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INFLUENCE OF SCLEROTINIA WILT ON SEED YIELD AND QUALITY OF SUNFLOWER WILTED AT DIFFERENT STAGES OF DEVELOPMENT

By

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Abstract

Wilt caused by Sclerotinia sclerotiorum (Lib.) de Bary reduced seed yield and quality of sunflower (Helianthus annuus L.). The amount of reduction depended upon the stage of plant development when wilt occurred. Less than 0.5% of the plants were wilted at the bud stage, 7.2% by the start of anthesis, thereafter approximately 6% of the plants wilted each week until the 8-week stage when 60% of the plants had been killed. Seed yields were reduced by more than 70% when wilting occurred within 4 weeks of flowering. This reduction was primarily due to lower seed weight. Oil content increased from 32.7% for plants wilted in the first 2 weeks, to 46.4% at the 8-week stage. Protein content of oil-free meal was fairly stable and averaged 53.1% during the first 5 weeks of wilting but increased to 57.7% after the 6-week stage. Fatty acid composition was relatively unaffected by wilting as linoleic acid content varied from 74.7 to 76.8%. Thus, the oil was considered to be of excellent quality regardless of when infection occurred.

Sclerotinia wilt caused by Sclerotinia sclerotiorum (Lib.) de Bary is the most serious disease of sunflowers (Helianthus annuus L.) in Manitoba (3). The disease occurs throughout the sunflower growing regions with annual infection ranging from light, under 10%, to very severe, or over 80% (P. Bergen, personal communication). Limited accurate data are available about the impact of this disease on seed yield as most data are developed by estimating the number of diseased plants, than adjusting a projected yield value. It is known, however, that wilting may occur at any stage of plant development with the majority appearing after flowering (5). Studies in Montana with artificial inoculation showed an increase in the number of wilted plants from 23.6% on 23 July to 73.0% on 16 September. Wilt was reputed to reduce whole plant yields by 50% (10). No information has been found on the effect of plants killed at different stages of development on seed and oil quality.

This study was undertaken to determine the effect of sunflowers killed by S. sclerotiorum at various stages of growth on seed yield and seed and oil quality.

Materials and Methods

A 0.25 ha field was infested with sclerotia collected from sunflower heads naturally infected by S. sclerotiorum by sowing sclerotia and seed of the cultivar "Saturn" at a ratio of 1:3 (w/w). A population of approximately 40,000 plants/ha was established with rows 1 m apart and plants thinned to a spacing of 0.25 m. There were six replicates each containing three rows 76 m long.

Plants were observed for symptoms of Sclerotinia wilt weekly starting at the mid-bud stage (7 July) and continuing for 10 weeks until the late seed development stage (15 September) (9). Week 1 (28 July) was considered to be one week after the onset of flowering. All diseased plants were marked and 12 representative wilted plants from each row were tagged every week. On 28 September, when plants were mature, 30 tagged plants were harvested from each replicate and stage. This number was reduced to representative samples of 20 heads which were dried, thrashed, and the resulting seed bulked, cleaned and weighed. A sample of 20 healthy heads was selected from each replicate to serve as a control.

The seed was then re-dried and subsampled to permit the determination of 1000 seed weight, hull percentage, and test weight (g/0.5 l). Oil content was determined by NMR, fatty acid composition by GLC(2), and protein content of dehulled and defatted meal by an automated nitrogen method (8).

Results

Incidence of Wilt - When the field was first rated at the bud stage an average of 0.5% of the plants were wilted. This increased to 7.2% at the start of anthesis, thereafter the increment was linear with approximately 6% of the total plants wilting each week (Fig. 1). Accurate data could not be collected after the 8-week stage because of interference from other diseases and normal senescence. Wilted plants died within a few days due to rapid wilting of the leaves and development of lesions on the roots and basal stem.

Effect of Wilt on Yield - Seed yield was significantly reduced by Sclerotinia wilt when wilting occurred during anthesis or seed development (Table 1). The most drastic reduction occurred when wilting took place during the first four weeks after flowering. Yields were reduced to less than one-third of the control. As wilting occurred later in the seed development period, the impact of the disease was reduced and there was a steady increase in the yield until the 8-week stage when seed yield reached 88% of the control. The potential yield for the plot, based on yields from healthy control plants, was 2230 kg/ha. The actual yield, accounting for wilting at various stages of plant development, was 1400 kg/ha, an overall reduction in seed yield of 37.2%.

Seed weight followed a similar pattern to overall yield and appeared to be the main yield component responsible for the reduction in yield ($r = 0.957^{**}$, 53 df). Severe depression in seed weight occurred when wilting took place within 2 weeks of flowering (Table 1). This effect became progressively less pronounced with later infections and commercially acceptable seed weights of 53.3 g were recorded by the 4-week stage.

The test weight was 165.8 g one week after flowering. This declined significantly to a minimum of 138.3 g when wilting occurred 3 weeks after flowering. Weight then increased steadily to 201.7 g at the 8-week stage, however, this was still significantly lower than the 214.0 g for healthy plants.

Fig. 1. Percentage of sunflower plants wilted at various stages of development.

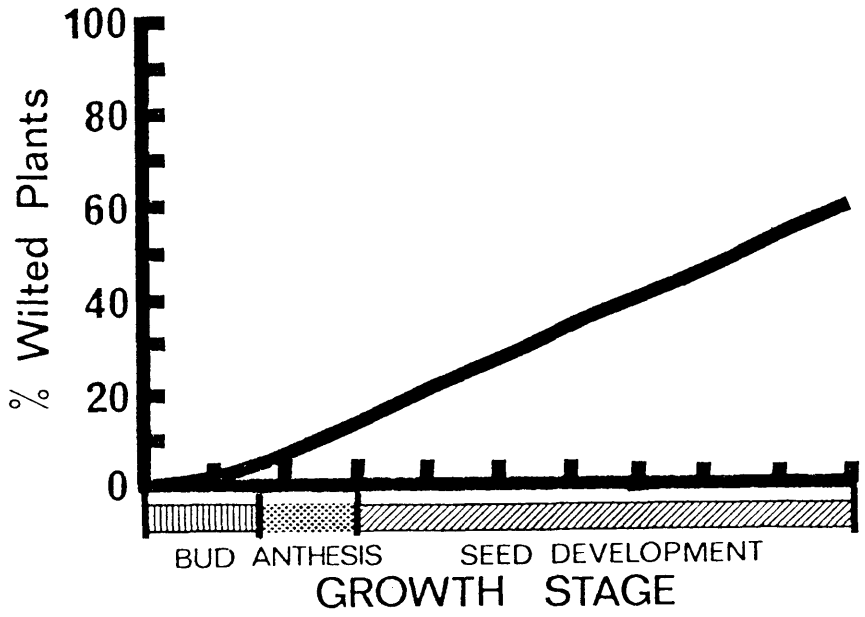

TABLE 1. Effect of time of wilting of sunflower caused by Sclerotinia sclerotiorum on seed yield and seed quality

Time of Wilting[a] (Wk)	Seed yield[c] (kg/ha)	1000 Seed wt. (g)	Test wt (g/0.5 l)	Hull (%)
1	30.8 g[b]	27.4 g	165.8 c	25.6 c
2	251.3 f	35.4 f	157.3 d	29.8 a
3	595.8 e	44.7 e	138.3 f	30.7 a
4	683.6 e	53.3 d	148.5 e	29.8 a
5	1088.2 d	53.3 d	158.5 d	29.4 a
6	1563.6 c	61.6 c	171.3 c	27.7 d
7	1474.4 c	65.4 bc	195.7 b	23.7 d
8	1962.1 b	68.8 b	201.7 b	22.5 d
Control	2230.0 a	76.0 a	214.0 a	22.4 d

[a] Weeks after onset of flowering.

[b] Means within columns followed by the same letter are not significantly different at the 0.05 level (Duncan's multiple range test).

[c] Estimate of yield assuming that all plants in plot had wilted at each stage.

Hull percentage was relatively low when wilting occurred in the first week, but increased to an average of 29.9% for those plants wilting between 2 and 5 weeks after flowering, then declined to 22.5% at the 8-week stage.

Effect of Wilt on Seed and Oil Quality - Oil content of achenes followed a reverse pattern to that observed for hull content ($r = -0.881^{**}$, 53 df.). Oil content increased from a low of 32.7% when wilting occurred at the two-week stage, to 46.4% at the 8-week stage (Table 2). There was no significant difference between stages 7 and 8 and control achenes. Despite the influence of hull percentage on oil content noted above, the relationship between stage of wilting and oil content of both achenes and seeds was almost identical ($r = 0.974^{**}$, 53 df).

When oil yield per hectare was calculated, the overriding effect of seed yield was observed. Oil yield increased gradually from 10.8 kg/ha at week 1 to 238.7 kg/ha at week 4, but more rapidly thereafter (Table 2). The differences in total oil between stages 7 and 8, and the control were significant at 665, 907 and 1026 kg, respectively, despite the lack of significance in oil content at these stages.

Protein content of the meal showed minor changes when wilting took place between 1 and 5 weeks after flowering, varying from a low of 52.3% at week 2 to a high of 54.7% at week 4. At the 6-week stage there was a significant increase to 57.9% which was typical of fully matured achenes.

The fatty acid composition of the oil was relatively stable regardless of the time of infection (Table 2). There was a significant reduction in palmitic acid from 7.6% at week 4 to 5.9% at week 8, but only minor changes in stearic

acid. When totalled, these saturated acids varied from 9.7 to 11.8%. The concentration of linoleic acid was considered high at all stages of wilting, varying from 76.8% at week 2 to 74.7% in the control seed. Oleic acid followed an inverse pattern (4 = -0.816**, 53 df).

TABLE 2. Effect of time of wilting of sunflower caused by Sclerotinia sclerotiorum on meal and oil quality.

Time of Wilting[a] (wk)	Achene Oil (%)	Oil/ha (kg)	Meal[c] Protein (%)	Fatty acids			
				Palmitic (%)	Stearic (%)	Oleic (%)	Linoleic (%)
1	36.1 d[b]	10.8 g	52.5 c	7.2 ab	4.4 a	13.6 b	74.8 cd
2	32.7 f	82.1 f	52.3 c	7.4 ab	3.9 b	11.9 c	76.8 a
3	33.5 ef	200.4 e	52.6 bc	7.4 ab	4.2 ab	12.1 c	76.3 ab
4	34.8 de	238.7 e	54.7 b	7.6 a	4.2 ab	12.3 c	75.9 abc
5	38.0 c	413.6 d	53.4 bc	7.1 bc	4.2 ab	13.6 b	75.1 bcd
6	40.5 b	634.1 c	57.9 a	6.7 cd	4.0 ab	14.5 ab	74.8 cd
7	45.1 a	665.3 c	57.4 a	6.3 de	4.0 ab	15.3 a	74.4 d
8	46.4 a	907.4 b	57.8 a	5.9 e	3.8 b	14.7 a	75.6 abcd
Control	46.1 a	1025.5 a	57.7 a	6.4 de	4.2 ab	14.7 a	74.7 cd

[a] Weeks after onset of flowering.

[b] Means within columns followed by the same letter are not significantly different at the 0.05 level (Duncan's multiple range test).

[c] Dry, defatted, and dehulled basis.

Discussion

Significant plant wilting generally became obvious during the late bud stage and continued throughout the remainder of the growing season. Yields at each stage of wilting were estimated assuming that all original plants in the plot were wilted. No effort was made to adjust yields for reduced competition as progressively more plants were killed, since it was assumed that interplant competition during the later stages of plant growth would have little effect on component compensation.

The major reduction in yield observed in plants infected with S. sclerotiorum was due to the rapid wilting and loss of leaf tissue somewhat similar to drought or defoliation. Sunflower plants subjected to drought during the 20-day periods before or after flowering suffered significant reductions in yield (6). Similarly, defoliation prior to flowering reduced yields by as much as 93% depending on the number and location of the leaves removed (4).

The changes in seed weight in this study were similar to those observed during normal development of sunflower seeds (1). Seed quality, expressed as seed weight, test weight, and percentage hull, reached commercially acceptable levels if wilting occurred no sooner than 6 weeks after flowering.

Oil content at the 1-week stage was much higher than 9% (1), 4.6% (2) and 1.3% (7) previously reported for 1-week-old seeds. This discrepancy might have been due to the less exact age of seeds in this study or to the possible continuation of synthesis and deposition of oil in wilted plants. Although the leaves of the wilted plants became flaccid and rapidly desicated, the capitulas retained their pigmentation and moisture content for several days, thus they may have been physiologically active.

Fatty acid composition did not follow reported trends where palmitic and linoleic acids are expected to be high, and oleic acid is low for the first 10 days after flowering. In the next 10-day period, palmitic acid and linoleic acids usually decline while oleic acid increases. Thereafter, linoleic acid begins a steady increase until 5 to 6 weeks after flowering when a maximum concentration is reached (2,7). In this study, plants wilted at any stage during seed development produced oil of excellent quality. The quality of the oil was generally similar to that extracted from achenes that had undergone at least 4 weeks of normal development. It would appear, therefore, that a certain amount of fatty acid synthesis occurred during and after infection. While there were significant reductions in palmitic and linoleic acids, and significant increases in oleic acid when wilting occurred at the 5-week stage or later, the differences were relatively small and of little economic concern.

This study has demonstrated that wilting caused by S. sclerotiorum at any stage of plant development from flowering to near maturity significantly reduced seed weight and yield. Seed quality, as measured by test weight, oil content, and protein content, was significantly and economically reduced if wilting occurred within 6 weeks of flowering. Oil quality could be considered unaffected by this disease. Factors that would delay field infection until at least 6 weeks after flowering may be expected to reduce the impact of this disease on yield and quality of sunflower seeds.

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