weeks was required to dry the head and top leaves and stalks to below 25% moisture (Shadden, Mullins and McCutchen, 1970; Allen, Wiese and Hudspeth, 1979) though this will be influenced by the weather.

VERY EARLY HARVESTING

Harvesting usually commences in SWA when the seed moisture drops below 10% in order to avoid artificial drying. At 13 to 15% seed moisture less shattering occurs and faster travel speeds (8 km/hr) are possible (Hofman, 1973) and harvest output increases as blockages do not hinder operations while seed cleaning is improved (Whitehead, 1977). However, some sunflower producers in the northern USA prefer to harvest at seed moisture contents as high as 20 to 25% prior to drying in order to minimize seed loss due to shattering and birds (Schuler, Hirning, Hofman and Lundstrom, 1978) and when the moisture content in the top of the plant probably exceeds 70%. As both the top of the plants and the seed only contain 10 to 15% more moisture at physiological maturity it was thought possible to combine sunflower at this stage. A John Deere 945 self propelled combine harvester was used in this investigation as it was one of the popular combines in the sunflower area of SWA and preliminary trials indicate that it could possibly be used to harvest sunflower seed at physiological maturity. This combine was fitted with South African sunflower header units including both shields and stalk walker attachment. The combine handled the high moisture material best when set as follows:

Cylinder speed 540 rpm
Concave clearance: 29 mm below and 20 mm top
Wind regulator: ¾ open
Top sieve: 3 mm opening
Secondary sieve: 80° opening

The very moist material was handled remarkably well by this combine although the combine travel speed (4 km/hr) was approximately 20% slower than with seed containing 10% moisture. There were few stoppages for blockages. Subsequent tests indicated that other combines like the John Deere 965 and 930 fitted with sunflower headers are also suitable while local tractor drawn harvesters were not tested.

This successful combining at physiological maturity is attributed to combine harvester improvement and attachments that minimize the quantity of plant material passing through the combine. The shield (deflector) prevented the sunflower plant from entering the harvester until the stalk walker below the head had carefully pulled the stalk and leaves down so that only the head and 5 cm or so of stalk were cut off and entered the combine. This pulling action of the stalk walker also minimizes plant material blocking the slots between the seed pans in front of the cutter bar.

The combined seed contained a considerable quantity of florets and small pieces of head and constituted about 5% of the mass when dried. As the pieces of head especially had a much higher moisture content than the seed, every possible effort should be made to ensure that the combine is operated as efficiently as possible. The oil mill in SWA accepts sunflower seed containing less than 10% non seed sunflower matter. In South Africa pre-cleaning of seed will be required as the top high-oil sunflower seed class FH 1 only allows a maximum of 2% foreign matter.

When harvesting was done near physiological maturity (35% moisture) no pre-harvest loss of seed due to bird damage or shattering was observed. Thus in this severe drought year when maximum bird damage would probably have occurred it was possible to eliminate seed loss from bird depredation by very early harvesting thereby achieving the objective of the project. Delaying harvesting until the seed contained approximately 25% moisture resulted in severe bird damage estimated at 25%.

Gathering losses varied widely and were influenced mainly by the uniformity of the stand and lodging. Heads out of reach of the header sometimes contributed as much as 8% to seed loss. This loss is considered to be comparable with the header loss achieved when combining at 10% seed moisture. Where the crop grew well with little lodging, minimal gathering loss occurred as reflected by the virtual complete absence of unharvested heads on the land after combining. Combine losses were less than 1%. Seed damage, determined by visually separating damaged and undamaged seed, was virtually nil. The hulls were strong even at 40% moisture and were less brittle than when very dry.

DRYING

The artificial drying of sunflower seed containing up to 25% moisture is done to a varying extent in most major producing countries having a temperature climate. This practice is not used in SWA but is applied to a limited extent in South Africa where a wide range of commercial driers are used to dry mainly wheat and maize. Sunflower is easily dried when compared with cereal crops as the seed is large and light, allows a relatively free flow of air to pass through it and contains much less moisture on a volume basis. The drying of very early harvested sunflower seed containing approximately 35% moisture down to 10% is essential for safe storage and marketing. In order to meet the needs of the relatively small scale sunflower grower in SWA it was considered advisable to develop a moveable, relatively low cost seed drying unit. The availability of large quantities of wood at low cost in SWA indicated a wood-fired system.

Batch drying of the seed mass (16t undried seed) harvested per combine per day was considered the most practical system. The fan and wood-burner heat-exchanger were mounted as a unit on wheels with the fan being driven by the PTO of the tractor via a V-belt system to increase the fan speed to 1200 rpm while using the normal PTO speed. This delivered an airflow of $16m^3\ min^{-1}\ m^{-3}$ seed. The burner heat-exchanger was designed to increase the air temperature by 15°C and to supply 630 000 kJ/hr with an efficiency of 60%. The drying unit was designed for four containers on either side of the air duct (Fig. 1). Each container (2.2m x 2.4m) would hold approximately 2t of wet seed when filled 1m deep. The containers were made out of square tubing and flat iron with a perforated false floor and flat iron bottom producing a 20cm deep plenum chamber that was coupled to the air duct.

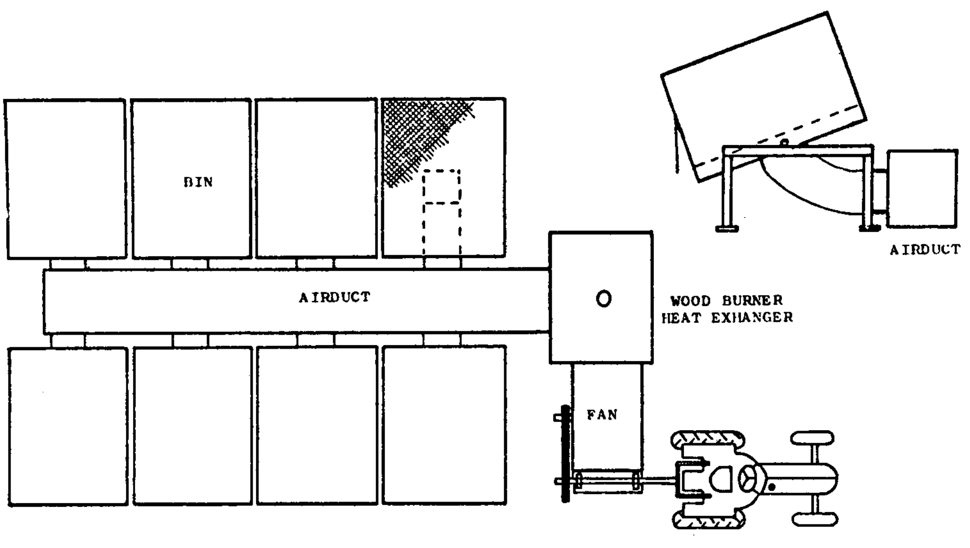

Fig. 1 — A diagrammatic presentation of the wood-fired, moveable batch drier with self emptying bins

The drier was used to dry sunflower seed harvested from commercial fields on a number of farms in the Tsumeb-Grootfontein districts of SWA. Overall the drier worked well. The fan supplied the required volume of 650m^3 min^{-1} at a static pressure of 65mm water pressure when all eight containers held 1m seed. The wood-burner heat-exchanger also produced the required 15°C rise in ambient temperature using a well stoked hard wood fire. The unit dried 16t of wet seed containing some 35% moisture to 10% moisture within 24 hr. The use of a portable stirrer to periodically stir the seed would improve the efficiency and uniformity of drying. The main criticism of the drier is the major effort (1, 5 days) required to move it from one farm to another as a result of the many seed containers required to dry the large volume of seed in 24 hr. This can be overcome by using a perforated false floor in existing farm structures as a permanent installation (Fig. 2) or possibly the use of a much lighter container system.

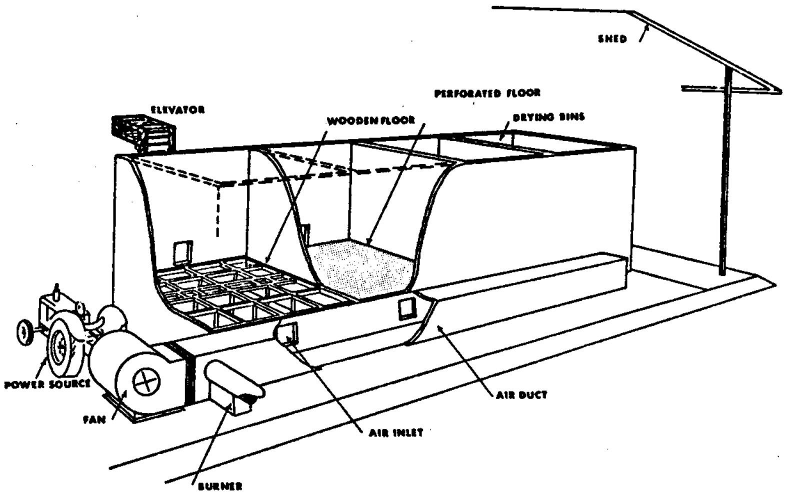

Fig. 2 — A permanent batch type installation with handling equipment.

The total cost of the drier including an estimated R3 000 for labour was R8 000. When all costs such as capital depreciation, interest on capital, fuel (R5/day), labour, etc are included the total drying cost is estimated to be less than R20/t of dry seed. This is less than the cost of a desiccant applied at a low rate.

DISCUSSION AND CONCLUSIONS

The extremely severe (30 to 60%) bird depredation of sunflower harvested in SWA when the seed contained less than 10% moisture necessitated the development of a very early harvesting system to enable the crop to be harvested before birds caused damage. Although Newman and Wyse (1980) consider it almost impossible to harvest mature sunflower with conventional machinery commercial sunflower fields were successfully combine harvested when the seed reached physiological maturity and contained approximately 35% moisture thereby completely avoiding bird damage. The combine harvesting can be done even earlier when the seed contains as much as 40% moisture though a slight (5%) reduction in seed yield and oil content of the seed may result. Noticeable bird damage appeared to commence at approximately 30% seed moisture. As severe bird depredation occurs in various areas of most sunflower producing countries this system of very early harvesting offers a practical method of eliminating this major yield reducing factor.

A number of self propelled combine harvesters equipped with modern sunflower header units successfully harvested sunflower containing up to 40% seed moisture. Careful adjustment of the combine and the use of slightly higher cylinder speeds, closer concave settings and a slightly slower land speed were the main adjustments. Further combine development appears necessarry to improve the combining tempo and screening efficiency of very early harvested sunflower. This high moisture seed required drying to 10% moisture for safe storage and an economical wood-fired batch drier was developed for this purpose. Commercial bin, batch and continuous-flow driers could also be used.

While the main benefit of this very early harvesting is undoubtedly avoiding bird damage, other important benefits are also derived. Probably the most important secondary benefit is that the 2 to 4 week earlier harvesting reduces the period that unfavourable weather like wind, rain and hail can adversely affect the crop. This would also prevent serious loss of seed due to shattering especially in high temperature, low humidity areas as well as during the harvesting of low moisture seed. Less lodging and head drop occur with earlier harvesting and fewer heads require picking up. Head rot has less time to damage the seed. Earlier marketing and payment for the crop is also of value. As the leaves and stalks are still green, livestock can make better use of this plant material. The early removal of the crop from the land reduces transpiration and the drying of the soil and when coupled with earlier soil tillage should result in improved moisture conservation and higher yielding following crops.

ACKNOWLEDGEMENTS

The assistance of Namswa Oil (Pty) Ltd in funding and manufacturing the drier is gratefully acknowledged. The strong support of the various sunflower growers who participated in this project is also acknowledged.

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ALLELOPATHIC ACTIVITY OF CULTIVATED SUNFLOWERS.

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ABSTRACT

Workers in North America have documented allelopathic activity in several species of weed-type sunflower. Such activity has been identified with allelochemicals produced by living plants and from decaying debris in the field. Autotoxicity, resulting from allelochemicals of sunflowers, has also been reported.

In Australian experiments, conducted over a three-year period, little evidence for allelopathic activity by naturalised (multi-head) roadside populations of sunflower, or by open-pollinated cultivars, was identified. However, in studies of an unreleased hybrid cultivar, evidence was consistently obtained for the production of the allelochemicals by living, senescing and dried foliage. Similar activity was identified in the male parent line.

Gas chromatographic/mass spectrometric analyses indicated the presence of similar organic compounds in washings of living foliage of the hybrid and its parent. The possible nature of these compounds and their relationship with allelochemicals previously identified in sunflower is discussed. The evidence is evaluated in the context of allelochemicals as agents which may contribute to the defence and/or competitive ability of those plants which possess them in active concentrations.

INTRODUCTION

In his review of defence substances in higher plants, Schildknecht (1981) refers to the "many hundreds of substances emitted day and night above and below ground by higher plants" as a means to protect themselves against other organisms, including other plants. This defensive capability is often better developed in weed than in crop species, Lovett (1982).

Cooper and Stoesz (1931) reported that *Helianthus scaberrimus* (Rough Sunflower), in common with other weed-type sunflowers, produces rhizomes which contribute to the development of a "fairy ring" effect. These authors cite an example in which a fairy ring was estimated to develop at the rate of 1 metre per annum over a period of 6 — 7 years. The centre of the ring was barren. In the absence of seed of *H. scaberrimus,* tests for allelopathic activity were conducted using seed of *Helianthus annuus* and *Triticum aestivum.* Allelopathic effects were confirmed although no suggestion as to the nature of the allelochemicals present was made.

Studies of allelopathy in various other sunflower species were made by Curtin and Cottam (1950). Such activity was, again, linked with the production of rhizomes in *H. rigidus, H. occidentalis, H. grosseserratus* and *H. tuberosus.* Of these species *H. rigidus* and *H. occidentalis* were found to be the most active. Anderson, Katz and Anderson (1978) further identified allelopathic activity in *H. mollis.* With many of these species of *Helianthus* autotoxic, as well as allotoxic, activity has been reported.

Wilson and Rice (1968) identify *H. annuus* as an important dominant in plant succession in abandoned fields in parts of Oklahoma and Kansas. Associated species often show reduced growth which cannot be attributed to competitive effects, as defined by Harper (1977). Leaf leachates, extracts of decaying leaves, root exudates and extracts of soils from the vicinity of *H. annuus* plants all inhibited germination and early growth of many species, including *H. annuus.* Chlorogenic acid and isochlorogenic acid were present in all extracts of organs of *H. annuus.* A suspected α-naphthol derivative and scopolin from leaf leachates were other possible phytotoxins. Wilson and Rice (1968) note that the type of phytotoxin varies with the plant part which produces it.

The fact that the allelochemicals of weed-type sunflowers are frequently autotoxic may contribute to the fact that such species often represent only a fairly brief phase in plant succession. Succeeding species, for example, *Aristida oligantha* in the case of *H. annuus,* are often not affected by sunflower allelochemicals (Wilson and Rice, 1968).

In reviewing allelopathic effects of sunflower, Rice (1974) notes that allelochemicals have differential effects on competing species, enter the soil, and show greater activity after the accumulation of plant debris than during active growth. This latter observation is probably a consequence of the concentration of allelochemicals, as discussed by Tukey (1969).

Whittaker (1970) takes the view that almost all plants have the ability to produce chemicals for their defence. Allelopathic activity is, however, often better developed among natural plant populations than is true of crop plants. Lovett and Levitt (1981) suggest that, given the close relationship between many weeds and crops, genetic manipulation to enhance the content of allelochemicals, which may perform defensive functions not only against plants but also against other organisms, may be possible.

To date, there are few reports of allelopathic activity being manifested by sunflower cultivars. Experiments of Tang and Young (1979) confirmed that most phytotoxins isolated from sunflowers were phenolics. In glasshouse experiments, Koeppe, Southwick and Bittell (1976) studied the effects of phosphorus nutrition on levels of chlorogenic acid in cv. Russian Mammoth and on leaching of phenolic compounds from living and dried plant parts. Caffeoylquinic acid and scopolin were identified as two of the possible allelochemicals present. In studies of the same cultivar, Hall and Blum (1977) varied nutrient and density levels in studies of allelopathy between sunflower and a weed species, whilst Leather and Forrence (1979) evaluated thirteen cultivars of sunflower for allelopathic effects upon populations of weeds. Weeds showed differing responses to aqueous extracts of dried sunflower leaf and stem material in controlled experiments. In the field, a sunflower-oat-sunflower rotation was shown to reduce weed cover.