TITLE : PHOTODEGRADABLE MULCHING FILM IN SUNFLOWER CROPS: ITS EFFECT ON PLANT GROWTH AND YIELD CHARACTERISTICS

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## ABSTRACT

In 1987, research was conducted on the Pisa coast to ascertain the effect of mulching with plastic film on the growth and some phenological and biometric/productive characteristics of sunflowers. The dry matter accumulated and the leaf area expressed in relation to the time proved far greater in the mulched plants than the controls throughout the growing cycle. Both characteristics presented an upward pattern which began immediately after emergence, then declined with the beginning of achene filling in the case of dry matter, and incipient flowering in the case of leaf area. This difference in plant size was not matched by any noteworthy difference in achene yield, which was only 3.4 quintals/hectare higher in the mulched plot (approx. 10%). The growth indexes studied (LAI, LAR, AGR, RGR and NAR) did not provide an adequate explanation of this behaviour, although they did help us understand some aspects of physiological plant behaviour. We propose in this respect to conduct research on the accumulation of assimilated materials which, on ripening, largely remain immobilised in the stalk and calathide of the sunflower hybrids currently grown.

## INTRODUCTION

Plastics have been used in agriculture for over 20 years, the polymer most commonly used being polyethylene in its various forms. It is most frequently used in agriculture for mulching.

The fact that the product can be destroyed without polluting the environment within a period compatible with farming requirements has led to its being used in extensive cultivation with mechanised harvesting.

This technique produces a reduction in plant cycle compared with conventional methods, as mulching enables sowing to be commenced earlier.

Other advantages are water saving, total weed control in the area covered by smoked film, partial reduction in fertiliser quantities and simultaneous plant emergence.

## MATERIAL AND METHODS

The tests were conducted in 1987 at the Zalum farm in Cascina (PI), an area characteristic of the Pisa plain. The climatic and pedological characteristics of the area are set out in Fig. 1 and Table 1.

The variety used was the tall, medium/late cycle hybrid TOPFLOR, grown on one plot with the cultivation techniques required by rational farming practice (control), and on another mulched with 30-micron photodegradable smoked film. The two plots were cultivated dry, and distributed in an experimental random

block pattern with 4 replications. The individual plots measured 500 square metres each (100 sq.m. per replication). The seed was sown on 20th January 1987 at 25 cm intervals in rows 75 cm apart, producing a density of 5 p/sq.m. The mulched plot was sown with a Polyasem seed-drill which simultaneously performs the following operations: deposit of seed over 4 rows, laying of film (which will totally disintegrate after flowering) and soil disinfestation using Lorsban (active constituent chlorpynfos).
The machine consists of a film unwinder and relative anchorage to soil, plus a mechanical drilling system combined with a pneumatic seed-drill.
A roller was fitted prior to the unwinder to ensure correct preparation of the seed bed (Tables 5, 6 and 7).
Destructive plant sampling for growth analysis was commenced on 19/5/1987 (this date corresponding to the 4th pair of true leaves), and terminated at the time of physiological maturity, which occurred simultaneously in both plots on 26th August 1987.
A total of 8 samples were taken from each plot at 14-day intervals, each of which covered 16 plants (14 for each replication). The areas used for sampling were pre-selected on the basis of constant density, and adjacent plants which had not been disturbed by previous sampling were collected.
The following parameters were measured on the plants sampled:

- weight of dry matter in leaves, stem and the remaining epigeal portion obtained by drying in a stove at 90°C to a constant weight;

- leaf area (including petioles) measured by Haiashi Denkho mod. AAM7 electronic planimeter. These values of the dry weight (W) and the leaf area (La) are expressed as a function of the time (T), using the regression method to identify the mathematical functions best suited to represent the phenomenon. In particular, we obtained quadratic exponential polynomial equations as indicated by Hurd (1977), Hunt (19787, Abbate et al. (1982) and Seddigh (1984), which supplied an excellent adaptation to the experimental points with a determination coefficient (R2) which in all cases proved high and significant on the "F" test for $P \leqq 0.01$ (Gometz et al., 1984).
  The equations for W and La were then used to determine the other indexes (LAI, LAR, RGR, AGR and NAR) by the method followed by Radford (1967), Hughes et al. (1967) (Tables 2 and 3).

The following parameters were also determined: the periods emergence - flower bud, flower bud - flowering and flowering - physical maturity; plant height, calathide diameter, achene humidity on harvesting, unit weight and hectolitre weight of seeds, achene production at 10% humidity, % of oil to dry matter in achenes and oil production per hectare.

## DISCUSSION OF RESULTS

The dry matter in the entire aerial part of the plant presented a continual increase until 95 days after emergence (this stage corresponding to the commencement of seed filling), after which it presented a gradual, marked decrease in both plots (Graph 1).

At the time of flowering, while the dry matter produced in the control plot amounted to 173.4 gm/plant, in the case of the plot mulched with black film it amounted to 241.2 gm/plant, a difference of almost 72%.
On the 118th day, almost at the time when the plants reached physiological maturity, the dry matter in the mulched plot amounted to 269 gm, as against 199.4 gm in the control plot. The curves relating to the accumulation of dry matter in the leaves, stem and calathide over a period of time presented an identical pattern.
Graph 2 shows that the leaf area per plant increases with time until reaching a maximum in both plots at the time of full flowering. However, these maximum values differ considerably, the leaf area in the control plot being 12052.2 sq.cm/plant, and that in the plot mulched with black film 16634.9 sq.cm/plant.

GROWTH INDEXES (Graph 3)

LAR) The ratio of leaf area to dry weight of the entire aerial part of the plant presented an almost identical pattern in both plots until the stage when flower buds were produced. Thereafter, the mulched plants presented a higher index until the end of the cycle, indicating that they require a larger photosynthesis area than the controls if they are to maintain the same amount of dry matter. The highest value was observed in both plots about two weeks after flowering (84.1 and 86.9 sq.cm/gm in the control plot and mulched plot respectively).

LAI) The leaf index per unit of land area presented the same bell-shaped curve as for the leaf area per plant, with maximum indexes at the time of full flowering, and far higher indexes (8.32) in the mulched plot than the control plot (6.06).

AGR) The absolute growth index presented a similar pattern in both plots. This index presented continual increases until the time of flowering (5.8 and 7.6 gm/day were the maximum values for the controls and the mulched plants respectively), then declined rapidly until reaching value 0 on commencement of seed filling in both plots, and falling to negative values on physiological maturity.

RGR) The relative growth rate of the plant presented a linear, decreasing pattern, commencing from the highest values at the time of production of the 4th pair of true leaves. After this phenological stage, the values remained higher in the mulched plot than the control plot until the full flowering stage, after which both values became almost identical at the time of seed filling, and then declined to - 0.280 and - 0.284 gm/day at the time of physiological maturity.

NAR) The net assimilation rate presented a pat ern linked to the various phenological stages. The values did not differ significantly between the mulched and control plots, the maximum index being recorded on production of the 4th pair of true leaves (37.2 and 31.1 gm/sq.m./day respectively). The curve subsequently presented a steep decline, reaching values of approx. 7 gm/sq.m./day in both plots at the time of production of the flower bud. From this time until full flowering, the descent of the curve slowed, remaining almost constant, indicating that the calathide had supplied a considerable photosynthesising impulse to the plant.
After flowering the curve descended again, reaching highly negative values at the time of physiological maturity of the plant.

## CONCLUSIONS

- The cultivation of sunflowers mulched with black film and sown at the normal time did not present any noteworthy difference from the controls in terms of the length of the phenological periods examined.
- At the time when seed filling began, the accumulation of dry matter decreased rapidly in both plots; at this physiological stage the growth indexes AGR, RGR and LAR presented 0 values, indicating that photosynthesis activity and plant growth terminate at this stage.
- The aerial part of the plant and all the various organs presented a considerable increase in accumulation of dry matter, leaf area and some of the indexes examined (LAI, AGR and LAR) in the mulched plot throughout the cultivation period or for most of it, while no significant differences were recorded for the RGR or NAR.
- This increase in the size of the mulched plants was not matched by an adequate increase in production in terms of achene yield, which was 3.4 q/h higher than the controls (approx. 10%).
- Combined examination of dry matter, leaf area and the other growth indexes does not provide a logical explanation of this extremely limited difference in production between the two plots. As no particular differences were observed in the use of light radiation (NAR), the mulched plants should have presented higher production than the controls in view of their more extensive leaf apparatus. However, it should be observed that the sunflower cultivars available nowadays are plants in which the final achene weight represents only some 1/3 of the total dry matter, while a considerable proportion of assimilated matter remains immobilised in the stalk and calathide (Blanchet, 1981).

Our next objective is to conduct research on the accumulation of nutrients in the various parts of the plant in order to obtain an explanation of this phenomenon.

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TAB.2– Indexes characteristics.

| INDEX | SYMBOL | EXPRESSION | UNIT OF MEASURE |
|---|---|---|---|
| leaf area index | LAI | $\frac{LA}{F}$ | undimensional |
| absolute growth rate | AGR | $\frac{dW}{dT}$ | mg/d |
| relative growth rate | RGR | $\frac{dW}{dT}\cdot\frac{1}{W}$ | g/g.d |
| leaf area rate | LAR | $\frac{LA}{W}$ | cm2/g |
| net assimilation rate | NAR | $\frac{dW}{dT}\cdot\frac{1}{LA}$ | g/m2.d |

W=total dry weight
LA=leaf area
T=time

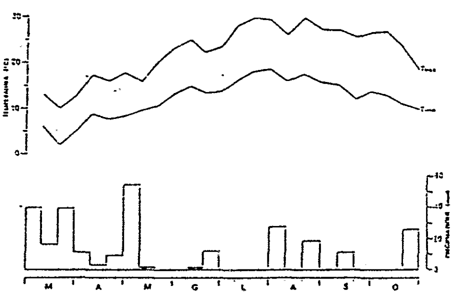
TAB.4–Reported only characters significant to statistic analisis

| CHARACTERS / TREATEMENTS | head diameter cm | hectoliter seed weight kg | achenes yield q/ha |
|---|---|---|---|
| test | 19.2 | 45.2 | 34.0 |
| mulching film | 22.1 | 47.4 | 37.4 |
| D.M.S. P≤0,05 | 2.1 | 1.6 | 3.0 |

TAB.3–Equation of the curves representing dry matter and leaf area time trend, determination coefficients (R2), and equations of the growth indexes of the two treataments

| | | |
|---|---|---|
| **TEST** | | |
| total dry weigth | $y1=e^{(-6.435128\cdot10^{-4}X^{2} + 0.123830X - 0.32669)}$ | $R^2 = 0.988$ |
| leaf dry weigth | $y2=e^{(-6.60167\cdot10^{-4}X^{2} + 0.109317X - 0.422252)}$ | $R^2 = 0.973$ |
| steam dry weight | $y3=e^{(-5.684878\cdot10^{-4}X^{2} + 0.107243X - 0.620133)}$ | $R^2 = 0.948$ |
| head dry weight | $y4=e^{(-9.995682\cdot10^{-4}X^{2} + 0.107316X - 0.63948)}$ | $R^2 = 0.915$ |
| leaf area | $y5=e^{(-1.594968\cdot10^{-3}X^{2} + 0.228256X + 1.262231)}$ | $R^2 = 0.892$ |
| RGR | $y6= -1.2870\cdot10^{-3}X + 0.12383$ | |
| AGR | $y7= y1 * y6$ | |
| LAI | $y8= y5/2000$ | |
| LAR | $y9= y5/y1$ | |
| NAR | $y10= y7/y5$ | |
| **MULCHING FILM** | | |
| total dry weight | $y1=e^{(-6.684047\cdot10^{-4}X^{2} + 0.129379X - 0.361961)}$ | $R^2 = 0.993$ |
| leaf dry weight | $y2=e^{(-6.626536\cdot10^{-4}X^{2} + 0.112614X - 0.468482)}$ | $R^2 = 0.972$ |
| steam dry weight | $y3=e^{(-5.98408\cdot10^{-4}X^{2} + 0.113028X - 0.605665)}$ | $R^2= 0.963$ |
| head dry weight | $y4=e^{(-1.042745\cdot10^{-4}X^{2} + 0.215609X - 5.85862)}$ | $R^2 = 0.959$ |
| leaf area | $y5=e^{(-1.516992\cdot10^{-4}X^{2} + 0.225972X - 1.365954)}$ | $R^2 = 0.887$ |
| RGR | $y6 = -1.3368\cdot10^{-3}X + 0.129379$ | |
| AGR | $y7 = y1*y6$ | |
| LAI | $y8 = y5/2000$ | |
| LAR | $y9 = y1/y5$ | |
| NAR | $y10 = y7/y5$ | |

FIG.1– Ten-day climatic data




TAB.1–SOIL CHARACTERISTICS

| | |
|---|---|
| clay | 42.4% |
| silt | 18.8% |
| sand | 40.8% |
| pH | 7.2 |
| total $CaCO_3$ | 1.28% |
| organic matter | 2.34% |
| total N | 1.32‰ |
| assim. $P_2O_5$ (met. Olsen) | 18 ppm |
| assim. $K_2O$ (met. Dirks e Sheffer) | 24 ppm |

| Density per hectare | Type of wheel | Type of sowing | Type of plate | Distance between the holes on the seeding line |
|---|---|---|---|---|
| 51 200 | 12 P | 1.1 1 1 | 9holes | 0.25 |
| 68 240 | 12 P | 1 2.1.1 2 | 12 " | 0.25 |
| 85.300 | 12 P | 2.2.1 2 2 1 | 15 " | 0.25 |
| 102 400 | 12 P | 2.2 2.2 2 | 18 " | 0.25 |
| 75.300 | 18 P | 1 1.1 1 1 | 18 " | 0.17 |

TAB. 5

SEEDING WHEEL CHARACTERISTICS.

SEEDING - MACHINE USED : 4 . ROWS

WHEELS : 12 P (12 PLIERS)

TYPE OF SEEDING : 1.2.1.1.2..

TYPE OF PLATE : 12 HOLES

DISTANCE BETWEEN THE HOLES ON THE SEEDING : 0,25 m,

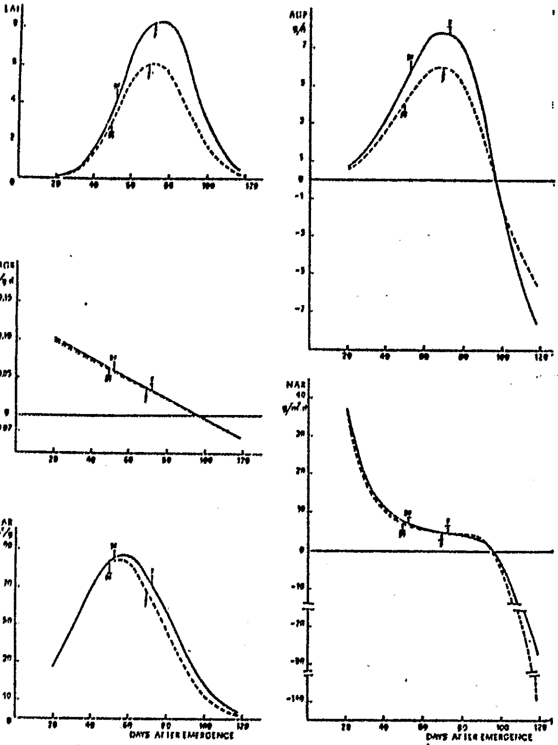
SEEDS DENSITY : 68240/HA

TAB. 6

TAB. 7 SEEDING - MACHINE CHARACTERISTICS

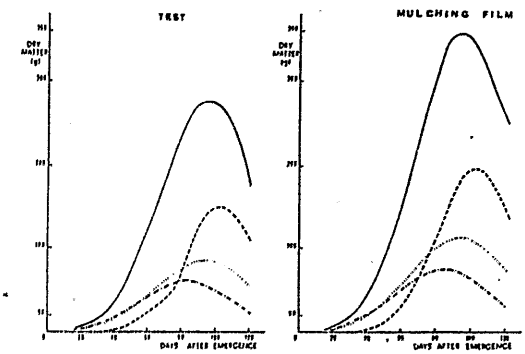
| CHARACTERISTICS | 2 ROWS | 4 ROWS | 6 ROWS |
|---|---|---|---|
| Rows number.<br>Working width. (m.)<br>Max. " " | 2 (1 module)<br>1.60<br>1.70 | 4 (2[illegible]les)<br>3.10<br>[illegible].20 | 6 (3 modules)<br>4.65<br>4.80 |
| Dist. between the seeding rows. | 0.75 – 0.80 | 0.75 – 0.80 – 0.75 – 0.80 | 0.75 – 0.80 – 0.75 – 0.80 – 0.75 |
| Weight<br>Tractor H.P.<br>Power take off<br>Two-way hydraulic lifter control | 800 kg<br>50<br>540 T/mn<br>minim. 35 L/mn à 150 bar | 1.400 kg<br><br>540 T/mn<br>minim. 35 L/mn à 150 bar | 2.100 kg<br><br>540 T/mn<br>minim. 35 L/mn à 150 bar |
| Yield / Ha. at 5 km/h mean value | 2 h 30 | 1 h 20 - 1 h 30 | 1 h |

GRAPHICS 3




—= mulching film
---= test
F = flowering
BF = flower bud

GRAPHIC 1




—= total dry weight
----= head " "
...= steam " "
-.-.= leaf " "

GRAPHIC 2