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# Yields of Three Cultivars of Sunflowers in Switzerland

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*ABSTRACT*

*The yields of three cultivars of sunflowers are reported. The amount of dry seeds per hectare varied from 2580 to 3115 kg and the oil content of the seeds from 49 to 62%. Various environmental conditions greatly influenced the oil content. The yields of seeds and of oil (kg ha$^{-1}$) were higher with lower population density (52 000 heads ha$^{-1}$ compared to 78 000 heads ha$^{-1}$). The total harvestable biomass (dry matter) varied from 7·8 to 9·4 t ha$^{-1}$. All cultivars reached maturity about 110 days after planting. The length of the vegetation period in Switzerland is thus not limiting for growing the oil seed type of sunflower.*

*Key words:* Sunflowers, yield, oil content, plant density, biomass.

## INTRODUCTION

The yields of annual energy crops in non-tropical regions, defined as the amount of harvestable dry matter produced per unit land area and year, are in many cases higher than those of perennial species. Amounts up to 44 t ha$^{-1}$ are produced with sweet sorghum.[1] In temperate regions high yields are also reported for sugar beets (about 20 t ha$^{-1}$ in Germany and the Netherlands[2]) as well as for other crops like wheat, potatoes, corn and sunflower which may all produce similar amounts of dry matter per annum.[3] The production of fuel from biomass requires in addition to the energy needed for planting and harvesting an energy input for the conversion process. Ethanol production from plants with carbohydrates



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as the main storage products has a relatively high heat consumption which lowers considerably the energy ratio given by: energy output $ha^{-1}$/energy input (agriculture and processing) $ha^{-1}$. For the production of ethanol from sugarcane this ratio is 2 : 2·7 (using bagasse for steam production) and only 2 or less for ethanol from sugar beet or corn.[4, 5]

For oil crops such a high energy consuming conversion technology to produce fuel is not necessary. Oil from sunflowers, for example, can be used as fuel for diesel engines either directly as crude oil or blended with diesel fuel.

Sunflowers are planted as oil-seed types and non-oil-seed types. The oil-seed types can produce the highest yields of oil per hectare of all temperate oil crops. In western Europe (EEC) planting of sunflowers is only of economic importance in Italy and France. Many cultivars of sunflowers also reach maturity in the climate of middle Europe. Korybut[6] has bred and recommended two cultivars for the climate of Switzerland. In the present work we have investigated growth and yields of these two cultivars and compared them with a French one.

## MATERIALS AND METHODS

Three cultivars (Schweizkor, Lisuko (Korybut) and Luciole (French cultivar)) of sunflowers (*Helianthus annuus*) were grown during 1983 in rectangular plots of 9·2 $m^2$ in the town of Zürich (Institute of Plant Biology). Planting date was 28 April. Each experimental field was run in triplicate. Population density was 65 000 plants $ha^{-1}$, with a spacing between rows of 45 cm. The influence of plant density on the yield was investigated in similar plots with 52 000, 65 000 and 78 000 plants $ha^{-1}$. The plots were initially overseeded and thinned out to the desired population after germination. Planting depth was 5 cm. Soil analysis revealed sufficient amounts of the nutrients N, P, K, Mg and Ca. No fertilizer was applied and the seedbags were only mechanically treated; weed was controlled mechanically by harrowing. The plants were covered with nets after flowering to protect them against birds. Meteorological data for the cultivation period are given in Table 1. All seeds were dried immediately after harvesting at a temperature of 35–40°C. The final water content was less than 5%. Stems, leaves and heads without seeds were shredded and aliquots of the material dried at 105°C to constant weight. Oil content of the seeds was estimated by extraction with carbon tetrachloride.

**TABLE 1**
Meteorological Data for the 1983 Cultivation Season (Zürich)

| | *April* | *May* | *June* | *July* | *August* | *September* |
|---|---|---|---|---|---|---|
| Mean temperature (°C) | 9·1 | 10·6 | 16·9 | 22·1 | 18·2 | 14·1 |
| Rainfall (mm) | 86 | 143 | 66 | 37 | 56 | 117 |

**TABLE 2**
Yields of Three Cultivars of Sunflowers[a]

| | *Luciole* | *Schweizkor* | *Lisuko* |
|---|---|---|---|
| Seeds, dry weight (kg ha$^{-1}$) | 3017 | 2833 | 2577 |
| Oil content of seeds (%) | 49·3 | 53·3 | 54·1 |
| Total oil extracted (kg ha$^{-1}$) | 1487 | 1510 | 1394 |
| Harvested biomass (dry matter without seeds, kg ha$^{-1}$) | 5441 | 4971 | 6129 |

[a] Plant density, 65 000 ha$^{-1}$. Each result is the mean of three plots of 9·2 m$^2$.

## RESULTS AND DISCUSSION

No difference in emergence of the three cultivars was observed. Heads became visible 50–55 days after planting. Fifty per cent flowering was observed 80 days after planting for Luciole, 82 days for Lisuko and 84 days for Schweizkor. Maturity was reached about 28 days after flowering. Maturity was reached significantly (5–6 days) earlier in Luciole than in Schweizkor and Lisuko. The earlier maturity resulted in a lower water content of the achenes at the time of harvesting, 132 days after planting. At this time Luciole contained 25%, Schweizkor 36% and Lisuko 37% water. Yields of the three cultivars are given in Table 2. The amount of dry seeds per hectare was highest for Luciole, followed by Schweizkor. The yields reported here are similar to those of nine cultivars tested for a two-year period in various countries. Yields of more than 3000 kg ha$^{-1}$ have been observed only under good growth conditions.[7,8] Crude oil content of the achenes is dependent on various culture conditions and varies considerably with the same

cultivar.[9, 10] In most cases the average content of seeds of cultivars planted worldwide does not exceed 50%.[11] As shown in Table 2, the oil content of the seeds varied between 49 and 54%. Due to a higher proportion of extractable oil in Lisuko and Schweizkor, no significant difference resulted in the yields of oil per hectare for Schweizkor and Luciole; Lisuko displayed only slightly lower values.

The great influence of environmental conditions such as soil composition and wind exposure on the crude oil content is evident when percentages of oil from Luciole grown in the different fields were investigated (compare Tables 2 and 3). In the fields given in Table 3 the seeds contained up to 61% of oil, whereas the content of the seeds from the other fields was only 49%. The plant density had no significant influence on the oil content of the seeds; however, the yield of seeds was significantly higher with lower plant population density resulting in 3070 kg $ha^{-1}$ with 52 000 heads compared to 2420 kg $ha^{-1}$ with 78 000 heads.

The amount of harvested total biomass (without roots) is shown in Tables 2 and 3. Total dry matter harvested from the fields with different plant population densities was higher than from the fields where the three cultivars were compared to each other, indicating more favourable environmental conditions which may also have led to the high oil content of the cultivar Luciole. The total amount of harvested dry

**TABLE 3**
Dependance of the Yields of the Sunflower Cultivar Luciole on Different Population Densities

| | *Population density (plants $ha^{-1}$)* | | |
|---|---|---|---|
| | *52 000* | *65 000* | *78 000* |
| Seeds, dry weight (kg $ha^{-1}$) | 3074 | 3115 | 2418 |
| Oil content of seeds (%) | 61·5 | 60·5 | 60·0 |
| Total oil extracted (kg $ha^{-1}$) | 1891 | 1885 | 1451 |
| Harvested biomass (dry matter without seeds, kg $ha^{-1}$) | 6393 | 6311 | 5820 |

[a] Plant density, 65 000 $ha^{-1}$. Each result is the mean of three plots of 9·2 $m^2$.

matter was in all cases less than 10 t $ha^{-1}$ and thus lower than for various annual or perennial crops.

The results of the present work confirm that sunflowers can be a suitable crop for the production of oil in Switzerland. Problems in planting sunflowers may arise not from the length of the vegetation period or too low temperatures but rather from damages as a consequence of stalk lodging. In the experiments presented here (1983) these damages were less than 5%; however, in a similar experiment carried out in 1982 more than 50% of the harvest was destroyed by wind and rain. The stem length of all of the three cultivars tested can exceed 2 m and the diameter of mature heads may be more than 30 cm. Thus these plants are quite sensitive to lodging. For the Swiss climate which quite often results in high rainfall and wind in autumn, the danger of the harvest being destroyed would be less with cultivars selected for smaller heads and shorter stems.

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