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The Role and Position of Sunflower in UK Agriculture

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EXECUTIVE SUMMARY

Sunflower (*Helianthus annuus* var. *macrocarpus*) belongs to the genus *Helianthus* that comprises over 100 annual and perennial species. Its seeds have a wide range of uses; the seeds of low oil content varieties are used for culinary and confectionery purposes, whilst the seeds of the high oil varieties are chiefly used for extraction of their oil. Sunflower oil has a 20-55% higher level of the polyunsaturated linoleic acid than oilseed rape, corn or soya oils, but UK sunflower oil has a 9-15% higher linoleic acid content than seed produced in Europe. Sunflower oil has a higher unsaturated index than rape oil but a poorer n-3/ n-6 fatty acid ratio (Anon., 1994). Sunflower oil is a semi-drying type and, when blended with linseed or other drying oils, is used in paints and varnish. The oil is also used as a lubricant and as a fuel oil for lighting. There are opportunities for the oil to be used in bio-diesel and in the manufacture of plastics. After oil extraction, the high protein cake is used in animal feeds. The hulls are used as abrasives and the whole plant can be used for forage and for silage. Whole seeds are used in pet-foods and birdseeds.

Sunflower as a commercial arable crop is relatively new, the first hybrids being introduced in the 1960s. The majority of the crop is grown in Europe and the Americas. Total world production of sunflower was estimated at 25 million tonnes with the majority coming from the former Soviet Union and Argentina. Within Europe, France, Spain and Italy accounted for 93% of the 4.4 million tonnes of production in 1997. UK production is limited to below 1000 tonnes.

The UK imports the equivalent of approximately 350,000 tonnes of sunflower seed; half is crushed in the UK and the balance imported as oil. The price of sunflower seed for crushing is very similar to that of soya and rapeseed, but the price of sunflower oil is usually higher. For the grower, the area aid payment for sunflower is the same as for oilseed rape and subject to alterations because of overshoots of the oilseed rape area and tonnage produced. Contracts for the purchase of harvested seed are available through merchants, either fixed price, or open price where the merchant markets the produce at a time agreed after harvest. Most UK sunflower seed is currently used in pet-foods but the sourcing of sunflower seed for oil production in the UK would lead to savings for the UK crushers. Currently, the imported seed has to be stored to ensure continuation of supply and approximately 2000 tonnes is crushed per day. Local supplies would reduce the storage capacity needed.

In the UK, the area in which sunflower can be grown is limited by a soil temperature requirement of 7°C at 10 cm depth at drilling and the need to achieve 1,400 day degrees above 6°C before mid-October to ensure harvest. This usually means a drilling date between 16 April and 5 May. Most soil types are suitable but those that warm quickly in the spring allowing earlier drilling are preferable. The crop is fairly drought tolerant due to its extensive deep rooting system but sensitive to compaction and post‑drilling cultivations should be minimised. The crop can be grown in a conventional arable rotation but avoiding close rotations with crops susceptible to *Sclerotinia sclerotiorum*. Drilling can be done with conventional cereals drills if alternate coulters are blocked to give row widths between 25 to 50 cm. Precision drills result in better in-row spacing. Target populations should be between 80,000 and 110,000 plants/ha and seed drilled at 2.5 to 5 cm depth into moisture. Fertiliser requirements are low at 25-50 kg/ha nitrogen and 40-60 kg/ha phosphate and potash. The crop is sensitive to Boron deficiency and deficiencies are treated accordingly. The choice of chemical weed control is limited but drilling in late April allows ample time to produce a stale seedbed through cultivation and total (non-selective) herbicides. After drilling, choice of weed control is limited to one chemical (Pendimethalin). The three weeks after drilling are the most critical; the crop should be monitored closely and adequate precautions taken to control pest attack. At this time, the crop is susceptible to damage from birds, rabbits and slugs. The diseases *Sclerotinia sclerotiorum*, *Botrytis cinerea* and *Verticillium dahliae* have been reported in UK sunflower crops but only *S. sclerotiorum* causes a serious potential problem. Late season aphid damage can reduce yield and quality but damage in the UK has been slight. Pests are again a problem at harvest with greenfinches and other seed eating birds causing damage. Crops of 6 ha or less have been completely destroyed. Sunflower can be harvested with a conventional combine, but fitting of harvesting trays and covering the reel tines can minimise harvest losses. Sunflower can appear as a weed in following crops and seeds can persist for up to 5 years. Crops following sunflowers are not adversely affected by late drilling.

Financially, total output of sunflowers is greater than that of other spring sown combinable crops. Variable costs are similar with the advantages of lower spray and fertiliser costs of sunflower being outweighed by higher seed costs. Overall, gross margins were higher but, when compared with winter sown oilseed rape margins, are £130/ha lower. Pesticide and fertiliser use in sunflowers are lower and the drilling of the crop occurs when farm workloads are light. Current farmer information indicates that those farmers who grow sunflowers find them profitable, low input, enjoy the rotational advantages and find the crop environmentally friendly. So why don’t more farmers grow the crop? Late harvest and profitability were cited as problems by non-growers. Currently there is too much risk associated with growing the crop and profitability is well below that of oilseed rape. Farmers who have never grown the crop but would like to do so need to be convinced of its profitability. They would also like guaranteed establishment, earlier harvest, good disease and weed control and information on growing the crop. Sunflower is proving popular as a cut flower with up to 20 ha grown in the UK. This can be very lucrative (£25,000 /ha) but they are very labour intensive and losses from outdoor production in wet seasons can be as high as 60%.

The review of the UK sunflower industry has indicated the main priority areas in which research must be concentrated. The first area is establishment; good crop establishment is critical for a profitable sunflower crop. Soil conditions and temperature have to be optimal before drilling can begin, seed rates are low in order to establish optimal populations. Problems encountered during this phase are many and research is needed to establish the requirements for successful establishment so that ‘blueprints’ can be provided. Second is technology transfer, in order to guide the development of the crop through its formative years, there will be a need to establish and develop links with farmers, breeders, merchants and end users. The review is a source of information to build on and, with support from the UKSA sponsoring demonstration sites and promotional campaigns, growers can be made aware of the potential of sunflowers as an alternative spring break crop.

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# INTRODUCTION

Since the introduction of the first hybrid varieties in France in the late 1960s, (Church & McCartney, unpublished) sunflower has become a viable crop in Europe and is now being grown in the UK. With the benefits of the Arable Area Aid Scheme (for which sunflowers are eligible as an oilseed crop) and new varieties coming forward suitable for UK conditions, there are now good opportunities for this crop.

Sunflower, as a spring break crop, will produce very competitive gross margins. Input costs are low and a quality oil is produced from the seed. Problems associated with establishing other spring sown crops in dry years do not apply to sunflower and, although late harvested, the establishment of winter wheat afterwards presents few major difficulties.

This review will address the profitability of the crop and try to identify why it is profitable for some and not for others. The problems of the late harvest, pest damage and weeds are discussed and solutions offered. The machinery requirements for efficient production of the crop are identified. All aspects of sunflower production are included. The main market is for grain production but a high proportion of the information will be relevant to the production of sunflowers as cut flowers. The production of cut flowers is discussed separately in Section 8.

The need for a review of the role and position of sunflower in UK agriculture has been strengthened during the production of this document, due to the lack of information available. General information on sunflower seed markets is readily available in the UK due to the large amounts of sunflower processed and consumed in the UK itself. The majority of husbandry information in this review is a mixture of adapted French information and practical experience from UK growers. Research on sunflower in UK situations is very limited and when mentioned is referenced to the appropriate source.

## The crop

Sunflower is an annual plant with a simple tap-root. The crop is drilled in April/May, it grows to a height of 1.5m and flowers during July/August. The stem is usually unbranched, the lower leaves are opposite and the upper ones alternate on the stem, there is usually one flower (Stace, 1991). Flower colour can range from pale yellow through to red but agricultural crops are usually yellow. The crop is harvested in September/October and the seed is black in colour. A detailed growth stage key is in Appendix I.

## Current UK farmer views

In 1997, a cross section of farmers was contacted for their views on sunflower production and they were asked the question “Have you ever grown sunflowers as a commercial crop?”. The total sample size was 51 and the responses were evenly distributed in the southern and eastern counties (Fig. 1.1). The answers can be split into four categories. These categories and their answers are detailed in Table 1.1. A copy of the questionnaire is included at Appendix II.

As can be seen, profitability is one of the top reasons given in all four categories. This can be linked to the variability and risk in growing the crop in the past. In the 1970s, there was interest in growing sunflowers in the UK but two major problems were encountered: firstly, the varieties available were very late to mature (October/November); and secondly, the weather during that period was particularly wet so harvesting was virtually impossible. This fact has stuck in the minds of farmers who continue to associate sunflowers with late, difficult harvests.

Those who continue to grow sunflower consider it profitable and cite rotational advantages, the low inputs and the environmentally friendly nature of the crop. They also enjoyed growing the crop. Conversely, those who have grown the crop but have now stopped state the late harvest as one of the greatest problems (86% of total replies); other reasons were pest and combine harvesting problems. Problems encountered at harvest were linked to the height of the crop and sample quality and these are discussed in Section 5.11.



Figure . Location and frequency of replies to questionnaire on sunflower production in England.

Table . *Unstratified survey of 51 farmers in England in 1997.*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Category** | | | | | | | | |
|  | |  | |  | | |  | |
| Have grown sunflower and continue  to do so | | Have grown sunflower and have now stopped | | Have never grown sunflower but would consider growing it | | | Have never grown sunflower and will not start | |
|  |  |  |  | |  |  |  |  |
| **Replies in this category** | **7** | **Replies in this category** | **14** | | **Replies in this category** | **28** | **Replies in this category** | **4** |
|  |  |  |  | |  |  |  |  |
| Why? | % replies | Why did you stop? | % replies | | What would encourage you to start? | % replies | Why not? | % replies |
|  |  |  |  | |  |  |  |  |
| Profitability | 71 | Late harvest | 86 | | Profitability | 96 | Late harvest | 75 |
| Rotational advantages | 57 | Profitability | 43 | | Guaranteed market | 86 | Profitability | 50 |
| Environmentally friendly | 43 | Pest problems | 29 | | Earlier harvest | 75 | Lack of equipment | 25 |
| Low input | 43 | Harvest problems | 29 | | Greater knowledge of the crop | 46 | Knowledge of crop | 25 |
| Enjoyed it | 43 | Marketing | 14 | | Good disease control | 39 | Rotations | 25 |
| Grass weed control opportunities | 14 | Weed control | 7 | | Correct equipment | 32 | Disease problems | 25 |
| Work planning | 14 | Seed cost | 7 | | Good weed control | 25 | Pest problems | 25 |
| Late drilling | 14 | Establishment | 7 | | Level of support | 4 | Bird damage | 25 |
| Home consumption | 14 | Disease problems | 7 | | As a crop on set-aside | 4 |  |  |
| To try them out | 14 |  |  | | Bird food market | 4 |  |  |
| Quality oil | 14 |  |  | | Breakcrop | 4 |  |  |
| Good break crop | 14 |  |  | |  |  |  |  |
| Guaranteed price | 14 |  |  | |  |  |  |  |

NB. 3 farmers each gave 2 answers

The other two categories are those who have never grown the crop. It is encouraging that the greatest number of replies were from those who would consider growing the crop. The reasons given which would encourage non‑growers to grow included greater profitability, a guaranteed market, earlier harvest, better knowledge of the crop, of disease and weed control and the information on the correct equipment. Many of these reasons can be linked to a lack of information in the arable sector on the growing of sunflower. The final category had the lowest number of replies which is encouraging. Apart from profitability, the major reason stopping these farmers from growing or even considering the crop is the late harvest.

# HISTORY

Sunflower belongs to the genus *Helianthus* that comprises over 100 annual and perennial species (Seiler, 1992), all of which originated in the New World (Baylis & Dicks, 1979a). These are broadly distributed from Canada to southern South America but with the largest proportion in the United States. Like the majority of important crops, the cultivated form, *Helianthus annuus* var. *macrocarpus*, is a cultigen, unknown in the wild. Like many of these (wheat, maize, rape) it seems to have originated in hybridisation or introgression between annual and perennial species and subspecies (Purseglove, 1968). The taxonomy is further complicated by the fact that modern European and North American production relies on hybrids (seed derived from crossing inbred lines) some of which carry germplasm introduced from other species, subspecies and varieties of *Helianthus* (Seiler, 1992). A comprehensive germplasm collection is located at the National Plant Germplasm Unit, Ames, Iowa, USA (Seiler, 1992).

Evidence from seeds found on an American-Indian archaeological site, dated at between two and three thousand years old and situated well away from the areas of natural distribution of the various annual species of sunflower, suggests that the ancestor of the crop may well have originated in this region (Purseglove, 1968). Further evidence from later sites and subsequently from Maya and Aztec carvings shows that the virtues of the crop were soon widely appreciated and that continued selection and cultivation led to further improvement (Purseglove, 1968).

During its time as a solely New World crop, it was grown principally for its seeds which were probably poorer in oil and richer in carbohydrate than the modern crop. These were typically hulled and eaten raw, though there is some evidence of their being ground to produce a type of flour (Purseglove, 1968). Other native uses ranged from dye production (yellow from the rays, black and blue from the seeds), to the production of baskets, and a coarse cloth from the stem and leaves (Rice, 1996).

Only in 1510 did sunflower reach the Old World when seeds brought from what is now New Mexico were propagated in the Madrid Botanic Garden (Purseglove, 1968). It appears that such early importations had a high heat requirement, since for several centuries production was chiefly confined to warm temperate regions and in Europe from Iberia to Southern Russia, where the practice of roasting and salting the seeds apparently arose (Rice, 1996). Apart from this, its uses seem to have remained much as they had been in the New World until, in 1775, its use as a source of oil was first recorded in Bavaria, though the first evidence of large scale production comes from Russia in 1779 (Purseglove, 1968).

Whereas low-oil varieties are still cultivated for culinary and confectionery purposes, modern production is directed chiefly towards oil production. Sunflower oil is well suited for use in cooking and, more recently, in the manufacture of compounded vegetable fats. Being a semi-drying oil, it is also used in blends with linseed and other drying oils for paint and varnish manufacture. Further uses are as a lubricant and as a fuel oil for lighting. A potentially large market exists for use as bio-diesel and in the manufacture of plastics (Church & McCartney, unpublished).

The USSR was the first country to produce combinable sunflower. Attempts had been made, on and off for two centuries, to grow the crop in England. However, it was the breeding of the first short-season hybrids in France in the late 1960s (Church & McCartney, unpublished), which offered the prospect of a vigorous, high yielding, short season crop, serious thought was then given to its potential role as a break crop in this country. Since the breeding of the first hybrids, the production of sunflowers has become a major industry in both Europe and America. In the UK, sunflower has been grown successfully in the last century (Wilson, 1849), in the 1940s (Hurst, 1946) and with limited success in the 1970s (Bunting, 1974).

Apart from oil production, the decorticated press cake serves as a high protein feed for livestock, whilst the hulls, approximately 30‑50% of the seed, are used in the production of abrasives (Rice, 1996). Sunflower is also grown as a forage and silage crop, often in combination with maize or sorghum as a means of enhancing protein levels, and as a constituent of pet-foods and wild-bird feeds.

# MARKETS

World oilseed output for 1997/1998 is forecast at a record 275 million tonnes (HGCA, 1997), due mainly to a sharp rise in US soyabean production, although rapeseed output is expected to be high. Total production from sunflower is also expected to increase from 23.7 million tonnes in 1996 to 25 million tonnes in 1997. This will include:-

|  |  |
| --- | --- |
| Former Soviet Union (FSU) | 8.2 m tonnes |
| Argentina | 6.0 m tonnes |
| Romania | 0.9 m tonnes |
| USA | 1.7 m tonnes |

Source: HGCA and USDA market reports.

Production in the FSU and Argentina is forecast to be substantially higher in 1997 than in 1996 (HGCA, 1997).

In Europe during 1997, 2.4 million hectares produced 4.4 million tonnes of sunflowers, 96% of which were for edible oil production (CETIOM, 1998). France was the major producer followed by Spain and Italy; together these three countries account for 93% of total production (Fig. 3.1). At the present time, UK production is very limited, being approximately 1,000 tonnes. Most of this will be used in pet foods or bakery products (UKSA, unpublished).

The figures in Table 3.1 relate to tonnes imported into the UK from all other countries and are split into two main groups. Consumption quality includes both human consumption and bird food markets. Crushing quality and consumption quality have different specifications. The specifications for consumption quality consist of admixture, purity of sample and seed quality, whereas crushing quality only requires oil content and admixture. The oil extracted from the imported crushing tonnage represents approximately half of the UK oil market, the balance being imported as oil.



Figure . European sunflower production - 1997. Source CETIOM

Table . *Sunflowers imported into the UK, 1993-1996 (t)*

|  |  |  |
| --- | --- | --- |
| Year | Crushing quality | Consumption quality |
|  |  |  |
| 1994 | 200,000 | 4,000 |
|  |  |  |
| 1995 | 198,000 | 22,000 |
|  |  |  |
| 1996 | 166,000 | 4,000 |

Source: Trade and UK Customs and Excise.

The figures would tend to suggest a considerable rise in the consumption quality group for 1995. However, it has been suggested that the actual figure should be in line with 1994 and 1996, and that the additional quantity was a crushing consignment under the incorrect tariff heading.

In 1997, UK imports of sunflowers for crushing exceeded the previous year by 30,000 tonnes for the first quarter of the year. Prices for the grain, oil and meal compared with soya and oilseed rape are shown in Figs 3.2, 3.3 and 3.4.



Figure . Market price for oil seeds for crushing in the UK Source: HGCA market reports.

From Fig. 3.2, it can be seen that there is a strong relationship between the prices of the three oilseed crops which tend to rise and fall together. Due to the strength of Sterling in 1997/98, UK produced oilseed has come under considerable pressure as prices have fallen.

Over a period of three years, the market price of sunflower oil has been consistently above that of competing oils, with only a brief period in early 1997 falling below others (Fig. 3.3).



Figure . Market price for oilseeds oil in the UK

Source: HGCA market reports.

The high protein content of soya means that it has a higher meal price than other oilseed crops by a considerable margin and this is consistent from year to year (Fig. 3.4). The margin is approximately £50 to £90 per tonne. This means that for the farmer, overall returns from soya are higher than from other oilseed crops. With regard to sunflower, its relatively high oil price and a meal price similar to oilseed rape means that sunflower is competitive with oilseed rape.



Figure . Meal price for oilseeds in the UK Source: HGCA market reports.

During the short period over which sunflowers have been grown in the UK, market prices for seed have fluctuated between approximately £150 to £225 per tonne. There was a major change with the reform of the Common Agricultural Policy in when support was shifted from price to the Arable Area Payments Scheme in 1992. The acreage payment for sunflowers is the same as for oilseed rape and subject to alterations because of overshoots of the oilseed rape area and tonnage produced.

A range of sunflower buy‑back contracts is available and can be either fixed price, where a value is locked in following the agreement, or open price where the merchant markets the produce at a time agreed after harvest. It is also possible for the grower to produce a crop without a contact, though it is essential to have good contact with the market if best prices are to be realised

The sourcing of sunflower from the UK would lead to savings for local crushers. Currently ADM Erith crushes 2,000 tonnes daily, and sufficient sunflower has to be imported and stored to ensure continuity of supply during the crushing run. A large supply of English sunflower would be beneficial, since greater reliance could be placed on local supplies and storage capacity reduced correspondingly (B. Fletcher, pers. comm.).

Around 14,000 tonnes of seed (one week’s throughput) would need to be crushed to fully evaluate the quality of the UK crop. Moreover, experience has shown that crops from different sources behave differently in the crushing plant. Nevertheless, seed sufficient for just one day’s crush (2000 tonnes) would at least give crushers familiarity with the UK crop (B. Fletcher, pers. comm.).

All the above points suggest an opportunity for producing a UK crop that is not in surplus and for which a market already exists.

## Niche markets

Niche markets are bound to be of more than average importance to a crop with so small an acreage as UK sunflower. At the present time, these markets are on a national scale, with around a third of sales taking place by mail order. In consequence, it would be uneconomic to rely on selling in the local area. There are at least three such markets:

1. *Pet and wild bird food*

This is a major niche market at the present time, with one supplier annually importing from 80 to 100 tonnes of the striped *Toma* variety from Hungary and Bulgaria. This seed is plump and medium sized, the seed coat is hard and although it meets the needs of parrots it is less well suited to our native species. Promotional work by the RSPB on all-the-year-feeding of garden birds has done much to increase demand for the softer shelled, black seeded varieties typical of UK production. Most suppliers are happy to source from the UK, provided there is continuity of supply and quality is consistent.

*2. Confectionery*

The varieties used for this purpose are striped, have a low oil content and are mostly of USA or Italian origin. They are used as ingredients in many products, including snack-bars, packeted savoury snacks, muesli and a variety of health-foods. It is neither possible nor even economic to attempt production in the UK, since they are late maturing and the named varieties are excluded from the Area Aid Payment Scheme. In the future, the breeding of shorter season varieties combined with an increase in market price might well offset the lack of Area Aid payments (B. Fletcher, pers. comm.).

*3. Industrial*

The market size is difficult to establish but the use of biodegradable vegetable oils is increasing, particularly on or near waterways in forestry or amenity areas. Germany, Austria and Scandinavia have introduced legislation to enforce its use for hydraulic oils, chainsaw lubricants and marine engines. The cost of the products is three to four times that of mineral oils. In the USA, high oleic sunflower oil is preferred to other oils due to its higher oxidisation value (B. Fletcher, pers. comm.). To date, high oleic varieties trialled in the UK have been unstable and late maturing, but there are new varieties that show some promise (P.D. Hutley‑Bull, pers. comm.).

## Marketing standards

European marketing standards for sunflower seed are as follows:

Oil content 44%

Moisture 9%

Admixture 2%

Hulled Seed 2%

The bonus or penalty for oil content is 1.5% of the contract price for every 1% over or under the standard (Cargills, pers.comm.).

## Quality

Sunflower has a different fatty acid composition from corn, soya and oilseed rape oils. The level of the poly-unsaturated linoleic acid is approximately 20-55% higher than in many other oils (Table 3.2). Sunflower oil has a higher unsaturated index than rape oil but a poorer n-3/ n-6 fatty acid ratio (Anon., 1994). The benefits afforded by the use of sunflower oil in the diet are unclear.

Table .. Fatty acid composition of sunflower and five major vegetable oils (%)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Fatty acids | | | | Poly-unsaturated/ Saturated ratio |
|  |  | Mono-unsaturated | Poly-unsaturated | |  |
|  | Saturated | Oleic | Linoleic | Linolenic |  |
|  |  |  |  |  |  |
| Sunflower | 12 | 16 | 71 | Trace | 6.0 |
| UK 1988 | -\* | 13 | 71 | -\* | - |
| UK 1997 | 10 | 22 | 68 | 0 | - |
|  |  |  |  |  |  |
| Safflower | 10 | 14 | 76 | Trace | 7.6 |
| Corn | 13 | 29 | 57 | 1 | 4.5 |
| Linola | 10 | 17 | 71 | 2 | 7.3 |
| Soya | 15 | 23 | 54 | 8 | 4.1 |
| Oilseed rape | 7 | 61 | 21 | 11 | 4.6 |

\*Not measured.

Source: Canola Council of Canada and UKSA.

In 1988, an experiment at IACR Rothamsted showed that there was a difference between the fatty acid profiles of sown and harvested seed (Table 3.3.; Church & McCartney, unpublished). The levels of linoleic acid increased between sown and harvested seed and the levels of oleic acid decreased. Table 3.4 shows the fatty acid composition of different sunflower varieties harvested in the UK in 1997.

Table . Comparison of fatty acid profiles between planted (p) and harvested (h) seed in 1988 - Rothamsted (%)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variety | Seed | Palmitic | Stearic | Oleic | Linoleic | Erucic |
|  |  |  |  |  |  |  |
| Sunbred 246 | *p* | 5.5 | 5.3 | 24.3 | 60.6 | 0.91 |
|  | *h* | 5.5 | 4.3 | 12.1 | 72.0 | 0.65 |
|  |  |  |  |  |  |  |
| Avante | *p* | 6.2 | 5.2 | 20.4 | 63.0 | 0.93 |
|  | *h* | 6.6 | 4.8 | 11.4 | 72.0 | 0.73 |
|  |  |  |  |  |  |  |
| Vincent | *p* | 6.5 | 4.2 | 29.0 | 57.0 | 0.70 |
|  | *h* | 5.8 | 3.9 | 15.0 | 72.0 | 0.68 |

Table .. Comparison of fatty acid profiles of UK varieties, seed harvested in 1997 (%)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variety | Palmitic | Stearic | Oleic | Linoleic |
|  |  |  |  |  |
| Coril | 5.9 | 3.7 | 22.0 | 70.1 |
| Irena | 5.7 | 5.3 | 22.2 | 66.8 |
| Petra | 5.6 | 4.6 | 21.2 | 68.5 |
| Printasol | 5.7 | 4.2 | 22.5 | 67.5 |
| Sanluca | 6.5 | 3.9 | 19.8 | 69.6 |
| Santafé | 6.2 | 4.1 | 23.4 | 66.3 |
| Sarah | 4.6 | 5.6 | 50.6 | 40.8 |
| Vincent | 6.0 | 3.8 | 20.0 | 70.1 |

Mean of 5 seeds/site and 3 sites. *Source: UKSA.*

# CLIMATE AND LOCATION

Sunflower is reasonably frost tolerant and can withstand temperatures as low as ‑5°C during the early stages of growth (Church & McCartney, unpublished). Frost damage is only likely to occur from the inception of the flower bud onwards, and this rarely takes place until the expansion of four or five pairs of leaves, about six or seven weeks after sowing (Church & McCartney, unpublished). Crop drilled from mid-April onwards are unlikely to be affected except in the coldest areas (Sells, 1991).

## Water relations

Sunflower is significantly more tolerant of dry conditions than other crops grown in the UK (UKSA, unpublished). The most water sensitive stages are the establishment phase and the stages between the unfolding of the ray florets to the completion of pollination. Drought stress during these periods limits both yield and oil content (CETIOM, 1998).

### Water requirements

In France, sunflower can produce reasonable yields where rainfall is as low as 420 mm (17") per annum. Much depends on the seasonal distribution of the rainfall and soil texture and structure (CETIOM, 1998). Sufficient seedbed moisture allows the roots to grow rapidly into the lower soil levels, and survive by exploiting the water table.

Water availability in the UK is not usually limiting, If the UK experienced drier conditions in the future and it becomes more difficult to establish traditional spring crops, it is reasonable to assume that sunflower might be grown on a larger area of land.

### Irrigation potential

Irrigation is used in the hot, dry regions of France and Italy to enhance yield (CETIOM, 1998). Use of irrigation in the UK would be limited to the establishment phase (Church & McCartney, unpublished), but there is currently no information available to UK growers.

## Thermal relations

Some aspects of the thermal physiology of sunflower, such as the role of soil temperature in determining optimal sowing date and of frosts and near-zero air temperatures in delineating the seasonal boundaries, have already been mentioned (Section 4.1), but the crucial matter of heat relations during the growing period still remains to be addressed.

Like many other spring-sown crops, the principal factor determining the rate of phenological development is the accumulation of heat, as influenced by mean daily air temperature above a base level characteristic of the species. The base value for sunflower is 6°C (Hutley-Bull, unpublished), the same as for maize. More importantly, its thermal response curve is also similar, being approximately linear from 10°C to over 25°C, and many of the techniques and statistical relationships developed in connection with the latter crop (Hutley-Bull, unpublished) are also applicable to sunflower.

### Present varietal requirements

The heat requirement of a maize variety, as indicated by the number of day-degrees or maize heat units (MHU) it requires to reach maturity

MHU = (maximum daily temperature °C + minimum daily temperature °C) -6

2

(Allison, 1963; Carr, 1977), forms the basis of systems for the classification of varieties/hybrids into maturity groups. This system is used both on a worldwide scale (FAO Numbers) and, more locally in France and, by extension, in the rest of Europe. The latter system, developed by the French national maize crops body (AGPM) has been adapted by Centre Technique Interprofessionnel des Oléagineux Métropolitans (CETIOM), the equivalent oilseed crops organisation, for use with sunflower and can be readily extended. This has been done by the United Kingdom Sunflower Association (UKSA) to cover the needs of the UK crop (see Appendix III).

Despite the undoubted success of this system in meeting the needs of the Continental grower, variety assignations made on the basis of trials carried out abroad cannot always be accepted as wholly relevant to the UK. This is because, whereas heat accumulation is typically by far the most influential factor limiting the growth of either crop, other environmental factors can sometimes play a significant part in determining the response of the crop to heat. That such non-thermal factors are of particular importance in the UK is evident from the fact that British crops of both maize and sunflower commonly require more heat to reach specific growth stages than the same varieties grown in nearby continental Europe, evidence of a reduction in heat use efficiency.

This phenomenon is known elsewhere; for example, a typical effect of drought-stress is to retard crop development regardless of thermal inputs. In Britain, however, not only are such conditions uncommon (for the time-being, at least) but the constraint may be observed in quite different circumstances. Although the causal mechanism has yet to be established, the available evidence (Hutley-Bull, unpublished) points to a form of stress associated with rapid fluctuations in air and soil temperatures and moisture levels, a feature characteristic of the insular climate. As has proved to be the case in maize, this problem can be remedied by selecting (or breeding) varieties having a natural tolerance towards this form of stress (Hutley-Bull, unpublished). However, it does point to the need for caution when making use of data relating to crops grown under more stable climatic conditions and to the importance of basing recommendations, wherever possible, on locally grown trials and farm crops.

Since conservative estimates of crop potential clearly need to take into account the possibility of sub-optimal heat use efficiency, the target values used in the following discussion include a small inflationary factor of five per cent to represent this feature (Hutley-Bull, unpublished). This value should be regarded as an estimate of the mean impact not as a constant, since stress can vary from site to site and from season to season.

### The growing season

Although adequate germination can be achieved with soil temperatures as low as 7.5°C to 8.0°C, it has been commonly observed that, where the soil temperature around and beneath the seed is a degree or so higher, fewer plant losses are experienced and emergence and establishment are more rapid. Because soil temperature in the superficial layer at which the seed is sown (2.5 cm to 5 cm) tends to vary considerably between soils and sites and is readily influenced by ephemeral features such as rain or frost, it is difficult to develop a consistent statistic for depth. However, since values for 30 cm depth show reasonable consistency, these may be used as a guide to the date at which sowing becomes feasible in various parts of the British Isles (Fig. 4.1).

The Meteorological Office has calculated monthly mean soil temperatures for UK recording stations. These have been interpolated by the Meteorological Office into a regular grid, base length 5 km, across the entire country. Because averages for 1 May, a typical sowing date for sunflower, are not available, estimates have been arrived at by averaging the monthly soil temperatures for April and May. This mean value approximates closely to 1 May. It is evident from Fig. 4.1 that the highest values, in excess of 10°C, are to be found in a broad area to the South of a line from the Wash to the Severn estuary. Values in excess of 10°C are also to be found in smaller areas along the Welsh coast, parts of Shropshire and around the Wirral.

### Relationship between mean and accumulated air temperatures

Eight Meteorological Office climate recording stations were selected from geographically diverse areas of the country. The 1961-1980 average air temperature for the months May to September inclusive, was extracted from Met. Office databases and the accumulated air temperature above a base of 6°C calculated from the daily values between 1980 and 1995. A regression analysis was done to enable accumulated air temperature to be estimated from these values (Table 4.1).



Figure . Average soil temperatures for 1 May

### Climatic constraints on sunflower production

Because the present climate of the British Isles ensures that sunflower is unlikely to suffer greatly from lack of water, except possibly during the establishment period, and because the crop is undemanding in respect of soil type and fertility, there are just two major constraints on production, both heat‑related. The first is the period available for production, as determined by the earliest date at which sowing is practicable and the latest date at which maturation ceases and harvesting can no longer be delayed. The second is the amount of heat available for use by the crop during this growing season.

Table . *Mean and accumulated air temperatures.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | May-September totals and means | | | |
|  | Mean Max. (°C) | Mean Min. (°C) | Mean  (°C) | Accumulated  (°C) |
|  |  |  |  |  |
| Ness Gardens, Merseyside | 18.0 | 10.1 | 14.1 | 1280 |
| Shirburn, Oxon | 19.3 | 9.4 | 14.4 | 1342 |
| Boxworth, Cambs | 19.2 | 9.5 | 14.3 | 1341 |
| Brooms Barn, Suffolk | 19.0 | 9.9 | 14.5 | 1347 |
| Pershore, Worcs. | 19.4 | 10.1 | 14.7 | 1389 |
| Manston, Kent | 18.7 | 11.0 | 14.9 | 1415 |
| Efford, Hants | 18.6 | 10.6 | 14.6 | 1373 |
| Torbay, Devon | 18.6 | 11.4 | 15.0 | 1419 |
|  |  |  |  |  |
| Mean |  |  |  | 1363 |

What follows is an attempt to identify those parts of the British Isles best suited to the production of economically viable crops of sunflower having a heat requirement suited to the production of current varieties. These will be for all but the most difficult of seasons, from the recent past to the present day. For the purposes of this report, a value of 1,400 day degrees heat input is to be regarded as the least which will supply the needs of semi-dwarf hybrids of the type defined by CETIOM as *très précoce*, presently the basis of the small UK production. Since the accumulation of heat is influenced by the length and seasonal position of the growing season, the chances of achieving this target have been assessed in relation to:

1. a five-month growing season from May to the end of September,
2. a maximal growing season of six months, from mid-April to mid-October,
3. a five and a half month season starting in May and finishing in mid-October,
4. an alternative five and a half month season from mid-April to the end of September.

The validity of each must also be considered both in relation to their practicability in different regions and also as regards their suitability to various rotations and cropping patterns. In the former instance, low soil temperatures may discourage early sowing, whilst severe frosts may make October harvesting impracticable. In the latter case, the options may be limited by the need to dispose of a preceding crop of grass before drilling or by the drilling date required by the crop which is to follow on.

As part of the 1961-90 climatology, the Met. Office has also calculated mean monthly air temperatures on the same regular 5 km grid which was used for soil temperature. These seasonal monthly mean air temperatures were also transformed into accumulated temperatures using the equation: Accumulated temperature = 145.1 (Tm) -748.11, where Tm = mean daily temperature. This allows a country-wide view of thermal accumulation over a five-month period (Fig. 4.2).

It is evident that given the year-to-year variations recorded for the study period, to consistently achieve the target sum of 1,400 day degrees would require the mean value for the period to be significantly higher. From statistical tables, it is calculated that to exceed a threshold during nine years out of 10, the mean value has to be 1.282 standard deviations greater. Since the standard deviation of the seasonal totals from the Met. Office sites was 100 degree days, this gives a required mean total of 1,400 + 1.282 (100) = 1,528 degree days.



Figure . Average accumulated temperatures (May to September >6°C)

### Present availability of heat

Evidently, if past records accurately reflect the future weather pattern, few parts of the country achieve seasonal means in excess of 1,400 degree days, let alone 1528 degree days. The warmest areas are around London, south Essex and north Kent, the south coast from Folkstone to the Isle of Wight and pockets in the South West and Severn Estuary.



Figure . Location of meteorological stations

Some idea of the range of values contributing to the mean can be arrived at by considering the annual variation of accumulated air temperature recorded for various climate stations. Thus, among the marginal sites, Shirburn, which lies at the foot of the Chilterns, near Oxford, has a mean value of 1,342 degree days for the sixteen years from 1980 to 1995 (Fig. 4.3) and seasonal totals ranging from below 1,200 degree days during 1996 to over 1,500 degree days in 1989. During this period the target requirement was achieved on only six occasions. By contrast, the mean for the Torbay station was 1,421 degree days, with a range of 1,223 to 1,604 degree days and a success rate of ten years in sixteen, plus three ‘near misses’. Year-to-year variation in thermal accumulation at these and other reference stations is illustrated by Fig. 4.4a - d.

a) Shirburn, Oxon



b) Torbay, Devon



c) Manston, Kent



d) Pershore, Worcs



Figure . Annual average accumulated temperatures (>6°C) for the five month period from May to the end of September.

### Extended growing seasons

Evidently, the heat accumulation between the beginning of May and the end of September is often inadequate for the needs of the present varieties and more so in some areas than others (Hutley-Bull, unpublished). In order to come closer to the long-term mean of 1,528 degree days, consideration must be given to the effects of increasing the length of the growing season. Four options were previously identified, namely:

1. a five-month growing season from May to the end of September,
2. a maximal growing season of six months, from mid-April to mid-October,
3. a five and a half month season starting in May and finishing in mid-October,
4. an alternative five and a half month season from mid-April to the end of September.

The first of these options has already been investigated and discussed; the remainder are now in need of consideration.

To determine the effects of extending the growing season, the accumulated temperatures for April and October were considered separately. The averages for the reference climate recording stations were 94 degree days for April and 160 degree days for October. A conservative estimate of the late April and early October totals was made by taking 50 per cent of these monthly totals. By adding the part-month totals to the May-to-September means for each of the reference stations, good estimates of the totals expected over the extended growing season were arrived at (Table 4.2).

Table . Accumulated air temperatures over an extended growing season (>6°C).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Monthly mean | | Total degree days (>6°C) | | |
|  | April | October | Mid Apr.- Mid Oct. | May 1 - Mid Oct. | Mid Apr.- End Sept. |
|  |  |  |  |  |  |
| Ness Gardens, Merseyside | 91 | 143 | 1397 | 1352 | 1326 |
| Shirburn, Oxon | 94 | 150 | 1464 | 1417 | 1389 |
| Boxworth, Cambs | 86 | 152 | 1460 | 1417 | 1384 |
| Brooms Barn, Suffolk | 89 | 154 | 1469 | 1424 | 1392 |
| Pershore, Worcs. | 99 | 149 | 1513 | 1464 | 1439 |
| Manston, Kent | 89 | 173 | 1546 | 1502 | 1460 |
| Efford, Hants | 96 | 175 | 1509 | 1461 | 1421 |
| Torbay, Devon | 106 | 183 | 1564 | 1511 | 1472 |
|  |  |  |  |  |  |
| Mean | 94 | 160 | 1490 | 1443 | 1410 |

Understandably, option b), the full six month growing season, produced the greatest increase; 127 degree days overall (an additional 47 day degrees in April and an additional 80 day degrees in October). The next most beneficial option was c), that presently favoured by many UK producers, namely a May sowing and an October harvest. This resulted in an additional 80 degree days and brought the total to over 1,400 degree days for all but the coldest station. Even d), the mid-April to September season, significantly increased the likelihood of meeting the target.

Extending the growing season into October increased the tally of ‘successful’ years to ten out of sixteen on the marginal site of Shirburn and ensured that the target was achieved every year at Torbay. More importantly, in the light of new developments in breeding extra-short season hybrids (Section 4.2.7 below), thermal accumulation at Shirburn reached, or came close to reaching, 1,300 degree days in fifteen out of the sixteen years (Figs 4.5, 4.6 and 4.7). If 1996 and 1997 are included, there is only one failure in eighteen years.



Figure . The effect of extending the growing season at Shirburn, Oxon - option c) May to October



Figure . The effect of extending the growing season at Shirburn, Oxon - option d) April to September



Figure . The effect of extending the growing season at Shirburn, Oxon - option b) April to October

Considering the Shirburn site, extending the growing season into October (option c) increased the tally of ‘successful’ years to ten out of sixteen (Fig. 4.5). The benefit from sowing in mid-April and harvesting at the end of September (option d) was smaller (Fig. 4.6). Sowing in mid-April and harvesting in mid-October (option b) clearly offered the best chance of producing mature crops (Fig. 4.7), though this was barely feasible, given the soil temperature and frost records for the Shirburn station.

### Future varietal requirements

The outcome of the 15 year analyses is of interest because it offers a reasonable risk assessment. It also forms the basis of comparison the changes which might arise from the introduction of new hybrids having a lower heat requirement than the earliest maturing material at present available commercially. In fact, such material is already in existence and is passing through official testing procedures on the Continent as well as undergoing independent trials in the UK. These new extra early hybrids require thermal inputs of approximately 1,300 day degrees to achieve seed moisture levels of less than 20%, adequate for harvesting. Their potential impact on four widely spread areas (Fig. 4.3), including Shirburn, is shown in Figs 4.8a to d.

### Future availability of heat

In the light of present concerns about global warming, it is well worth considering the likely effects of increased heat availability on the production potential of hybrids in the early and extra-early classes. Since an overall temperature increase of as little as 1°C would be likely to influence soil as well as air temperatures (Harrison & Butterfield, 1996), mid-April sowing could well become the norm, leading to a typical season running from April to September (Figs 4.9a to d). In the event of such a climatic change, it might prove feasible to grow mid-season varieties presently unsuitable to the UK in southern areas, *Early* varieties (1,400 day degrees) in the Midland zone and *Extra-Early* varieties (1,300 day degrees) in more northerly areas where production is presently regarded as unreliable.

a) Shirburn, Oxon



b) Pershore, Worcs



c) Torbay, Devon



d) Manston, Kent



Figure . Annual average accumulated temperature above or below a baseline of 1,300 degree days

a) Shirburn, Oxon



b) Pershore, Worcs



c) Torbay, Devon



d) Manston, Kent



Figure . Annual average accumulated temperature if temperature increased by 1°C per day, above or below a baseline of 1,400 degree days

# GENERAL HUSBANDRY

## The place of sunflower in the rotation

Sunflower is a spring sown crop which has the following rotational advantages:

* A break in a run of cereal crops.
* Opportunity for weed control using total (non-selective) herbicides before drilling.
* Allows preparation of a ‘stale seedbed’. The seedbed is prepared and sowing is delayed until the first flush of weed seedlings have appeared, the soil disturbed as little as possible. The weeds are then killed chemically, few seedlings may further appear.

However, sunflower is best grown following cereals or fallow, not after crops that may increase the risk of *Sclerotinia sclerotiorum* (stem and head rot - see Section 5.8) such as oilseed rape or potatoes, or after crops which leave large residues of nitrogen in the soil e.g. kale, sugar beet or permanent pasture. In France, sunflowers are grown as a breakcrop in place of oilseed rape or spring cereals (Sells, 1990) but their substitution for oilseed rape depends on the commodity price, this is discussed in more detail in Section 7.1.

Sunflowers will volunteer in subsequent crops for one or more years (See Section 9.1). This is not a problem in cereals but could provide a weed control problem in crops such as potatoes and peas.

## Soil type, pH and lime requirements

Sunflower can be grown on almost any soil type, but as with most crops the best soil type is a well-drained loam that will warm up rapidly in spring enabling plants to get off to a good start (P.D, Hutley-Bull, pers. comm.). Potash rich clay/clay-loam soils are particularly suited to sunflower but the drought tolerance of the crop also makes it suitable for use on droughty soil types.

The optimum pH for sunflower growth is 6 to 7.5. Soils with a low pH should be avoided. In very acid soils, yield can be decreased by 30% and trace element availability may become limiting (Schnieter, 1981; CETIOM, 1998). Lime should be applied to bring the pH up to 6.0 and overliming avoided as this may limit the availability of Boron.

## Cultivations and drilling

Soil conditions at drilling are very important, as is the preparation of the seed‑bed which should be fine and firm as for peas. Compaction must be avoided since sunflower produces deep anchoring roots that are sensitive to such conditions (CETIOM, 1998).

The site should be autumn ploughed and subsoiled if there is any risk of compaction. Fertiliser applications should be made in late March/early April, followed by spring‑tine or similar cultivation to remove wheelings. Alternatively, an early top dressing can be applied. A good seedbed can generally be achieved with a rotary harrow (UKSA, 1997).

### Drill type

Most seed-drills can be adapted for use with sunflower. It should be borne in mind that sunflower is a non-branching crop and its capacity to compensate for uneven plant spacing and sub-optimal plant population is constrained. Thus, accuracy of drilling has an important bearing on yield and quality. Experience and research (Church & McCartney, unpublished) have shown that although a cereal drill tends to deliver the seed in clumps with unequal spacing between the plants, yields are similar to those achieved with a precision drill. The available drill types are detailed below:

1. *Pneumatic disk-drills*. If a vacuum drill of the type used for maize is available and the row spacing can be adjusted to achieve the same plant spacing within and between rows, yields well in excess of those obtained with adapted cereal drills can be expected (Hutley-Bull, unpublished). An additional benefit is the more efficient suppression of weed growth between rows arising from more rapid closure of the canopy. However, despite these potential advantages, with many drills of this type it is difficult to achieve a row spacing of much less than 65 cm, around twice the optimum for typical target populations. This wide row spacing can be justified where weed control is to be achieved by inter-row cultivation, but the competition between plants for light and nutrients is exacerbated by crowding within the rows. Yields are often no better than those achieved with pneumatic cereal drills (Church & McCartney, unpublished; Kahlifa, 1984; Cook & Raw, 1993).
2. *Belt-drills.* Belt-drills of the Stanhay type have been used with great success to achieve near-optimal plant spacing, but particular care is needed when preparing the seedbed to ensure that the seed is planted at the correct depth. Problems may be encountered when using belt-drills on heavy or stony soils.
3. *Pneumatic cereal drills.* Optimal row spacing can be achieved with modern cereal drills by blocking-off alternate coulters. However, because these drills are not well adapted to low populations required by sunflower, plant spacing within the rows tends to be very uneven. This is reflected not only in a decrease of yield potential where plants are too crowded but also in different head size, leading to variable maturity (Cook & Raw, 1993).

For drills of all types, accurate calibration is essential, both to achieve the optimal plant population and to conserve expensive seed. Grower experience has shown that best results are achieved by calibrating the drill for a full hectare (UKSA, unpublished). Unless the drill has a press-wheel behind the seeder unit, the seedbed should be consolidated immediately after drilling, using a Cambridge roller. This not only conserves moisture and improves seed-soil contact but increases the effectiveness of subsequent herbicide applications.

### Variety choice

The number of available varieties suitable for use in the UK is limited to five for 1998, whereas in France the number is approximately 150. This difference in the number of varieties is due to the small scale of the UK sunflower industry. Varieties have been trialled in the UK for many years (Hutley-bull, unpublished; Cook, 1993; Cook, unpublished). The currently available varieties are all semi-dwarf types and are very similar for all measured plant characters. The past varieties include two dwarf varieties, Allegro and Corsun, which were approximately 60 cm shorter than the semi-dwarf types and were also earlier flowering and maturing. These types were introduced to provide a shorter crop with early maturity; but had the lower yield and lower oil content of the seed. Vincent and Coril are similar to the current varieties but have been superseded because they are no longer sold into the American and French markets. The variety Sarah is an example of a high oleic variety assessed in the UK but unsuitable for UK conditions, maturing too late to harvest.

Table .. Varieties grown at ADAS Boxworth, 1993-1997

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variety | Yield  (t ha-1) | Flowering date  (50% flowers open) | | Variety  type\* | | height  (cm) | | Maturity  score | Oil content  (%) |
|  |  |  | |  | |  | |  |  |
| Currently available varieties | | | | |  | |
| Printasol | 2.64 | 1 August | | sd | | 152 | | 7.4 | 44.5 |
| Santafe | 2.34 | 1 August | | sd | | 162 | | 8.2 | 43.0 |
| Sanluca | 2.27 | 2 August | | sd | | 162 | | 8.0 | 44.4 |
|  |  |  | |  | |  | |  |  |
| Past varieties |  | |  | |  | |
| Allegro | 1.39 | 25 July | | d | | 78 | | 9.0 | 42.1 |
| Corsun | 1.89 | 30 July | | sd | | 78 | | 8.4 | 45.1 |
| Vincent | 2.33 | 30 July | | sd | | 147 | | 8.6 | 43.1 |
| Coril | 2.41 | 3 August | | sd | | 130 | | 7.8 | 44.1 |
| Sarah | 2.20 | 6 August | | t | | 162 | | 4.2 | 45.5 |

\*For explanation of the variety types see Appendix III.

### Sowing date

Sunflower will not germinate in a cold soil, and only very slowly (up to 35 days) when the soil temperature is around 5°C. Since extending the germination period increases the risk from soil pests and diseases, it is generally best to wait until the average daily soil temperature exceeds 7°C (at 10 cm). Typically, sowing dates are between 16 April and 5 May (Dixon & Lutman, 1992). Table 5.2 indicates sowing and harvest dates achieved in Cambridgeshire.

The crop is most vulnerable to pest, disease and environmental factors before and immediately after germination. It should be frequently inspected in the three weeks following drilling and immediate action taken to control pest damage. If there is adequate moisture, it is better to delay drilling slightly than to go too early, so that germination and emergence are rapid (Church & McCartney, unpublished; Dixon & Lutman, 1992).

Table .. Sowing date, harvesting date, variety, days from sowing to harvest and accumulated day degrees (°C) over a base air temperature of 6°C at ADAS Boxworth 1990-1997

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | Sowing date | Harvesting date | Variety | Days from sowing to harvest | Accumulated day degrees (°C) over a base of 6°C |
|  |  |  |  |  |  |
| 1990 | 18 April | 18 September | Sierra | 152 | 1397 |
| 1991 | 8 May | 8 October | Vincent | 152 | 1373 |
| 1992 | 4 May | 9 October | Vincent | 157 | 1479 |
| 1993 | 20 April | 16 October | Vincent | 178 | 1370 |
| 1994 | 1 May | 14 October | Vincent | 165 | 1421 |
| 1995 | 28 April | 28 September | Vincent | 153 | 1511 |
| 1996 | 1 May | 15 October | Printasol | 168 | 1392 |
| 1997 | 28 April | 23 September | Printasol | 154 | 1348 |

## Seed treatments

In the UK most seed is sold treated with metalaxyl, alone or in mixtures. The seed is imported from America or France already treated (B Fletcher, pers. comm.). There has been no research to study the efficacy of seed dressings in the UK environment.

## Plant population and distribution

Plant population is a critical factor in the production of a sunflower crop and has an effect on several parameters including:

1. Moisture content at harvest is higher at lower populations. Previous work has shown that head size tends to be larger at low populations and consequently these take longer to dry out (Narwal & Malik, 1985; Church & Rawlinson, 1991; Cook & Raw, 1993).
2. Yield of seed is also higher at low populations but in a sunflower crop, care has to be taken to balance head size with yield. Smaller heads dry out more quickly but larger heads yield more (Cook, Raw & Hill, 1995). Larger heads are also more susceptible to bird damage (Cook, Hill & Raw, unpublished) and infection from *B. cinerea* (Church & Rawlinson, 1991).
3. Plant density will influence the proportion of radiant energy intercepted by the crop and consequently photoassimilate acquisition and partitioning. It will, therefore, have a direct impact on yield and quality. There is scant evidence on the influence of density on physiological parameters such as optimum leaf are index (LAI), attenuation co-efficient (K), radiation use efficiencies or the manner in which these vary in current varieties or between densities. This basic knowledge would improve the precision of sunflower production in the UK.

Trial results indicated that a population of between 80,000 and 110,000 plants/ha was optimal for yield at a row width of 34 cm (UKSA, unpublished).

The optimal sowing depth is 2.5 to 5.0 cm according to seed size and conditions (CETIOM, 1998). The aims should be to sow into moist soil, to cover the seed well and to protect it from bird damage. Under particularly dry conditions, it may be necessary to sow more deeply in order to find moisture.

Since seed weight can vary considerably, both between varieties and seed batches, it is essential to sow by number, using the 1000 seed weight to give the equivalent weight. Actual sowing rates should be between 10% and 20% higher than the target plant population to allow for losses during establishment. The lower figure applies to later sowings, light soils, warm seedbeds and conditions generally favourable to germination; the higher to heavy clay soils under less favourable conditions (UKSA, unpublished).

Seed rate formula

Seedrate kg/ha = Target popn/m² x TSWT (g) x 100

% germination x % establishment

Target populations for three varietal groups and target spacings within rows required to achieve these with four different row widths are shown in Table 5.3.

Table .. Target row spacings and seed rates

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variety type\* | Target population (plants/ha) | Seeding rate (seeds/ha) | Between-row spacing  (cm) | | | |
|  | | |  |  |  |  |
| These figures relate to the use of a corn-drill. Where a pneumatic disk-drill or belt-drill is employed the target population may be reduced by taking the value shown here as the seeding rate. | | | 25 | 38 | 50 | 75 |
|  | | | In-row spacing (cm) | | | |
| Tall | 80,000 | 88,000 | 50 | 33 | 25 | 17 |
| Semi-dwarf | 100,000 | 110,000 | 40 | 26 | 20 | 14 |
| Dwarf | 120,000 | 132,000 | 33 | 22 | 17 | 11 |

\* for explanation of these variety types see Appendix III, Source: Hutley-Bull (unpublished).

## Nutrient applications

Traditionally, sunflower has been grown on light and shallow soils, but with increasing returns the crop can be found on better soils. Sunflower has a high uptake of potassium but little of this is removed in the seed (Table 5.4).

Table . Sunflower nutrient balance for a yield of 2.0 t ha-1

a) macronutrients

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Uptake | Removal | Residues |
|  |  |  |  |  |
| Nitrogen | N | 91 | 51 | 46 |
| Phosphate | P2O5 | 34 | 25 | 9 |
| Potassium | K2O | 229 | 17 | 211 |
| Magnesium | MgO | 51 | 9 | 43 |
| Calcium | CaO | 120 | 6 | 114 |

b) micronutrients

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Uptake | Removal | Residues |
|  |  |  |  |  |
| Iron | Fe | 418 | 61 | 358 |
| Manganese | Mn | 235 | 24 | 211 |
| Zinc | Zn | 199 | 85 | 114 |
| Copper | Cu | 34 | 14 | 19 |
| Boron | B | 226 | 46 | 181 |

Source: Halliday & Trenkel (1992) and CETIOM (1998).

### Macronutrients

#### Nitrogen

Sunflower has an inherently low fertiliser nitrogen requirement. Nitrogen is needed by the crop between 5 leaf pairs (GS 2.5, see Appendix I) and the start of flowering (GS 4.1) (CETIOM, 1998). The deep rooting nature of the crop means that nitrogen is taken up from the deepest strata of the soil. Adjustment of the rate is important as too much nitrogen favours disease development, delays maturity and lowers seed oil content (Church & McCartney, unpublished; Narwal & Malik, 1985). The crop removes quite high levels of nitrogen in the grain, so available soil reserves to the following crop will be quite low, possibly rated as index 0 (P. Dampney, pers. comm.).

French experience (CETIOM, 1998) indicates an application rate of between 0 and 80 kg ha-1 depending upon soil type. Crops under irrigation receive the higher rate. UK experience indicates that between 25 and 50 kg ha-1 is sufficient (Fig. 5.1), often no nitrogen needs to be applied to the crop (UKSA, unpublished).

#### Phosphate and potash

Sunflowers export quite low levels of potassium and phosphate in the seed (Table 5.4), but need quite high levels in the soil. The need for potassium is higher than that of phosphate. A normal maintenance application would be 40-60 kg ha-1 of phosphate and the same of potash (CETIOM, 1998).



Figure . The effect of nitrogen rate on yield of sunflowers - UKSource UKSA, unpublished.

### Micronutrients

#### Boron

The crop is very sensitive to boron deficiency on calcareous or sandy soils with low soil boron levels and in areas of high temperature and solar radiation. Boron is involved in the process of growth and development. A deficiency of the nutrient affects cell structure and division plus fertility and the germination of pollen and the pollen tube. Effects on seed set can be dramatic and many hollow seeds develop on a high percentage of heads. Other symptoms are red-brown interveinal necrotic patches, abnormal development of sections of the head and abnormal neck breakage. The majority of Boron is taken up between 5 leaf pairs (GS 2.5) and the start of flowering (GS 4.1) (Merrien & Perny, 1997). Symptoms during the vegetative phase are seen only in cases of severe deficiency, usually growth is good although some patches of poor growth are seen. Table 5.5 indicates the growth stages and application rates for Boron in sunflower.

Table . When, and how, to apply Boron to sunflowers

a) Application parameters and treatment method

|  |  |  |
| --- | --- | --- |
| Factor | Soil Boron level | Treatment |
|  |  |  |
| Non-calcareous pH<7.5 | 0.5 ppm | Soil incorporated |
| Calcareous pH>7.5 | 0.5 ppm | Foliar spray |
| Sandy | 0.5 ppm | Foliar spray |
| Climatic risk - high temperatures and solar radiation | 0.2-0.3 ppm | Soil incorporated or foliar spray |

b) Date of application and dose rate

|  |  |  |  |
| --- | --- | --- | --- |
| Treatment | Growth stage | Form | Dose rate |
|  |  |  |  |
| Soil incorporated | At drilling | Solid or liquid | 1.2 kg ha-1 |
|  |  |  |  |
| Foliar spray | 2.5-3.2 | Liquid | 300-500 g ha-1 |

Source: CETIOM (1998)

#### Molybdenum

Deficiencies can be a problem in very acid soils (<pH 5.0) and can be corrected by a foliar application of 10-20 g ha-1 Molybdenum (CETIOM, 1998). In soils that are this acidic, Copper and Manganese will probably be deficient as well.

## Weeds and their control

### Introduction

Although the height and broadly spreading leaf canopy of all but the most dwarf varieties allow sunflower to compete very effectively with weed growth from as early as the fourth week from emergence, the crop is nonetheless highly sensitive to above and below ground competition during the initial period of establishment (CETIOM, 1998). The effects of early competition are particularly marked where low soil temperatures and/or poorly aerated soil retard the growth of the crop relative to that of the weeds and where low plant populations or uneven drilling delay the closing of the crop canopy (P.D. Hutley-Bull, pers. comm.).

Another influential factor in weed control is the spatial distribution of the crop. Broad drill-rows, such as the 75 cm (30 in) rows typical of crops sown with standard maize drills, tend to crowd plants within the rows, exacerbating inter-plant competition and thereby reducing crop vigour, whilst at the same time allowing ample space for weed growth between rows (P. D. Hutley-Bull. pers. comm.). Although, ideally, plants should be spaced equidistantly within and between rows to minimise both sorts of competitive stress, even reducing row width by a third to 50 cm (20 in), offers considerable benefits to weed control (P. D. Hutley-Bull, pers. comm.).

Failure to adequately control broad-leaved or grass weeds during crop establishment typically leads to a reduction in relative growth rate, delaying canopy closure and thereby extending the vulnerable period (CETIOM, 1998). In extreme cases, this can result in crop loss; more commonly, it leads to lack of uniformity, to an overall reduction in crop vigour and to a concomitant loss of yield. Additionally, phenological development may be retarded, delaying maturation and creating harvesting problems. Harvested seed may be contaminated with weed seeds and penalties imposed on sale of the crop. Cleaning seed can be an extra cost.

### Problem weeds

Although a detailed evaluation of the threat posed by individual weed species would be inappropriate in the present context, a brief consideration of the principal classes of weed with reference to particularly common examples may not be out of place.

Perennial broad-leaved weeds are no more of a problem than in the case of many other arable crops. The further proliferation of short or prostrate species, such as knotgrass, redshank and sometimes docks, may actually be retarded by crops of sunflower having an optimal canopy density. Conversely, climbing and twining weeds, such as field bindweed, black bindweed and even bittersweet may benefit from the opportunity offered by the tall straight stems (P. D. Hutley-Bull, pers. comm.).

As with most arable crops, perennial weeds are best controlled outside the crop though, where inter-row cultivation is practised, weed growth may be weakened. Few such weeds are strongly affected by the herbicides approved for use on sunflower, though a temporary weakening may be achieved, allowing the crop to achieve greater dominance.

Perennial grass weeds are rarely much of a threat to sunflower except at very high densities. Additionally, because the crop is not only spring-sown but can be sown as late as May, it offers a good opportunity for controlling weeds during a long, and latterly warm, half-fallow.

Annual broad-leaved weeds are commonly the most threatening, particularly those, such as fat-hen, which tend to germinate after drilling but grow more vigorously than the crop, a difference exacerbated by low soil temperatures. Erect weeds, of which fat-hen is again an example, can also create problems if not controlled sufficiently early, since their form enables them to rise above the developing crop canopy and make rapid growth (S.K. Cook, pers. comm.). Problems arising from weeds of this type in crops of dwarf sunflower (see Appendix III) seem to have contributed significantly to the poor record of this class. Because of their stature and vigour, crops of semi-dwarf hybrids are generally far less susceptible to damage from this source. Many such weeds can be controlled by a single herbicide application.

Annual grass weeds are sometimes present at significant levels in sunflower, particularly where the crop has been slow to get away or where broad drill-rows or patchy establishment allows room for development. Occasionally, backward crops can be overwhelmed in parts by annual meadow grasses or by annual rye‑grass. Even cereal volunteers can sometimes present problems. Where this is the case, an opportunity exists for chemical control.

### Chemical weed control

Although relatively few herbicides are approved, fully or off-label, for use in sunflower, the nature of the crop means that few are actually required. This is not to say that there is adequate cover under all circumstances, but the opportunities for chemical control are such that the grower need not feel unduly anxious. Leaving aside the opportunities offered by applications of glyphosate or paraquat before seed-bed preparation, the earliest and, until recently, the only available window of control is offered by:

1. Trifluralin. Formulated as *Treflan* or *Tristar*, this requires to be applied to a fine, moist tilth and then incorporated into the upper soil layer during seed-bed preparation. Where this can be achieved, a range of broad-leaved weeds, including the potentially most pernicious, can be successfully controlled. Ironically, its usefulness is often curtailed by climatic and edaphic factors characteristic of the very areas best suited to sunflower production. Thus, in situations where the soil is light and rainfall relatively low, there is a serious risk of losing what moisture is available for crop germination because of the initial cultivation and incorporation. This product is only effective pre-emergence of the weeds.
2. Pendimethalin. Formulated as *Stomp 400 SC*, this is approved for use after sowing but before crop emergence. This is also most effective where the surface is firm and where the soil is reasonably fine and, above all, moist, conditions which are not always easy to achieve at the time of sowing. However, given sufficient soil moisture at the time of application or shortly after, the growth of a wide range of broad-leaved weeds is curtailed or inhibited and there is even some control of grass weeds. This product is only effective pre-emergence of the weeds.
3. Sethoxydim This, the only chemical approved in the UK for weed control post-emergence of the crop, is the active ingredient of *Checkmate* which may be applied once, not less than twelve weeks before harvest, for the control of grassweeds and cereal volunteers.

Assuming that the products at present approved remain available for use in sunflower, the only element lacking for adequate weed control is a wide-spectrum, post-emergence, broad-leaved herbicide. In the absence of approval for a product based on aclonifen, there remains a distinct possibility that herbicides submitted for approval on other crops and capable of meeting this need could be made available on an off-label basis.

It is also worth noting that, although sethoxydim is the only approved means of post-emergence grass weed control at the present time, should the product cease to be available for this purpose, it is highly probable that off-label approval could be successfully sought for fluazifop-p-butyl (active ingredient of *Fusilade 250 EW*). This is already approved for use on sunflower in France and elsewhere and on some other spring-sown oilseed crops in the UK.

### Cultural weed control

Sunflower crops grown in wide rows allow an ideal opportunity for cultural weed control (Schnieter *et al*., 1981). A tractor mounted steerage hoe can be guided along the rows and this method has been used successfully in the UK (R. Brown, pers. comm.). Mechanical weed control is most successful when soil conditions are dry and the weather is set fair.

## Diseases and their control

### Introduction

Sunflower is the host of a number of fungal, bacterial and viral pathogens (Table 5.6) which can cause varying amounts of crop damage. The spectrum of diseases experienced by the crop is dependent upon the climatic conditions and the prevalence of the causal pathogen. Thus, geographic location and cultivation methods can play important roles in disease problems suffered by sunflower crops. In this section, we discuss the diseases known to affect sunflowers grown in the UK, review potential diseases which could be important if UK production expands and consider current future disease management strategies.

### Sunflower diseases reported in the UK

Although sunflower has been grown intermittently in the UK for many years, there is still relatively little experience of sunflower production under UK conditions. Thus, as far as we are aware, there have been no systematic studies of sunflower disease problems in the UK. However, three fungal pathogens, *Sclerotinia sclerotiorum*, *Botrytis cinerea* and *Verticillium dahliae*, have been reported in UK crops. Of these, *S. sclerotiorum* probably represents the biggest potential problem in the growing crop.

Grower experience suggests that occasionally problems may arise during the establishment of the crop but the causes of poor establishment are not clear. It is often unclear whether poor establishment is due to disease, or the activity of slugs or insects or both.

#### Sclerotinia wilt and rot

*Sclerotinia sclerotiorum* (Lib.) de Bary, is considered a major pathogen of sunflower world-wide (Kolte, 1985; Maservic & Gulya, 1992; Gulya *et al*., 1997). It causes disease in all the major sunflower producing countries throughout the world (Kolte, 1985). Severe losses can occur; for example, infection rates of 90% have been reported in Canada (Maservic & Gulya 1992). The pathogen can cause three distinct diseases, depending on the time and mode of infection (see below): basal stalk rot (wilting), stem rot (wilting) and head rot.

The pathogen has a large host range (Boland & Hall, 1994). It attacks field, forage, vegetable and ornamental crops, trees and shrubs and numerous herbaceous weeds (Zimmerman & Hoes, 1978). In temperate climates, the fungus over-winters as soil-borne sclerotia, survival structures which form in infected tissue. The sclerotia can germinate in the soil producing mycelia which can infect roots directly causing basal stalk rot and wilting. Alternatively, they can germinate carpogenically to produce saucer shaped fruiting bodies, apothecia, up to one centimetre in diameter which release microscopic ascospores that can infect stems and heads (stem and head rot). The ascospores are readily dispersed by wind (Steadman, 1983) and have been detected in the air up to 150 m from the nearest source (Williams & Stelfox, 1979). Sunflower heads can be infected by ascospores at any time from flowering to maturity, symptoms appearing as a white mycelial mat and rot spreads rapidly throughout the flower head (Zimmerman & Hoes, 1978). Ascospores can also infect leaves (Sedun & Brown, 1987), although symptoms are not easily detected. The fungus infects stems, usually through a leaf node from infected leaves, destroying the inner pith, causing wilting, and.

Table .. Common fungal diseases of sunflower World-wide

|  |  |  |  |
| --- | --- | --- | --- |
| Disease | Causal Agent | Symptoms | Notes |
|  |  |  |  |
| Sclerotinia wilt and rot | *Sclerotinia sclerotiorum* | See text | Has been found in UK crops. See text. |
| Botrytis head rot | *Botrytis cinerea* | See text | Has been found in UK crops. See text. |
| Verticillium wilt | *Verticillium dahliae* | See text | Has been found in UK crop. See text. |
| Downy mildew | *Plasmopara halstedii*  *(P. helianthi)* | See text | Found in France1, 2, important. See text. |
| Phomopsis stem canker | *Phomopsis spp., P. helianthi* | See text | Found in France1, 2, 3, a major problem. See text. |
| Charcoal rot | *Macrophomina phaseolina* | See text | Found in France1, 2, 3, important. See text. |
| Alternaria blight | *Alternaria helianthi* | Brown spots on leaves, stems and back of head | Found in France1, 2, 3. See text. |
| Phoma black stem | *Phoma macdonaldii* | Brown spots on leave spreading to black lesions on stems | Found in France. An increasing problem. See text. |
| Rust | *Puccinia helianthi* | Rust coloured lesion on foliage | Minor pathogen in France1, 2, 3. Unlikely to be a problem in UK. |
| Rhizopus head rot | *Rhizopus arrhizus, R. nigricans* | Brown sunken lesions on the back of the head, whole head may be affected. | Minor pathogen in France only in hot seasons 1, 2, 3. Unlikely to be a problem in the UK. |
| Powdery mildew | *Sphaerotheca fuliginea*  *Erysiphe cichoracearum* | White powdery lesions on leaves | Minor pathogen in France1, 2, 3. Causes limited damage in temperate climates, but can be serious in the tropics4. Unlikely to be a problem in UK. |
| Septoria leaf spot | *Septoria helianthi* | Necrotic diamond shaped lesions on leaves. | Common in USA, China, India, favoured by warm moist conditions4. Unlikely to be a problem in the UK |
| White rust | *Albugo tragopogonis* | Raised yellow lesions on leaves. | Has been observed in most sunflower producing countries, but only damaging in Argentina, Australia and South Africa4. Unlikely to be a problem in the UK |

(Cont’d)

Table 5.6 : Common fungal diseases of sunflower World-wide. (cont’d)

|  |  |  |  |
| --- | --- | --- | --- |
| Disease | Causal Agent | Symptoms | Notes |
|  |  |  |  |
| Minor foliar pathogens | *Ascochyta compositarum*  *Cerscospora spp.*  *Colletotrichum helianthi*  *Entyloma compostitarum*  *Epicoccum neglectum*  *Itersonilia perplexans*  *Myrothecium* spp.  *Phialophora ateris*  *Phyllosticta wisconsinensis*  *Sordaria fimicola* |  | These fungi have been reported to cause leaf spot symptoms on sunflower crops in different parts of the world. None is considered to be major pathogens4. Unlikely to be a problem in the UK. |
| Bacterial soft rots | *Erwinia carotoovra*  *Pseudomonas* spp. | Brown rot, on back of head or upper stem | A minor pathogen in France1, 2, 3, associated with warm, humid climates, especially in irrigated crops2. Found in other parts of the World5. Unlikely to be a problem in the UK. |
| Bacterial foliar diseases | *Pseudomonas syringae* pv. *tagetis*  *P. s.* pv. *helianthi* | Localised leaf lesions | Widespread throughout the World, but generally only of minor importance4. Unlikely to be a problem in the UK. |
| Viral diseases | Sunflower mosaic  Cucumber mosaic  Sunflower ringspot  Sunflower yellow blotch and leaf crinkle  Tobacco ringspot  Tobacco streak  Tomato spotted wilt | Various foliar lesions | Viral diseases have been reported from many parts of the World4, 5. However, they generally do not cause significant damage. They are very infrequent in France2, 3 and are rarely fund in North America4. |

1Lamarque (1985b); 1Bonjean (1986); 3CETIOM (1996); 4Gulya *et al.,* (1997); 5Kolte (1985)

forming a light coloured lesion round the stem (Zimmerman & Hoes, 1978, Maservic & Gulya, 1992). Stem infection causes wilting and often leads to collapse of the plant. Sclerotia form in diseased tissue (roots, stems and heads) and can be returned to the soil during harvest or when an infected plant collapses

Sclerotia have been found to survive in soil for up to 7 years (Gulya *et al*., 1997), although survival depends on the soil type and depth of burial. Wet soils and high temperatures (>27ºC) have been found to be detrimental to sclerotia survival and dry soils cool soils are favourable. Myceliogenic germination of sclerotia takes place over a wide range of temperatures, but the optimum is between 18 and 25ºC (Maservic & Gulya, 1992). Likewise, apothecia development can occur over a wide temperature range (4-32ºC) but requires wet soils and light. The optimum temperature range is 20-25ºC (Gulya *et al.,* 1997). A high relative humidity is needed for ascospore discharge, although it probably responds to humidity changes (McCartney, unpublished). In experiments at IACR-Rothamsted, ascospore release usually occurred around noon corresponding to soil drying (McCartney & Lacey, 1991). The optimum temperature for ascospore release is about 20ºC (Maservic & Gulya, 1992), but takes place over a wide temperature range.

The potential for the development of disease epidemics is determined by occurrence of appropriate climatic conditions and the concurrent presence of inoculum (usually ascospores). In France, a joint study by the Institute National de la Recherche Agronomique and Météorologie National (CETIOM, 1981), identified the weather conditions favourable for infection by *S. sclerotiorum* and developed a climatic model to estimate the occurrence of those conditions from weather measurements. In the UK, results from studies on the relationship between inoculum (airborne ascospores) and the plants. McCartney & Lacey (1991, 1992b) showed that there was about a five week delay between infection and the appearance of symptoms, whether on stems or heads suggesting that ascospore monitoring could form a useful part of a disease forecasting scheme. The type of infection appears to depend on when ascospores are present (McCartney & Lacey, 1992a, 1992b, and unpublished): stem lesions occurred when ascospores were in the air before flowering while head lesions were more common when the ascospore peak was during flowering.

##### Control/Management

Strategies for disease control rely on either minimising inoculum or preventing disease development (or a mixture of both). Minimising inoculum includes cultural practices and methods to reduce soil-borne sclerotia. While disease prevention includes chemical control and breeding for resistance.

*S. sclerotiorum* has a wide host range. Table 5.7 shows the relative susceptibility of a number of crops to *S. sclerotiorum*. UK and French surveys have shown that the severity of attacks on susceptible crops is related to the number of susceptible crops grown in the rotation (Fitt, McCartney & Davies*,* 1992). Reducing the number of susceptible crops in the rotations reduces the number of sclerotia returned to the soil and the longer the time between susceptible crops, the fewer sclerotia will survive to produce inoculum. The use of rotations should be accompanied by adequate weed control as many weed species are host to the fungus (Boland & Hall, 1994). In experiments at IACR-Rothamsted, where oilseed rape was artificially inoculated with sclerotia, field poppies growing in the plots were also infected by the fungus (McCartney, unpublished). Several studies suggest that a five-year rotation separating sunflower from another host crop is needed to prevent inoculum build up (Kolte, 1985; Fitt, McCartney & Davies, 1992; Gulya *et al*., 1997).

Table . Relative susceptibility of different crops to infection by Sclerotinia sclerotiorum

|  |  |  |
| --- | --- | --- |
| Crop | Degree of Crop Damage | Production of sclerotia |
| Sunflowers | \*\*\*\* | \*\*\*\*\* |
| Phaseolus beans | \*\*\*\* | \*\*\*\* |
| Winter oilseed rape | \*\*\* | \*\*\* |
| Potatoes | \*\* | \*\* |
| Spring field beans | \*\* | \* |
| Spring oilseed rape | \*\* | \* |
| Linseed | \*\* | \* |
| Peas | \* | \*\*\*\* |

There are several strategies available to try and reduce the survival of sclerotia of *S. sclerotiorum* in the field. The use of sclerotia free seed is an obvious first step. Where the rotation allows, shallow cultivation that leaves the sclerotia near the soil surface may accelerate their degradation, however, this must be followed by a non-susceptible crop (Fitt, McCartney & Davies, 1992; Gulya *et al.*, 1997). Deep cultivation will bury sclerotia, but it may be many years before they are destroyed (Fitt, McCartney & Davies, 1992). There has been much interest in using soil-borne micro-organisms as biological control agents against sclerotia (Kolte, 1985; Gulya *et al.,* 1997). Over 30 species of fungi and bacteria have been reported to parisitize *S. sclerotiorum* sclerotia. Although many of these parasites have been successful in reducing the impact of the disease under controlled conditions, practical economic disease control using biological control agents has still to be realised (Gulya *et al.*, 1997).

Cultural methods can be used in an attempt to alleviate the effects of disease. Plant population has been shown to have little effect on disease incidence (Péres *et al.,* 1992a; Gulya *et al.*, 1997), however, high populations may increase the chances of root infections (Gulya *et al*., 1997). Changing row spacing may reduce infections (Péres *et al.,* 1992a; Gulya *et al.*, 1997), possibly by altering the microclimate allowing soil to dry more quickly and so reducing inoculum. High levels of nitrogen and irrigation may also increase the potential for infection (Péres *et al.,* 1992a; Gulya *et al.,* 1997). However, such manipulation of the crop canopy can also effect yield, thus there must be a balance between expected loss through disease and by changes in cultural practices.

The use of resistant or tolerant varieties is the most effective method of reducing the impact of disease on crops. The search for resistance to *S. sclerotiorum* has been one of the major objectives in sunflower breeding programmes world-wide. There appears to be a lack of immunity in both cultivated and wild sunflower populations (Gulya *et al.*, 1997). The lack of immunity is generally true for most crops which are hosts to the fungus. However, there have been many reports of sunflower genotypes with low susceptibility or moderate resistance (Gulya *et al.*, 1997). Accessions of other species of *Helianthus* have been reported to show some resistance to the pathogen and may offer an opportunity of increasing the tolerance of commercial varieties. Commercial varieties with some degree of tolerance are available in France.The status of susceptibility of varieties suitable for UK production to *S. sclerotiorum* is not known.

Some herbicides such as atrazine and simazine, linuron and dinoseb have been reported to have detrimental effects on apothecia formation while others (trifluralin, pendimethalin and metribuzin) have been reported to stimulate carpogenic germination of sclerotia (Gulya *et al.*, 1997). It is unlikely that pre-emergence treatment with herbicide would have a significant effect on subsequent disease development. In the UK, only trifluralin and pendemethalin are available for weed control and hence are likely to have little effect. The fungus is difficult to eradicate in the soil because the sclerotia are dormant, few in number and widely scattered, and because fungicides applied to the soil are generally short lived (Maservic & Gulya, 1992).

Several fungicides have proved effective against ascospore infections in a number of crops (Fitt, McCartney & Davies*,* 1992; Gulya *et al.*, 1997). These include benomyl, PCNB, iprodione, vinclozolin, and MBCs. Péres *et al.*, (1992b) reported that four fungicides: vinclozolin + carbendazim; flusilazole + carbendazim; difenoconazole + carbendazim; and carbendazim were effective against the pathogen on sunflowers in greenhouse and field trials. Vinclozolin + carbendazim has been cleared for use on the crop in France. However, accurate timing of application is needed for fungicide treatments to be effective as the spray must be applied at the time of infection, before disease symptoms are visible. Because the crop is vulnerable to attack over a relatively long periods, timing of applications is difficult and more than one spray may be required to ensure protection (Gulya *et al.*, 1997). Currently, in the UK, no fungicides have been cleared for use on sunflower crops. Even if effective fungicides were available for use in the UK, routine treatment, especially with more than one spray, would not be justified, since infection does not occur every year. Fungicide treatment would be appropriate only if accurate methods of forecasting or detecting infection were available to determine when sprays were needed. Work at IACR-Rothamsted (see above) has suggested that monitoring of airborne inoculum could help identify when the crop was at risk of infection. However, no simple methods are yet available to routinely monitor ascospores. In Canada, a scheme has been developed to monitor infection of oilseed rape crops by detecting ascospores on petals (Morrall & Thomson, 1991). ADAS/IACR Rothamsted have also developed the test for UK crops, but equivalent methodologies do not exist for sunflower crops. In the UK, ADAS has used buried sclerotia to identify when apothecia have been produced and whether ascospore production coincided with oilseed rape flowering and favourable weather conditions. Between 1985 and 1991, good disease control in oilseed rape was achieved in South East England following ADAS spray warnings (Fitt, McCartney & Davies*,* 1992). A similar scheme may be helpful in identifying years with a high potential of ascospore infection.

#### Botrytis head rot

Botrytis head rot or grey mould is caused by the ubiquitous fungus *Botrytis cinerea* Pers. ex Fr. It occurs frequently in sunflower crops during relatively cool (15-25ºC), wet growing conditions and may cause extensive damage (Kolte, 1985; Gulya *et al.*, 1997). The disease has been recorded in all European countries and has been considered one of the major diseases of sunflower in France (Mitchalik & Piquemal, 1986). Disease can develop on seedlings, stems and leaves, but only if the fungus gains entry through wounds. However, it is most damaging when it infects heads. Symptoms first appear as sunken brown spots on the back surface of the heads. As the infection develops, the lesions spread and the back of the head becomes soft and turns grey due to the production of conidiophores and conidia. When infection occurs late in the season it may cause yield loss by increasing seed loss during harvest (Lamarque, 1985a), but early infection may cause loss in both yield and quality by decreasing the weight of seeds and by partially hydrolysing the oil to form free fatty acids.

The fungus is spread primarily by airborne conidia, although dispersal by rain splash may occur (Jarvis, 1980). Small irregularly shaped sclerotia can be produced but these rarely produce apothecia and ascospores (Gulya *et al.,* 1997). The role of ascospores in infection of sunflowers is unknown. Like *S. sclerotiorum*, *B. cinerea* has a wide host range. Thus, the potential for occurrence of inoculum may be high. Generally, sunflowers are not susceptible to *B. cinerea* until the production of pollen has begun on heads during flowering. Senescing flower parts, especially the corolla, stigma, anthers and bracts are very susceptible to infection which is stimulated by the presence of pollen (Ladsous *et al*., 1988). Conidia require free water to germinate, and can do so at temperatures between 3 and 30ºC, although the optimum range is between 17 and 27ºC (Gulya *et al.*, 1997). The length of the latent period, that is the time between infection and the appearance of symptoms, appears to depend on the growth stage when infection takes place (Church, 1992; Church, *et al.*, 1992). The latent period decreases as the age of the plant at infection increases, so that symptoms appear about the same time even though infection may have occurred at different growth stages. The variability in latent period has implications for the chemical control of the disease (see below).

In a five-year study (1985-1990) of sunflower cultivation at IACR-Rothamsted, Botrytis head rot was the only significant disease found (Church *et al.,* 1990; Church & Rawlinson, 1991). However, there were large differences in disease incidence and severity between seasons, with little disease developing in dry warm years. These results suggest that in ‘average’ years, the disease could cause losses when concentrations of airborne conidia are high. The appearance of disease occurred first on early sown, early maturing varieties, but this was probably because the development of symptoms is related to crop maturity (see above). The study provided no evidence that variety, sowing date or seed treatment had affected susceptibility.

##### Control/Management:

Chemical control of Botrytis head rot is often considered unfeasible because the fungus is ubiquitous (Gulya *et al.,* 1997) and the crop is susceptible over the whole of the flowering period, making forecasting the timing of control measures difficult (Church *et al.*, 1992). In a trial at IACR-Rothamsted fungicide spray treatments decreased the incidence of the disease and increased yield significantly (Church, *et al.*, 1990), however five spray applications were necessary. Systemic fungicides have no effect; they are either absorbed or rapidly degraded before reaching the sites of infection (Péres, 1986). Church *et al.* (1990) suggest that if a desiccant is applied when the seed moisture is about 30%, the effect of the disease can be decreased by advancing the harvest date by up to seven days. Desiccation does not result in loss of yield since oil content increases until physiological maturity, and then declines. Some studies suggest that two sprays with an appropriate fungicide during flowering may be effective (Kolte, 1985). In France, vinclozolin has been cleared for use on sunflower crops.

The development of resistant or tolerant varieties may be the most effective means of controlling Botrytis head rot in sunflowers (Kolte, 1985; Gulya *et al.,* 1997). Complete resistance to the fungus has not been found in cultivated or wild *Helianthus* species but differences in susceptibility to both natural and artificial inoculations have been reported (Gulya *et al.*, 1997). These findings offer the potential for the production of at least disease tolerant varieties. However, at present, we know of no varieties suitable for the UK that are tolerant of Botrytis head rot.

#### Verticillium wilt

*Verticillium dahliae* Klebahn is a damaging soil-borne pathogen with a wide range of hosts. In the UK, these include other oilseed species such as linseed (Fitt *et al.,* 1992) and oilseed rape as well as lupins, brassicas and solanaceous crops (Moore, 1959). Like *S. sclerotiorum,* the fungus persists in the soil as microsclerotia however, it invades the host through the root system causing wilting and premature senescence. In the field, symptoms of *V. dahliae* on the leaves can be very similar to those of natural senescence. In other plant species, symptoms can range between foliar chlorosis with progressive marginal and interveinal necrosis and defoliation, rapid collapse and death of leaves or gradual yellowing and premature defoliation (Hawksworth & Talboys, 1970). The microsclerotia of *V. dahliae* may persist in the soil for a number of years (Schnathorst, 1981) initially in the debris of infected host plants, and possibly later, as free microsclerotia infecting roots after contact (Hawksworth & Talboys, 1970). However, transmission by superficial infection of seed has been reported for sunflower (Sackston & Martens, 1959). The disease is favoured by high soil temperatures with an optimum of 24°C (Schnathorst, 1981).

*V. dahliae* is widespread in all temperate regions and on the continent of Europe, and where temperatures during the growing season are high, it causes serious disease on sunflower. The fungus had not previously been reported as a pathogen of sunflower in the UK until 1994 (Church & McCartney, 1995). In August 1994, verticilliosis-like symptoms were noticed in a maturing crop of sunflower at IACR-Rothamsted. Wilting plants with chlorotic areas on some leaves, and dark areas of microsclerotia at the base of stems, were first observed on 11 August. As the plants matured, dark stripes were also observed on the stems. Many stems became brittle and later collapsed. Infected xylem showed a brown discoloration, later turning to black, and microsclerotia developed. *Verticillium dahliae* was isolated from all parts of the plant.

Once symptoms were present, the disease developed most rapidly in early maturing varieties. The incidence of verticilliosis-infected plants increased from 7.7% to 25.3% between 18 August and 23 August on the early maturing variety, Allegro, and from 2.3% to 5.3% between the same dates on a later maturing type, PAN9405. Incidence ranged from 24.5% to 89.8% at harvest, depending on variety. Early maturing varieties appeared to be more susceptible than later maturing types.

The disease is associated with high temperatures during the growing season. The mean air temperature at IACR-Rothamsted for July/August 1994 was about 2°C above the 30-year mean which may have promoted the development of the disease. It was thought that the source of infection could have been an infected crop of linseed grown on the same site in 1989 (Church & McCartney, 1995).

If sunflower becomes established as a viable alternative oilseed crop in the UK,  *V. dahliae* could become economically damaging to the crop but probably only in warmer than usual summers. Several other crops which may be used in rotation with sunflower are also susceptible to the fungus. A recent study has shown that UK *V. dahliae* isolates, from a range of host species, were able to infect a number of other hosts including sunflower, lupin, linseed, hemp and oilseed rape (Fitt & Woodwark, 1996). This may lead to a build-up of inoculum in the soil with a consequent increase in the potential for damaging epidemics.

##### Control/Management:

As the disease is propagated by soil-borne microsclerotia, it is important that sclerotia-free seed is used to eliminate contamination of pathogen-free fields. Other control measures include breeding for resistance, crop rotation and chemical and biological agents.

Resistance to V. dahliae has been found in many wild species of Helianthus and has been used as a basis for developing resistance in commercial crops (Gulya et al., 1997). However, the fungus has geographical genetic variability, so resistant varieties developed in one area may not be effective in others. Most commercial oilseed hybrids are resistant to the North American race of V. dahliae (Gulya et al., 1997). A resistance screening programme is being developed in France, but little is known of the resistance status of sunflower varieties to UK races of V. dahliae.

Because the fungus invades through the roots, chemical control by foliar sprays is not possible. Several methods have been tried to reduce soil contamination by microsclerotia (Gulya et al., 1997). Fumigation has been successful, but is expensive. Other methods include: soil solarization using transparent polyethylene sheeting; flooding; and soil acidification using aluminium sulphates. However, such methods would be too expensive or impractical for routine use in the UK. Biological control methods are also being investigated but none is yet commercially available (Gulya et al., 1997).

Crop rotations have not generally proved to be very effective, primarily because microsclerotia can survive for long periods of time and V. dahliae can persist on the roots of immune varieties (Gulya et al., 1997). Even so, the severity of Verticillium wilt on oilseed rape, for example, is known to be reduced by rotation with non-susceptible crops (Svensson & Lerenius, 1987).

### Potential disease of sunflower crops in the UK

Table 5.6 lists the major and some of the minor diseases of sunflower recorded World-wide. Many of these diseases are unlikely to be potentially damaging in the UK, either because environmental conditions in the UK are unfavourable or because the causal agent is unlikely to become common in the UK. The diseases most likely to pose a potential threat to UK sunflower crops are those currently important in France, particularly in the western and northern growing regions. For these pathogens, UK environmental conditions are likely to be favourable and the chances of the introduction of the causal organism are likely to be higher. Five diseases fall into this category: Downy mildew, Phomopsis stem canker, Phoma black stem, Charcoal rot, and Alternaria blight.

##### Downy mildew

Downy mildew of sunflowers is, along with Sclerotinia and Phomopsis, one of the three most important diseases in France (Pilorgé, 1997). The disease is cased by the obligate fungal pathogen *Plasmopara halstedii,* (Farl.) Berl. and de Toni, often referred to as *P. helianthi* in Europe. The fungus can cause downy mildew on at least 80 species, but evidence that isolates for other species can infect sunflowers is rare (Gulya *et al.*, 1997). The fungus has been reported in all sunflower growing areas except Australia (Gulya *et al.*, 1997). It is common and more prevalent in temperate regions (Gulya *et al.*, 1997; Kolte, 1985). Yield loss is due to a combination of plant death, smaller heads, lower oil content and lighter seeds.

The fungus primarily infects through the roots via zoospores released from soil‑borne oospores to produce systemic infections. Oospores can survive in the soil for a considerable time, and periods up to 14 years have been reported (Kolte, 1985). Early infections can cause seedling damping off or post emergence death and later infections produce stunted plants with chlorotic and puckered leaves. When suitable leaf wetness prevails, infected leaves will produce dense white layers of asexual zoosporangia on their undersides. The zoosporangia can be dispersed by rain-splash or wind to infect leaves directly, but this is thought to be of minor importance in the effects of the disease (Gulya *et al.,* 1997; Kolte, 1985). Oospores are returned to the soil from the residue from infected plants (Kolte, 1985). Systemic infections can result from infected seed (Kolte, 1985), but it is thought that such infections are rare (Gulya *et al.*, 1997). Oospore germination is favoured by wet soils, so epidemics are associated with wet weather. The optimum conditions for oospore germination appear not to be known, but a vernalisation period of freezing temperatures may be required (Gulya *et al.,* 1997). This may reduce the chance of infection in the UK. Zoosporangium germination takes place over a wide temperature range (5-28ºC, optimum 16-18ºC) and the optimum temperature for seedling infection is between 18 and 24ºC (Kolte, 1985). Under UK conditions, infection may not be particularly limited by water requirements (although recently there have been several dry springs) but relatively low soil temperatures may reduce infections, especially at the seedling stage.

The disease can be controlled by a combination of the use of resistant varieties and chemical seed treatment. Several races of *P. halstedii* are known, but germplasm lines resistant to all races have been developed (Gulya *et al.*, 1997). Varieties resistant to the European race are available in France and new varieties resistant to all races are becoming available. Fungicides are effective against all races of the fungus and are used as a seed treatment to control the disease in the USA and in France. In France, treatment of imported seed is obligatory. Metalaxyl is the most widely used seed treatment but other fungicides are effective, for example, oxadixyl and benalaxyl (Gulya *et al.,* 1997). However, metalaxyl resistance has been detected in France. Because of the availability of resistant genotypes, development of resistance in varieties suitable of UK conditions should be possible. Seed treatment is relatively cheap and should be used if the disease becomes established in the UK.

The potential for downy mildew becoming established in the UK cannot be ignored. Environmental conditions are probably not limiting. If inoculum became common, it is likely that the disease could occur in UK crops. It is, therefore, important that disease free seed is used and that seed treatment should be considered as a routine measure.

#### Phomopsis stem canker

This is a relatively recent disease in sunflower. It was first reported in Yugoslavia in 1980, but has since been reported in other parts of Europe, including France (Regnault, 1985), and in the USA (Gulya *et al.*, 1997). In France, the disease is considered one of the three most damaging for cultivated sunflowers (CETIOM, 1997b). It is most prevalent in the South West, but occurs in all areas (Pilorgé, 1997). The disease is caused by the fungus *Phomopsis helianthi,* Munt. (although other *Phomopsis* species may be implicated) which produce grey-brown stem lesions. The lesion may encircle the stem making the plant prone to lodging. The pathogen initially infects through leaves before spreading into the stem. Severely infected fields can suffer large yield losses.

The disease is spread by wind and splash dispersed ascospores released from perithecia on previously infected plant debris. Stem lesions form 25-30 days after initial infection. The ascospores mature between 15 and 30ºC (optimum about 25ºC) but require free water to infect. This probably explains why the disease is more important in south west France than in other regions. Frequent or abundant rainfall from budding to flowering appears to favour infection, but symptoms generally appear after flowering, regardless of sowing date.

It is generally accepted that a rotation of at least one year without sunflowers significantly decreases inoculum from infected crops and that removing or burying infected stems (>15cm deep) reduces the risk of infection the following year. The disease can be controlled with fungicides, but more than one application is usually needed (LePage, 1995; Gulya *et al.*, 1997). In French trials, fungicide combinations such as fenpropimorph + mancozeb + carbendazim or flusilazole + carbendazim gave the best control (LePage, 1995). Current spray recommendations in France depend on the risk in the growing region and susceptibility of the variety (Table 5.8; Penaud & Joufferet, 1997). When first reported all commercial varieties were susceptible to *P. helianthi* (Gulya *et al.*, 1997). However, several sources or resistance have been identified and hybrids with high levels of resistance are becoming available (LePage, 1995).

Given the apparent lack of alternative hosts (e.g. wild sunflowers) and the relatively high optimum temperatures for ascospore production, it would appear unlikely that this disease would become important under UK climatic conditions. Even if the fungus became established, which is unlikely because of the lack of alternative hosts, cultural practices (such as the 4-5 year rotation adopted to reduce the risk of Sclerotinia rots) should significantly reduce the risk of Phomopsis stem canker in the UK. It is, therefore, unlikely that chemical control measures would be routinely needed. However, if large areas of the crop were grown in a relatively small region, the risk of Phomopsis becoming important would be increased.

Table .. Fungicide strategies for the control of Phomopsis in France (from Penaud & Joufferet, 1997)

|  |  |  |  |
| --- | --- | --- | --- |
| Variety susceptibility | High risk area | Medium risk area | Low risk area |
|  |  |  |  |
| Tolerant | no spray | no spray | no spray |
| Very low | one spray | no spray | no spray |
| Low | one spray | one spray if growing conditions favour the disease | no spray |
| Medium | two sprays | one spray | one spray if growing conditions favour the disease |
| Highly | do not grow | do not grow | one spray if growing conditions favour the disease |

#### Phoma black stem

Phoma black stem has been recorded in most sunflower growing areas of the world. Occasionally it has been the most frequently noted disease in the Great Plains of the USA, but in most other countries it is either scarce or of minor importance (Gulya et al., 1997). However, in France it has become of increasing importance since 1990 (Penaud & Péres, 1997) and is now considered a major problem (CETIOM, 1997a). The pathogen overwinters as pycnidia in infected sunflower residue. In the spring, perithecia of the sexual stage (Leptosphaeria lingquistii) release airborne ascospores which can infect seedlings or dead plant material to produce mycelia of the asexual stage (Phoma macdonaldii) (Gulya et al., 1997). Subsequent disease spread is by asexual pycnidiospores, primarily by rain-splash or insects (Gulya et al., 1997). Pycnidiospores can germinate over a range of temperatures (5-30ºC) but require free water. The optimum infection conditions are 25ºC with 24h wetness, and longer wetness periods are needed at lower temperatures (Gulya *et al.*, 1997). The conditions for ascospore production are not known (Péres & Pilorgé, 1997).

The fungus infects leaves causing dark lesions, particularly on the veins (CETIOM, 1997a). Infection can spread to the stems (although they can be infected directly) and cause dark lesions which can girdle the stem (Gulya *et al.,* 1997, CETIOM, 1997a). Stem lesions scan cause premature lodging. In France in 1994, new symptoms were observed on sunflower heads: dark lesions on the back of the head (Pilorgé, 1997). The disease has been found in all regions of France.

Sunflower varieties with levels of resistance to *P. macdonaldii* have been identified but there are no totally resistant varieties available (Gulya *et al.*, 1997). Because the disease has only recently been identified as a problem in France, very little progress has been made by French breeders in developing resistant varieties. Cultural practices such as delayed planting, control of possible insect vectors, and avoiding excessively high nitrogen levels, may reduce the incidence of Phoma (Gulya *et al.*, 1997). Good sanitation such as removal of crop debris should also help to reduce inoculum levels. Chemical control is not generally used to control this disease in most parts of the World. Recent trials in France have achieved some degree of fungicide control but up to five sprays were needed to reduce disease incidence by about 70% (Penaud, 1997). Currently, in France, no specific chemical control measures against Phoma are recommended. However, spraying to control Phomopsis (see above) may be beneficial against Phoma.

Based on the French experience, if *P. macdonaldii* is introduced into the UK, then Phoma black stem could become a potential problem. However, as the disease seems to be favoured by warm wet weather, it is unlikely that it would occur in damaging amounts in all seasons. Until relatively large areas of sunflower are grown, inoculum availability is likely to be limited because it overwinters on debris from infected plants. Thus, the potential for Phoma to become an important disease in the UK is probably small, at least over the short term.

#### Charcoal rot

Charcoal rot of sunflowers is caused by the soil-borne fungus *Macrophomina phaseolina* (Tassi) Goid (Gulya *et al.*, 1997). The pathogen has a wide host range and usually shows little host specificity. The fungus infects through the roots from microsclerotia in the soil. Infection does not usually take place until after anthesis (Gulya *et al.,* 1997). Symptoms of charcoal rot do not become apparent until after flowering. A yellowing and wilting of leaves is followed by the development of ash-grey to dark brown or black lesions from the soil line (Gulya *et al.,* 1997; Kolte, 1985). The fungus destroys the inside of the stem, the pith becoming dry and often forming horizontal layers, grey in colour, and containing mircosclerotia. Microsclerotia are returned to the soil in plant debris can act as inoculum for successive crops. Microsclerotia germination is favoured by high temperatures (30-35ºC) and in France it is only a problem is the south and south west (Bonjean, 1986).

Fungicide control is not possible after symptoms have appeared but fungicides such as benomyl are effective as seed treatments. Soil-applications against microsclerotia are impractical. Stressed crops are more susceptible to attack, thus cultural practices which reduce stress are helpful. Genetic sources with tolerance to attack have been found (Gulya *et al.*, 1997), so there is potential for some partially resistant hybrids to be developed.

Because of the high temperatures needed for the germination of microsclerotia it is highly unlikely that, under current climatic conditions, charcoal rot will prove to be threat to UK grown sunflower crops.

#### Alternaria blight

Sunflower can be infected by at least four species of *Alternaria*, but *A. helianthi* is the most common, occurring in all areas where the crop is grown (Gulya *et al.*, 1997). Although present in France, the pathogen is considered of minor importance (Bonjean, 1986). The pathogen(s) cause circular leaf lesions with grey centres and brown borders. In severe cases, the disease can cause defoliation and yield losses of up to 80% have been reported (Gulya *et al.*, 1997). Infection is favoured by relatively high temperatures (optimum between 24 and 27ºC) and high humidity or periods of leaf wetness (Kolte, 1985). The pathogen can also cause stem and head lesions and seedling blight.

Most cultivated sunflowers are not resistant to *A. helianthi*. However, resistance has been identified in other *Helianthus* species, offering hope for the development of resistant varieties (Gulya *et al.*, 1997). Chemical control of Alternaria blight can be effective but several sprays are often required (Gulya *et al.*, 1997). Seed treatments using several different fungicides are very effective against seedling blight (Gulya *et al.*, 1997).

The climatic requirements for infection suggest that Alternaria blight is unlikely to be an important disease under UK conditions. This view is supported by the relative unimportance of the disease in France.

#### Viral and bacterial diseases

Diseases caused by both viruses and bacteria have been reported on sunflower crops (Table 5.6). However, they are generally regarded as of minor importance. As viral or bacterial diseases are not considered to be important in France, it is unlikely that they would be damaging under UK conditions.

### Conclusions

Current experience in growing sunflowers in the UK suggests that there are few disease problems associated with the crop. Although several diseases either have been found or are potentially damaging, only two, Sclerotinia rot and wilt and Botrytis head rot, appear to pose an immediate threat to yields. For both diseases, it is currently not economically realistic to try and control them using fungicides, even if appropriate compounds were approved for use on the crop. Sclerotinia control is still best achieved by good rotation practice. However, there is much effort, world-wide, to develop resistant or tolerant varieties. Botrytis appears to be less of a problem than initially thought and the use of a desiccant may reduce damage caused by the pathogen. Thus, while the area of the crop in the UK is relatively small, the crop can be considered a ‘zero fungicide’ one.

If the crop begins to expand, disease pressure may increase and the potential for new diseases will also increase. Of the major sunflower diseases currently occurring in France, downy mildew and Phoma are probably the most likely to cause problems in the UK. Thus, mechanisms must be set up to monitor the UK crop for disease, and research into disease control measure must be set in place.

Most of the disease observed in the UK has been on the developing or mature crop. There have been several private reports of poor emergence of the crop when grown in the UK. The reasons for this have not been identified. The possibility that they have a fungal or bacterial cause cannot be ruled out, as some of the sunflower pathogens can result in seedling death (e.g. downy mildew). Research into the causes of poor emergence needs to address the possibility that it is caused by disease.

## Pests and their control

### Insect pests

A large and diverse number of insect species attack sunflower (Charlet *et al.*, 1997). Rogers (1992) lists more than 150 genera containing species which have been recorded as being of economic importance to sunflower crops. As sunflower is native to North America, many of the pest species are also native to that continent. However, in Western Europe, insect pest problems are of less concern than in Eastern Europe and other parts of the World (Rogers, 1992; Charlet *et al.*, 1997).

#### Western Europe

Several insect pests have been recorded in Germany, Italy and in France (Charlet *et al.*, 1997). Ballanger *et al.* (1985) have listed over 20 species of insect pest found in cultivated sunflower in France. These included leatherjackets, wireworms, symphylids at the seedling stage, weevils and leaf miners on young plants and capsid bugs (*Lygus* spp.), leafhoppers, thrips, aphids (*Brachycaudus helichrysi*, *Aphis fabae*), noctuid and pyralid moths (*Homoeosoma neubuella*, European sunflower moth) on mature plants. Most of these species are considered to be minor pests. Only aphids and the European sunflower moth are thought to be major pests (Lamarque, 1985b; Hariot, 1986a, 1986b; CETIOM, 1997b).

The leaf curling plum aphid, *B. helichrysi* Kalt., has a world-wide distribution. It attacks sunflower often in association with *A. fabae* (Charlet *et al.*, 1997). *B. helichrysi* overwinters on *Prunus* spp. and alate forms migrate to sunflowers in May or June. Plants may be attacked from the two- to four-leaf stage until harvest. Aphid colonies continuously infest the upper leaves, moving from older leaves to younger ones as the plant grows. They cause the leaves to shrivel and curl, not because of virus transmission but through the action of their saliva. The aphid can also attack the buds and disk flowers on the head. High populations (625 per plant) have been shown to reduce yield by up to 16% (Charlet *et al.*, 1997). Recent studies in France (Lerin & Badenhausser, 1995) found that when aphid populations were greater than 100 per plant at the budding stage then yield losses occurred, but if the population was less than 100 per plant at this stage, and declined, no damage occurred. This gives growers enough time to monitor populations and judge whether they are increasing or declining and treat accordingly. Aphid infestations can increase infections by *S. sclerotiorum* and *B. cinerea*. Infestations can be controlled by insecticide applications. However, as *B. helichrysi* has a number of natural predators, chemicals with low toxicity to these predators and to pollinating bees should be used. In France, spraying is recommended when the aphid population begins to increase explosively (CETIOM, 1997b; CETIOM, 1998). Several insecticides have been cleared for use on sunflowers in France (CETIOM, 1998). Resistance to attack by *B. helichrysi* has been transferred from wild *Helianthus* spp. (Rogers, 1992) and varieties with some resistance are available in France (CETIOM, 1997b). Cultural practices to minimise infestations include early planting, weed control and careful use of nitrogen fertiliser (high levels encourage attack) (Charlet *et al.,* 1997).

The adults of the European sunflower moth, *H. neubuella*, are light grey, 11 to 12 mm long with two dark spots on the centre of the wings and white underneath the leading edges (Charlet *et al.*, 1997). The hind wings are transparent and whitish with grey edges. The larvae are a dull greenish yellow with dark stripes on the back and two stripes on each side. The moth usually has two generations per year and the second one lays eggs on the inner wall of the ring of coalesced stamens of early bloom sunflowers. The first two larval instars feed on pollen and the last three on the seeds. A single larva may destroy up to 10 seeds and up to 100 larvae have been found on a single head (Charlet *et al.*, 1997). Varieties resistant to attack have been developed. Plants with high levels of phytomelanin in the seed reduce larval feeding. Zagatti *et al.* (1991) have isolated the sex pheromone of *H. neubuella* for use as a population monitoring tool in France where the moth was considered a potential serious pest

#### Insect pests in the UK

Little information has been published on observations of insect pests and the damage they cause on sunflower crops in the UK. It is, therefore, difficult to give a confident assessment of potential insect pest problems for sunflower production in the UK if the crop were to expand over the next few years. There have been reports of minor damage caused by tortrix larvae, leaf minors and looper caterpillars in Bedfordshire and thrips in Hampshire (Rawlinson & Dover, 1986). *B. helichrysi, A. fabae* and *Myzus persicae* were recorded in Oxfordshire in 1986, but again caused little damage (Rawlinson & Dover, 1986). Insect fauna occurring on sunflower were recorded on crops at Rothamsted between 1986 and 1991 (Anon, 1986, 1987, 1991). Aphids, including *B. helichrysi, A. fabae, M. persicae, Macrosiphum euphorbiae*, and other *Aphis* spp. have been found. *B. helichrysi* was found in all years when observations were made, and colonies of more than 1,000 individuals were found in 1991. Polyphagous lepidoptera larvae, mirid bugs, leaf hoppers, leaf miners (Diprea and Hymenoptera) and thrips have been recorded in small numbers, but have caused only minor damage. Large numbers (sometimes more than 300 per head) of pollen beetles, *Meligethes aeneus*, have been observed on sunflower heads at Rothamsted. The infestations on inflorescences were found to be beneficial through self-pollination and not detrimental to seed production (Anon, 1991). No reports of the occurrence of the European sunflower moth were recorded. *B. helichrysi* has also been found on crops at ADAS Boxworth (Cook, unpublished) but caused little damage. In 1996, silver Y moths (A*utographa gamma* L*.*) were observed feeding on flowers at ADAS Boxworth, but no caterpillars were found.

Seedling damage by soil-borne insect larvae has been reported in France as has damage by aphid infestations. Both can be controlled by an insecticide spray and larvae can be controlled by insecticidal granules distributed along the rows or by a pre-sowing spray. Several products have been authorised for use in France (CETIOM, 1998). Information on seedling damage by insect larvae is limited for the UK. Such attack may be responsible for some of the reports of poor establishment of crops in the UK. Research is urgently needed into this problem.

In the UK, on growing sunflower crops, only aphid damage appears to pose a potential threat. This can be controlled by the timely application of insecticides (if approved) or by the development of resistant varieties. If the area of sunflower expands, careful monitoring of crops will be required so that insect pest problems can be rapidly identified. In addition, further work is needed to investigate the role, if any, that insect damage plays in the occasional poor emergence of sunflower seedlings. However, based on the experience of other western European countries, is seems unlikely that insect pests would pose a major threat to UK sunflower production.

#### Other pests

Other non insect pests of sunflower likely to occur in the UK include nematodes, slugs, birds, badgers and rabbits.

In Europe, members of the sparrow family (*Ploceidae*) are important pests of sunflower (Linz & Hanzel, 1997). Pigeons (*Columbiae*) have also been found to damage crops in France (Lamarque, 1985b) and have been reported to cause damage on UK crops. Birds can cause damage at the seedling stage by grazing emergent plants and when the crop matures by eating the seeds. In the UK, three crops in Hampshire (6 ha in total) and a 6 ha crop in Suffolk were completely lost during establishment in the early 1980s (Rawlinson & Dover, 1986). Finches (*Fringillidae*) have caused damage to nearly mature crop heads at ADAS Boxworth (Table 5.9). The birds tended to roost in hedges surrounding the field and on telephone wires crossing the field. They tended to venture only up to 24 m into the crop, presumably because of predators. Maximum flock sizes were 488 in 1992 and 300 in 1994. In a small field (less than 4 ha), bird damage can be considerable and the whole crop can be lost (Osborne, 1988). To decrease damage to seedheads, plant spacing should be controlled to reduce the head size and increase head angle to discourage perching (Cook *et al*., unpublished). Bird protection measures such as those used for oilseed rape crops could be used in areas where bird damage is likely.

Table .. Finch damage on sunflower prior to harvest at ADAS Boxworth, 1992 and 1994

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Distance from field edge (m) | Damage (% /head) | | Seed eaten (kg/ha) | |
|  | 1992 | 1994 | 1992 | 1994 |
|  |  |  |  |  |
| 0-12 | 12.0 | 9.2 | 1291 | 415 |
| 12-48 | 5.0 | 4.0 | 531 | 185 |
| Centre of field (>48) | 1.3 | 0.5 | 138 | 23 |

Grazing of seedling crops by rabbits has been found in France, especially where crops are planted close to woodland areas (Lamarque, 1985b; CETIOM, 1996) and at ADAS Boxworth (Cook, Unpublished). Damage is usually limited to field margins. In vulnerable crops, electrified rabbit fencing should reduce the chances of rabbit grazing. Other mammalian damage can be caused by mice and badgers (Cook, unpublished), with the latter the damage may be localised.

The nematode *Pratylenchus neglectus* was found in sunflower in France in 1984 (Hariot, 1986a, 1986b). The potential for nematode damage in UK crops is difficult to assess.

Slugs (*Arion silvaticus)* have been observed to cause damage, especially at the seedling stage, in experimental sunflower plots at Rothamsted (Anon,, 1987; McCartney unpublished). The results of the questionnaire in this report (Section 1) also suggest that slug damage can be a problem in UK crops. Slugs can be a problem in seedling sunflower crops in France (Hariot, 1986a, 1986b; CETIOM, 1996; CETIOM, 1998). Two species have been identified as causing damage, *A. hortensis* and *Agriolimex reticulatus* (Hariot, 1986b). The crop is most vulnerable when one pair of leaves has emerged. Lumpy or stony soils with high levels of organic debris are most at risk (Hariot, 1986b). Hariot (1986b) recommends controlling *Arion hortensis* damage using molluscicide granules, by placing them on the surface immediately after sowing. For *A. reticulatus*, he recommends the use of slug traps: molluscicide granules placed under canvas or tile covers. In high risk crops in the UK, molluscicide granules may need to be considered to control seeding damage by slugs. In France, four molluscicides have been authorised for use against slugs in sunflower crops: bensultap, mercaptodimethur, metaldehyde and thiodicarb (CETIOM, 1998).

### Conclusions

Currently, sunflower crops in the UK appear to be relatively free of pest problems. However, the situation may change if the area of the crop expands significantly. Aphid damage seems to pose the biggest threat, but, pest damage at the early stages of crop growth may also cause problems. Further research is needed to quantify the potential of other pest species to damage sunflower crops in the UK. Work is especially urgent to identify the causes of pre- and post-emergence damage occasionally observed in UK sunflower crops.

## Other agrochemicals

Growth retardants could improve sunflower husbandry in the short term prior to improvements in breeding. In 1979, growth regulators were used to prevent lodging in a high population of sunflowers and hence consequently advanced maturation by two weeks (Baylis & Dicks, 1979b). Currently, no growth regulators are approved for use in sunflowers and there has been little need for them. In France, growth regulators are not recommended for normal situations, but where plant populations are high (> 60,000 plants ha-1) or an excess of nitrogen has been applied, then a growth regulator can be used. Either ethephon or mepiquat chloride plus ethephon is applied at the five-leaf stage (GS 2.5) (CETIOM, 1998).

## Harvest and storage

### Harvest

Harvest will ideally take place during September. At 30% seed moisture, oil quality is at its highest and the seed can be harvested and subsequently dried. However, it is more commonly harvested either when the seed has dried down naturally to 15‑20% moisture, or after the application of a desiccant (*Reglone*) at 30% seed moisture (Anon, 1997b). Desiccants require high clearance machinery when applied to the taller, later maturing varieties (B. Fletcher, pers. comm.).

The seed is at 30% moisture when the back of the head is yellow and the bracts have begun to turn brown (see Appendix I). By 20%, the bracts are 75% brown, the back of the head is becoming mottled and 75% of the lower leaves are senescent. In early maturing varieties the time for desiccation usually occurs in late August or early September, with harvest 7 to 10 days later. For the later-maturing types, this is more likely to be mid- to late-September (UKSA, unpublished). *Reglone* (Diquat) has off‑label approval for use on UK sunflower crops. If harvest is delayed, both quality and quantity of oil are impaired (CETIOM, 1998).

A conventional cereal combine can be used with little modification, but if sunflowers are grown regularly then harvesting trays can be fitted to the cutter bar (R. Brown, pers. comm.). These would cost approximately £800 for imported French trays but could easily be made in farm workshops for under £200. The reel tines should also be covered to avoid impaling the flower heads. Combine settings should be similar to those used for harvesting beans and the crop should be harvested during the day when dry . Care should be taken to avoid overloading the returns auger. Preferred combine settings are as follows:

|  |  |
| --- | --- |
| Drum speed | 400‑600 rpm |
| Concave setting | Wide open |
| Sieve size | 10‑12mm |
| Fan speed | Adjusted to avoid losses over the back |
| Forward speed | 5‑6 mph (running speed) |

Source: UKSA

To minimise the amount of admixture with the grain, only a small amount of the stem should be cut. Some heads may fall forward, away from the combine table. This will be reduced by a relatively fast forward speed, or by using specially designed trays which are attached in front of the knife to assist harvesting (Anon, 1997b). Use of the forward speed in conjunction with the height of cut should ensure an even flow into the machine. Seed size and weight in some, mainly later-maturing, varieties is relatively large. This proves advantageous at harvest since stronger aspiration can be applied in the harvester and a cleaner sample obtained.

The stubble can be chopped by the combine or by using a forager or heavy discs (N. Cross, pers. comm.). The field can then be ploughed and drilled if the following crop is a cereal. Volunteers can be dealt with using a broad-leaved herbicide, but they may continue to appear throughout the spring (see Section 9.2).

### Drying and storage

Sunflower seed dries quickly and can be harvested at a relatively high moisture content, but the seed should never be stored wet and care must be taken when drying. Sunflower seed will heat up if allowed to stand while wet. Use of a drying floor is the safest method and the seed should be at a maximum depth of 1 m. The best method of drying is to use cold air until the moisture content falls to 15%. The seed can then be cleaned and heat (using the same temperature as for oilseed rape) used to reduce the moisture to 9% for long term storage. The seed should be left for seven days to allow the seed moisture to equalise before drying again if necessary. Sunflower seed has a lint‑like coating which can easily be rubbed off to form a light oil bearing dust. If this is taken into the unprotected intake of a continuous drier there is a **high risk of fire**. Drying methods which include any form of agitation or movement of the seed should, therefore, be used carefully. A method that has proved successful is to reduce the bulk of the moisture on a floor dryer and then complete the operation in a continuous dryer.

# ENVIRONMENTAL

Adopting sunflower into the arable rotation may provide a range of potential benefits, these include:

* More broadly based rotations with attendant advantages resulting from increased bio-diversity.
* The inclusion of sunflowers in the rotation allows uncultivated stubble to be left into the winter period which provides a site for farmland birds to feed.
* The opportunity to exploit long winter fallows, here the delay in cultivations can be used as a period in which volunteers and grass weeds germinate, allowing the use of a total (non-selective) herbicide prior to cultivation.
* Their low nitrogen requirement makes them suitable for Environmentally Sensitive Areas
* Whilst their current pesticide requirement amounts to a single early season herbicide. The crop is drilled on wide rows and it can be produced without herbicides through the use of mechanical weed control.
* Reductions in the costs of pesticides and fertilisers and in the costs associated with their application.
* More profitable production from light soils and in areas of low summer rainfall.
* The provision of a short season arable crop ideally suited to organic and low-input production systems.

Sunflowers are grown on many farms in the UK for use as game cover. These areas are usually small and limited to strips to provide tall cover away from hedges and woods. The presence of sunflower on the farm, either as game cover or as a commercial crop, attracts a wide range of insects, birds and mammals both to feed and use the crop as shelter. Their positive impact on insect life is as both a nectar bearing crop and as one in which production does not involve the use of insecticides.

When in flower they also attract a wide range of human beings, ranging from artists to television crews.

# ECONOMICS

## Financial performance of sunflower crops in the UK

Sunflowers have been grown at ADAS Boxworth, Cambs for several years. Gross margins are presented in Table 7.1.

It is important to note that on the Hanslope soil at Boxworth, there have been no crop failures with generally consistent yields and competitive gross margins compared with other combinable crops. At other local farms, gross margins have been higher where yields have been similar, due to niche markets. This has resulted in a gross margin some £100 per hectare more than Boxworthin spite of higher variable costs.

Table . *Gross margin of sunflowers at ADAS Boxworth 1992 to 1997*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | mean |
|  |  |  |  |  |  |  |  |
| Yield (t ha-1) | 2.0 | 2.2 | 1.9 | 1.8 | 2.3 | 1.7 | 2.0 |
| Market | Crushing | Crushing | Crushing | Pet food | Pet food | Pet food |  |
| Price (£ t-1 ) | 147 | 190 | 190 | 163 | 220 | 185 | 183 |
| **Crop output (£ ha-1)** | **294** | **418** | **361** | **293** | **506** | **315** | **364** |
| Area payment (£ ha-1) | 400 | 444 | 366 | 456 | 475 | 455 | 433 |
| **Total output (£ ha-1)** | **694** | **862** | **727** | **749** | **981** | **770** | **797** |
|  |  |  |  |  |  |  |  |
| Seed | 155 | 159 | 164 | 104 | 181 | 200 | 161 |
| Herbicides | 62 | 53 | 36 | 39 | 39 | 0 | 38 |
| Insecticides | 0 | 0 | 0 | 30 | 0 | 0 | 5 |
| Nitrogen | 18 | 17 | 19 | 19 | 15 | 9 | 16 |
| **Total variable costs** | **235** | **229** | **219** | **192** | **235** | **209** | **220** |
|  |  |  |  |  |  |  |  |
| **Gross margin (£ ha-1)** | **459** | **633** | **508** | **557** | **746** | **561** | **577** |

NB crop area has been between 4 and 7 ha per year.

The yield of the crop has been variable as has the price, both of which have varied by some 30%. It is significant that the area payment has exceeded the gross output of the crop in all but one of the six years it has been grown at Boxworth. However, total output is acceptable at £694 to £981 per hectare.

Seed is an expensive input and it may be possible to reduce this cost once the crop is more widespread and more suitable varieties become available (D. Harris, pers. comm.). At Boxworth, input costs are some £200 to £250 per hectare, giving a reasonable gross margin.

The figures in Table 7.2 from a commercial farm in Cambridgeshire show similar yields to those at Boxworth and in most years, better prices. The input costs are significantly lower for seed and sprays, but higher for fertiliser. Overall, the performance at Boxworth has been repeated on a commercial farm.

The crop is compared with alternative spring crops at Boxworth in Table 7.3. The figures for sunflowers are comparable to the alternatives, with yields being similar apart from the larger yield of spring beans. Due to summer drought, linseed had a poor year in 1995 which lowered its average yield. The price received for sunflowers is consistently better than for the alternatives, with beans being the lowest of the group. The prices used in the table are those for a commercial crop going into general crushing oil. If there was sufficient UK produced sunflower seed to crush as a separate commodity, the crop may be subject to increased premiums from the crushers because of reduced transport costs (Sells, 1991). There may also be a premium associated with the improved oil quality (see Section 3.3).

Table . *Sunflower performance on a commercial farm in Cambridgshire*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 1992 | 1993 | 1994 | 1995 | 1996 | Mean |
|  |  |  |  |  |  |  |
| Yield (t ha-1) | 1.7 | 2.2 | 2.2 | 1.9 | 2.5 | 2.1 |
| Price (£ t-1) | 158 | 205 | 184 | 182 | 250 | 196 |
| **Crop output (£ ha-1)** | **261** | **445** | **397** | **346** | **625** | **415** |
| Area payment **(£ ha-1)** | 400 | 444 | 366 | 456 | 472 | 428 |
| **Total output (£ ha-1)** | **661** | **889** | **763** | **802** | **1097** | **843** |
|  |  |  |  |  |  |  |
| Seed | 95 | 97 | 88 | 54 | 104 | 88 |
| Sprays | 15 | 16 | 11 | 15 | 21 | 16 |
| Fertiliser | 11 | 17 | 52 | 23 | 54 | 31 |
| **Total variable costs** | **121** | **130** | **151** | **92** | **179** | **135** |
|  |  |  |  |  |  |  |
| **Gross margin (£ ha-1)** | **540** | **759** | **612** | **710** | **918** | **708** |

NB crop areas have been up to 30 ha per year.

Table . *Comparison of spring crop gross margins*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Sunflowers | Spring oilseed rape | Linseed | Spring beans |
|  |  |  |  |  |
| Yield (t ha-1) | 2.1 | 2.2 | 1.8 | 3.7 |
| Price (£ t-1) | 180 | 170 | 145 | 100 |
| **Crop output (£ ha-1)** | **378** | **374** | **261** | **370** |
| Area payment | 455 | 455 | 497 | 372 |
| **Total output (£ ha-1)** | **833** | **829** | **758** | **742** |
|  |  |  |  |  |
| Seed | 103 | 44 | 54 | 86 |
| Sprays | 44 | 87 | 57 | 30 |
| Fertilisers | 30 | 74 | 57 | 30 |
| **Total var. costs (£ ha-1)** | **177** | **205** | **168** | **146** |
|  |  |  |  |  |
| **Gross margin (£ ha-1)** | **656** | **624** | **590** | **596** |

Source: ADAS Data.

NB: yields are six-year mean, prices and area payments are for 1997.

Gross outputs are very similar except for linseed which is probably due to the poor year referred to above. The Arable Area Payment for sunflowers was the same as that for other oilseed crops, including oilseed rape. The payment for linseed was higher than that for other oilseeds and protein crops, in this case the payment for spring beans, was lower. This means that total output of sunflowers was higher than alternative spring sown crops.

Variable costs for sunflowers are in the same range as the alternative crops, with oilseed rape being the highest and beans being the lowest. There is potential for a significant fall in the seed price, but little change to fertiliser costs. With regard to sprays, an increase in the area of sunflowers may mean that there will be greater pest and disease pressure and consequently these costs may increase to compensate for the possible fall in the seed cost.

Overall, the crop appears to have the potential to compete well with the alternative spring crops on the heavy clay soils of Cambridgeshire. Traditionally on these soil types, a six-course predominantly winter-sown rotation has been followed; wheat, wheat, winter oilseed rape, wheat, wheat and winter beans. The area allocated to the break crops is partially replaced by spring cropping and sunflower could be grown. To minimise disease risk then sunflower should replace winter oilseed rape, but currently sunflower profitability is lower (Table 7.4) and risk of failure greater than the crop they would replace.

Although spring cropping is not best agronomic practice on heavy clay soils, if a spring crop alternative is needed then sunflowers are potentially better than linseed, spring beans or spring oilseed rape. The later establishment of sunflower presents no problem in terms of clashing with other arable operations and the late harvest would probably be no later than the other alternative spring crops. Later harvesting would be preferable as this would not clash with the cereal harvest (Sells, 1991).

When comparing sunflowers with winter oilseed rape (Table 7.4), the advantage is with the winter oilseed rape crop, because of its higher yield. However, it needs to be established in the early autumn which clashes with other work and is difficult when following a crop of winter wheat, for example. Fertiliser and pesticide use in winter oilseed rape is higher than sunflowers. If sufficient crop were produced to attract a £10 quality premium, this would amount to £25/ha, reducing the advantage of the winter oilseed rape crop to approximately £100 per hectare. Further reductions might be possible if the seed costs of sunflowers were reduced. At Boxworth, the area of sunflower has not been increased due to the higher profitability of winter oilseed rape and, the lower risk associated with this crop.

Table . Gross margin of sunflower and winter oilseed rape

|  |  |  |
| --- | --- | --- |
|  | Sunflower | Winter oilseed rape |
|  |  |  |
| Yield (t ha-1) | 2.1 | 3.4 |
| Price (£ t-1) | 180 | 175 |
| **Crop output (£ ha-1)** | **378** | **595** |
| Area payment | 455 | 455 |
| **Total output (£ ha-1)** | **833** | **1050** |
|  |  |  |
| Seed | 103 | 41 |
| Sprays | 44 | 130 |
| Fertilisers | 30 | 95 |
| **Total var. costs (£ ha-1)** | **177** | **266** |
|  |  |  |
| **Gross margin (£ ha-1)** | **656** | **784** |

Source: ADAS Data.

### Short and medium term economic situation

#### The present economic situation

At the present time, the market price of most combinable crops produced in the UK has fallen substantially due to the recent rise in the strength of Sterling. Prices for these commodities are driven by world markets priced in dollars and, at the time of writing (June 1998), sunflower seed and rape seed are at similar levels.

The second component of output in the EU is the Arable Area Payment. Oilseed crops currently receive an Arable Area Payment of approximately £455 per hectare compared to £257 per hectare for cereals. This makes their use as a break crop attractive economically as well as agronomically. In choosing a break crop, the farmer will look at the profitability and ease of production. With its higher yield, winter oilseed rape will probably be the most favoured option for many farmers.

In France, sunflowers are a well established crop, grown over a large area. In areas of the country where there is a choice between winter oilseed rape or sunflowers, the choice will be for the winter oilseed rape when there is adequate rainfall in the autumn for establishment (J. Orson, pers. comm.). However, oilseed rape requires moist conditions to germinate and become established and in dry years, this may not be available. There is then a tendency to switch to sunflowers the following spring, having lost the opportunity to grow the more profitable winter oilseed rape crop (CETIOM, 1998).

In the UK, sunflowers are clearly not yet at this stage of acceptance and in many areas, a spring break crop is often seen as a last measure where a winter crop has not been possible. A major fear for many UK farmers, whether perceived or real, is that poor establishment may occur as a result of drilling a spring crop into a soil which is drying out.

As in many other businesses, farmers are averse to both risk and change and the process of dealing with risk is referred to as risk management. In macro-economic terms, this has been widely studied for many years (Barry, 1984), where farming patterns are seen as the result of subjective probabilities. In the process of applying a risk management approach to individual farms in the UK, farmers need to ensure that their actions are economically justified in the more market orientated market conditions of the present time (Harris, 1996). This contrasts with their current views of management decisions and risk (Pooley, 1996).

#### The likely effects of market changes and Agenda 2000

Changes to the way the European Union supports agricultural production may fundamentally alter cropping decisions. The proposals under the Agenda 2000 reforms (Anon., 1998) include making Arable Area Payments similar for cereal and oilseed crops, but leaving a premium for protein crops. This would remove the differential between oilseeds and cereals making oilseeds far less attractive. Hence, a farmer would grow an oilseed crop when, for example, rotational benefits were sought, such as control of weeds which are difficult in cereals, particularly where herbicide resistance may have developed. In the case of controlling herbicide-resistant black-grass, the preferred option was continuous cereals rather than a rotation for economic reasons, (Orson & Harris, 1997). Other advantages from growing break crops, particularly spring break crops, will include spreading the work over a longer period. This may mean fewer overtime hours being worked and possibly reduced machinery costs if smaller capacity machines can be used to establish the crops over a longer period.

The fact that sunflowers receive the same support as oilseed rape means that where it is possible to grow sunflowers as a commercial crop, winter oilseed rape will be preferred because the establishment of a winter crop is perceived as having a lower risk and the average yield of winter oilseed rape is greater than sunflower.

If Agenda 2000 is implemented in its current form, then gross margins for both sunflower and oilseed rape would fall by £109 /ha. This would put the viability of the UK sunflower industry under considerable pressure. The best prospect for the crop would be to achieve a yield increase of at least 0.5 t/ha which would bring sunflower gross margins up to within £30-40 of that achieved by oilseed rape. This yield increase is achievable as yields of up to 5 t/ha have been achieved in France and Germany (mean UK yields are currently 2.1 t/ha), particularly as in the UK, water availability is not usually limiting as it can be in Europe.

# SUNFLOWER AS CUT FLOWERS

The interest of sunflowers as cut flowers appears to have been revived in 1990, the centenary of the death of Vincent van Gogh. This coincided with the introduction of Japanese ‘pollen free’ F1 varieties. Florists had previously been deterred from using sunflowers because of excessive production of pollen (Anon., 1997). In these new varieties the anthers are trapped in the flowers and only produce pollen in very hot weather (Rice, 1996). Marks and Spencer that pioneered the sale of sunflowers as cut flowers and they still lead the market. Approximately 20 ha of sunflowers are currently grown for cut flowers.

The crop is mainly grown outdoors with about one hectare of indoor production. Marks and Spencers and the supermarkets prefer a straight-stemmed flower with a 10‑14 cm head. Success of production is dependent upon the weather, and in a wet harvest year such as 1997 losses can be as high as 60% (L.R. Mason, unpublished).

The varieties used for horticultural purposes are shown in Table 8.1.

Table . Sunflower varieties used for horticultural purposes

|  |  |
| --- | --- |
| Variety | Comments |
|  |  |
| Full Sun (F1) | Yellow petals with contrasting dark centers. |
| Sunbright (F1) | Industry standard. Orangey yellow petals with a black centre. |
| Sunbeam (F1) | Golden yellow petals with yellow stamens but green centre. |
| Sunrich Lemon (F1) | Soft yellow petals with black centre. It is claimed that it flowers 10 - 14 days earlier than other F1 hybrids. |
| Sunrich Orange (F1) | Orange - yellow petals with black centre and it is again claimed that it flowers 10 - 14 days earlier than other F1 hybrids. |
| Moonbright (F1) | Soft yellow petals with a black centre. |
| Valentin | Sulphur yellow petals. This is a new (not F1) variety that is claimed to be earlier flowering and smaller heads. |
| Sonja | Orange petals with black centre. Again this is a new (not F1) variety which claims to have smaller leaves and flowers. |
| Taiyo | Not F1 but does not produce large amounts of pollen. Becoming more widely grown. |

Spacing is the single most important factor when determining the size of the final product. The recommendations on spacing from the seed companies have varied in recent years from 5 - 7 cm between plants to 12 - 15 cm. From ADAS observations, the latter spacing is probably correct although if the supermarkets move towards smaller flowers, then the closer spacing may be more appropriate (L.R. Mason, unpublished; Anon., 1997). The space between rows tends to be 30 - 40 cm but can be wider if the crop production method demands it. The average seed count of the F1 varieties is about 25 per g and 50 g sown will result in approximately 1000 plants. Hence, to achieve a spacing of 12 - 15 cm, about 0.4 - 0.6 g of seed per metre of running bed is required. This will, however, be dependent on the target flower size (L.R. Mason, unpublished).

Production of flowers outdoor for sale depends on continuity of supply and spacing is important to achieve the desired head size. Most of the outdoor sunflowers are sown in-situ. Drilling dates are between mid-late March and July, approximately every 2-3 weeks for continuity of supply. Very early sowings can be protected from the cold with spun type fleece (Anon, 1997a).

The crop is generally grown unsupported but windbreaks can be provided in exposed situations. Irrigation is needed only in times of extreme drought or to aid establishment in a dry seedbed (L.R. Mason, unpublished).

Harvesting will usually take place from July through to September. The season can, however, be shortened or increased depending on the prevailing weather conditions at flowering. Great care is needed when harvesting sunflowers because the petals can be easily damaged. The flower is usually harvested just as the ray florets become outstretched but can be harvested tighter if required. Once cut, the stems should be placed in water immediately. Sunflowers, as cut flowers, are very prone to a disease known as ‘bacterial blockage’ which prevents the stems from taking up water and causes premature wilting. The water therefore should contain a suitable bactericide from research and ADAS observations the most suitable treatment is probably “Chrysal RVB improved” because this product also contains a surfactant to aid water flow along the xylem tissue % (L.R. Mason, unpublished).

Production of flowers under glass is possible but can be expensive as assimilation lighting is necessary. Flower size can be smaller and quality can be poor. The seeds can be direct sown or raised in plugs and transplanted, at similar spacing to outdoor crops. Some varieties can require support from netting. The growth regulator daminozide is used to shorten stems, especially at higher temperatures. Daylength control is required, usually 14 hour days until 5 leaf pairs (GS 2.5) then 11 hours or less in order to initiate flowering (Anon., 1997).

## Economics

The production of cut sunflowers appears to be very lucrative (Table 8.2) but, as previously discussed, there can be additional costs if the flowers are produced under glass. Also, in wet seasons, losses can be up to 60%.

Several growers of crops for the crushing market have sold cut flowers into the local markets. Returns have been approximately 20p per stem but heads have to be cut and delivered early in the morning. These enterprises have not been costed thoroughly and have not developed into large scale commercial operations. In 1997, one grower advertised and opened up the fields to the pick-your-own market. The vagaries of the UK climate do not allow for exact targeting of flowering date and a quality product is not guaranteed. Losses for PYO operations can be quite severe due to trampling of the crop.

Table . Gross margin for sunflowers grown as cut flowers for supermarket sale

|  |  |  |  |
| --- | --- | --- | --- |
|  | **£ unit-1** |  | **£ ha-1** |
|  |  |  |  |
| Plants per square meter:- | 34 |  |  |
| Stems per square meter:- | 34 |  |  |
| Seed rate (g per 100 sq. m) | 200 |  |  |
| Percentage space utilisation:- | 100 |  |  |
| Percentage cut:- | 70 |  |  |
| Area in square meters | 10000 |  |  |
|  |  |  |  |
| **Total number of plants** | **340000** |  |  |
| **Total number of stems** | **238000** |  |  |
| Price £ per stem:- | 0.2 |  |  |
| **Total Output Value £ ha-1** |  |  | **47600** |
|  |  |  |  |
| **Variable costs** | **£ unit-1** |  | **£ ha-1** |
| Seed cost | 0.416 |  | **8320** |
| Fertilisers:- |  |  | 500 |
| Sprays:- |  |  | 500 |
| Sterilisation:- |  |  | 0 |
| Carriage:- (per stem) | 0 |  | 0 |
| Miscellaneous |  |  | 600 |
|  |  |  |  |
| **Total variable costs** |  |  | **9920** |
|  |  |  |  |
| **Gross margin** |  |  | **37680** |
|  |  |  |  |
| **Labour costs** |  |  |  |
| Hourly rate:- | 2.4 |  |  |
| Number of hours per hectare | 5000 |  |  |
| Cost of labour |  |  | **12000** |
|  |  |  |  |
| **Returns after labour** |  |  | **25680** |

Source: L.R. Mason, unpublished

# AFTER SUNFLOWER

## Following crops

Information on crops following sunflower is limited. At ADAS Boxworth, sunflowers have been grown since 1990. Table 9.1 shows that although sunflower is harvested 74 days after oilseed rape, the following wheat crop is drilled only 25 days later. The length of time between breakcrop harvest and drilling the following wheat crop becomes increasingly weather dependent as the wheat drilling date moves to late October. This is shown by the method of primary cultivation. The plough was used on 5 out of 6 occasions after the harvest of winter beans and winter oilseed rape; after the sunflower harvest, it was only used 50% of the time. The cultivations used in the preparation of the wheat seedbed are dependent on the autumn weather. In the case of following sunflowers, it is preferable to use non-inversion techniques to leave a relatively weed free tilth on the surface and allow birds to eat the remaining sunflower seeds to reduce the number of volunteers.

Table . *Mean date of drilling and harvest and yield of wheat following crops of sunflowers, winter beans and oilseed rape 1992-1997*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Breakcrop | Average date of harvesting breakcrop | Average date of drilling wheat crop | Days between harvest and drilling the following wheat crop | Yield after breakcrop as a % of mean yield |
|  |  |  |  |  |
| Sunflower | 7 October | 27 October | 20 | 102.0 |
| Winter beans | 18 August | 8 October | 51 | 103.3 |
| Winter oilseed rape | 25 July | 28 September | 68 | 103.6 |

Source: ADAS Boxworth.

## Sunflower as weeds

Sunflower can persist in the soil for up to five years and they have the ability to germinate from great depth. At ADAS Boxworth, on a clay soil susceptible to cracking, sunflowers germinate in the cracks and appear in following crops. Growth is more vigorous where the crop is less competitive, especially on headlands and in gateways. Germination can be over a long period. The little experience in control of volunteer sunflowers in the UK has shown that *Ally* (metsulfuron-methyl) can provide control in cereals (J Orson, pers. comm.)

French experience in controlling volunteers in sugar beet indicates resistance to control at the cotyledon stage but, when they have two leaves, clopyralid provides some control (Dixon, Lutman & West, 1989). The larger the sunflower the higher the rate needed (Hough, 1993). In peas, bentazone provides an expensive means of control (Hough, 1993).

# CONCLUSIONS

## Sunflower, now and in the future

This review has identified that sunflower can be a viable crop under some UK situations, but that there is a significant risk associated with growing the crop. This level of risk is perceived by UK farmers and has prevented the wider uptake of sunflowers as a commercial crop.

The UK is on the edge of the climatically suitable zone for currently available sunflower varieties. Annual accumulation of 1400 day degrees above a base air temperature of 6°C, plus a soil temperature of at least 7°C (at 10 cm) at drilling, are critical for successful establishment and timely harvest of the crop. The temperature sensitivity of the crop means that drilling has to be delayed to avoid frosts during the establishment phase, but delayed drilling can lead to a late harvest when weather conditions are deteriorating. Currently, based on the above criteria only a small area of the UK is suitable for growing a sunflower crop. The breeding of new varieties which have a lower temperature requirement has been achieved, and the first one of these is currently being trialled. Availability of such varieties should increase the area of the UK suitable for successful production of sunflowers. Specific breeding programmes for varieties for UK use are limited due to the small area of UK sunflower grown. This in itself has restricted a possible expansion of the crop area.

Through the review, crop establishment has been noted as a problem area. Soil type is not limiting, although soils that warm quickly in the spring are preferred. Sowing date is dictated by soil temperature, and if seed is drilled too early germination and establishment are protracted, leaving the crop vulnerable to pest and disease attack. Poor crop establishment is associated with a number of causal mechanisms; although the precise cause in any particular case may be unclear. Contributing factors are poor soil consolidation, lack of moisture, excess moisture, incorrect drilling depth and consistency, the action of slugs and pigeons. Many more may be implicated. In a sunflower crop plant spacing is critical, seed is expensive and it is preferable to precision drill the crop to achieve the desired low spacing for maximum yield. This can only be achieved successfully if we have a high certainty of successful germination and establishment of all seed. It is therefore important to reduce the risk associated with this establishment phase.

The sunflower crop currently requires low agrochemical inputs. Fertiliser requirements are low, although use of the micronutrient boron, in certain situations, is essential. The crop offers great opportunities for weed control through the use of stale seedbeds and non-selective herbicides prior to drilling. Pest and disease pressures are low, but can be expected to increase with an increased cropping area. *Sclerotinia* spp. can be a problem but can be limited by rotation; removing oilseed rape from the rotation reduces the levels of this soil borne disease. In the future, use of resistant or tolerant varieties may be commonplace. Alternatively, a monitoring system for ascospore production to warn of high infection periods where a protectant spray may be applied, could be developed. Botrytis is a disease that is not easily controlled in sunflower, and the UK crop is more likely to suffer because of the UK’s maritime climate and the later harvest date of the crop. Again, resistant or tolerant varieties could be bred.

Profitability is one of the most important driving forces in world agriculture, and if a crop is not shown to be profitable then it will not be grown by the industry. The review has shown that in the UK, consumption of sunflower products is high. Sunflower products are perceived by the nation to be healthy, and hence demand is high and will probably remain so. All UK consumed sunflower seed is imported, but a large proportion is crushed here. A UK produced supply could reduce storage costs for the crushers. The quality of UK produced sunflower oil is different that that produced on the continent. This could this command a premium price for the UK product. Only bulk supplies would allow the crushers and refiners to evaluate the oil. Currently, UK produced seed supplies a niche market for pet foods, particularly wild-bird food, but still the UK product has to compete for price and quality with seed from eastern Europe. The UK product has the advantage of tracebility which is becoming an important factor to UK consumers.

At the farm level the crop has been shown to be profitable, it appears more profitable than other spring sown break crops and has performed well at Boxworth and elsewhere in Cambridgeshire. At Boxworth gross margin of sunflower is £52 /ha higher than other combinable spring crops. But, when compared to oilseed rape, sunflowers are much lower in profitability (by £130 /ha). The current Agenda 2000 proposals put the viability of the UK sunflower industry under considerable pressure, and yields would have to increase by over 0.5 t/ha to compensate (mean UK yields are currently 2.1 t/ha).

Risk and profitability are the major factors limiting farmer uptake of the crop. Sunflower is currently too risky to grow and profitability is well below that of oilseed rape. The other benefits associated with the crop are negligible by comparison. At the present time, with no large economic or husbandry benefit to its credit, there is no particular reason that farmers should grow sunflower.

## Recommendations for further Research and Development

This review has identified the areas in which research must be concentrated.:

1. *Crop Establishment*. Good crop establishment is critical to profitable sunflower production. Soil conditions and temperature have to be optimal before drilling can begin, seed rates should be low in order to establish optimal populations. In a wide range of crops (including oilseed rape, sugar beet and vegetable crops), the likelihood of successful establishment has been shown to be dependent on a host of biotic and abiotic characteristics which can act singly and in combination. This will almost certainly be the case with sunflower, yet currently we cannot ascribe the causes of seed/seedling loss accurately. Identifying the causes of seed and seedling losses between sites and seasons must be undertaken. Questions to be considered would be: What is the relative effect of sowing depth, moisture availability and soil structure on establishment success? Is there scope to overcome some of these deficiencies by grading or modifying the seed prior to drilling? What is the impact of pests and diseases? Is there scope for reducing the time between germination and emergence by application of a starter fertiliser?
2. *Post-Emergence Development*. There appears to be scant information on the basic physiology of sunflower production in the UK. Information on source/sink relationships, radiation use efficiencies, attenuation use efficiencies, and canopy development would greatly enhance our ability to improve yield through husbandry manipulation. What environmental triggers control growth (i.e. biomass increment) and development? Most information on variety evaluation, crop nutrition, pest and disease control, environmental interactions and weed control originates from France. This can provide some guidance to UK growers, although as the UK sunflower crop increases it will be pertinent to produce information based on UK situations. Certainly, with the continued breeding and selection of new varieties more suited to UK conditions, there will a need to define the physiological performance of crops under a range of environments in the UK.
3. *Quality Appraisal*. Factor affecting fatty acid composition of the seed require further investigation. It has been shown that the fatty acid composition of seed grown in the UK is different to that of the parent seed and this could be exploited to provide a better quality oil. Therefore seed from UK crops should be analysed for their fatty acid spectrum and the variability accounted for by testing different husbandry effects in quality. This would include date of harvest, harvesting method, storage conditions and processing method.
4. *Harvest Technology*. Timing and mechanics of harvest, drying and storage of seed have been cited as problems by farmers and have acted as barriers to the expansion of the UK sunflower area. The review has indicated that following crops do not suffer due to this delayed harvest, but there has been a national trend towards earlier drilling of cereals. Work needs to be done to further quantify the effects of late drilling on the yield of winter wheat following sunflowers.
5. *Heat use efficiency*: Calculations using UK crop data have indicated a lower heat use efficiency than sunflower grown on the continent. Information gained from post-emergence development studies (see point 2) could provide information to explain these differences.
6. *Crop monitoring*. As the area of commercial sunflower increases, existing occurrences of pest and disease may change. Consequently, there will be a need to monitor commercial crops for the incidence of pest and disease. Further research should be targeted to the most important.
7. *Technology transfer*. In order to guide the development of the crop through its formative years, there will be a need to establish and develop links with farmers, breeders, merchants and end users. The industry is dependent on breeders developing new varieties with wider UK potential. The review is a source of information to build on and, through the UKSA, using demonstration sites and promotional campaigns growers can be made aware of the potential of sunflowers as an alternative spring break crop.

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