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Effects of transparent polyethylene mulching and different planting densities on tomato grown for processing in Sicily

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SUMMARY – Tomato cultivation is steadily increasing in the Sicilian countryside where careful management of clay soils allows successful yields. The crop is established in the first week of May and rainfall is adequate to obtain a sufficient production without irrigation. In these areas a recent development in tomato production for processing is the use of transparent polyethylene (PE) mulching. The aim of this study was to verify the effects of transparent PE mulching vs bare soil and of three different plant densities (0.74, 1.1 or 2.2 plants/m^2) on a tomato crop in the Sicilian countryside. Applying PE mulch and planting at a density of 2.2 plants/m^2 resulted in the highest yield (58.6 t/ha). The lowest production (15 t/ha) was obtained on bare soil and by planting at a density of 0.74 plants/m^2.

Key words: Tomato, mulching, planting density, polyethylene.

RÉSUMÉ – *"Effets du paillage en polyéthylène transparent et de différentes densités de plantation sur une culture de tomate industrielle en Sicile". La culture des tomates industrielles en Sicile s'est diffusée, il y a quelques années, dans les terrains argileux de l'intérieur des collines. La culture est effectuée sans irrigation en rotation avec le blé, à travers les techniques les plus communes de la culture en sec. Dans ce cas, la technique du paillage avec de la pellicule plastique est très utile à la réduction des pertes d'eau par évaporation. Le but de cette recherche est d'évaluer la réponse productive des tomates industrielles au paillage avec du polyéthylène transparent et à différentes densités d'installation (0,74, 1,1, ou 2,2 plantes par m^2). Le paillage avec du polyéthylène transparent a permis, par rapport à la terre nue, de faire augmenter considérablement la production de fruits destinés au commerce. On a obtenu les meilleurs résultats (58,6 t/ha) en appliquant la technique du paillage et en adoptant une densité d'installation de 2,2 plantes par m^2. Par contre, on a obtenu la plus faible production dans un sol qui n'a pas été soumis au paillage, en adoptant une densité d'installation de 0,74 plantes par m^2.*

Mots-clés : *Tomate, paillage, densité des plantes, polyéthylène.*

Introduction

Tomato culture for processing in Southern and Central Italy is mainly concentrated along the coastal areas where climatic conditions are particularly favorable to the crop. However, in Sicily, in the last 20 years tomato cultivation has steadily increased in the hilly countryside and it covers about 1000 hectares. The limited amount of rainfall, mainly concentrated in the fall-winter months, is adequate to obtain a sufficient production without irrigation. Although heavy clay soils are very common in these areas, careful application of dry farming techniques allows successful yields. Growing tomato and other warm season crops on transparent film-covered beds is a common commercial practice in many areas of the world. The main advantages of this practice are higher soil temperatures, reduced evaporation and fertilizer leaching, and limited soil compaction as compared to bare soil (Lamont, 1993). Beneficial effects of transparent polyethylene (PE) mulching are also evident in semi-arid conditions without irrigation. Fruit yields of processing tomato grown under dry land conditions were substantially improved by transparent PE mulching (Rudich, 1979). In the Sicilian hilly countryside under dry land culture and at relatively high elevation (600-900 m) the tomato crop cannot initiate before the first week of May, when air and soil temperatures are conducive to normal growth, and it must end by the second week of September as early low fall temperatures are a limitation for regular fruit ripening. Therefore, the total potentiality of the crop is not exploited. In this situation, dry farming techniques such as plastic mulching may improve tomato yield. This work was undertaken to evaluate the effects of transparent PE mulch on a tomato crop grown without irrigation in the Sicilian countryside (950 m elevation) using different planting densities.

Materials and methods

The experiment was conducted on vertic xerochrept soils near Valledolmo in the province of Palermo, 950-m elevation. The soil, relatively high in organic matter content (5%), was prepared by plowing in the summer and by periodic tilling in the fall in order to control weeds and to reduce moisture evaporation. Fertilizers were incorporated during the tillage at the rates of 66, 132, 96 kg/ha of N, P_2O_5 and K_2O, respectively. The experiment was arranged in a split-plot design with mulching treatments (mulch or no mulch) as main plots and plant densities (0.74, 1.1 or 2.2 plants/m^2) as sub-plots. Transparent PE film 1.2 m wide and 50 mm thick was laid by hand. On 12 May 2000 tomato plug type transplants 'Interpeel' were hand planted in the center of mulched and unmulched plots on single rows 150 cm apart. In-row spacings were 30, 60 or 90 cm according to the experimental design. There were four replications and individual experimental plots measured 15 m^2. Soil temperatures at 5 cm depth were measured at hourly intervals during the growing period using thermocouple probes positioned in the middle of the mulched or unmulched plots and connected to a microprocessor logging thermometer (Hanna Instruments, R.I., USA). Anthesis dates of first cluster on main stem were recorded. Cumulative marketable yields were recorded by July 30, August 18 and September 28 (total yield) for each treatment. Plant diseases and insects were controlled by applications according to the local culture recommendation. All data were subjected to analysis of variance (ANOVA) and mean separation was performed by Duncan's multiple range test. Percentage data were subjected to arcsin transformation before analysis.

Results and discussion

During the growing season the automated data collection system allowed diurnal measurements of soil temperatures for each plot.Transparent PE mulch increased soil temperatures in comparison to the bare soil (Fig. 1). Maximum soil temperatures (from 24.1 to 26.8 °C) were measured under transparent PE film between 10:00 and 16:00 h. During the day period, soil temperatures below transparent PE were from 6.7 to 10.5 °C higher than those in the bare soil. Night and predawn soil temperatures under transparent PE during the growing period were always above 11.5 °C; the transparent PE film increased night and predawn soil temperatures by 1.3-3.3 °C in comparison to the bare soil. Mulching accelerated flowering (Table 1).

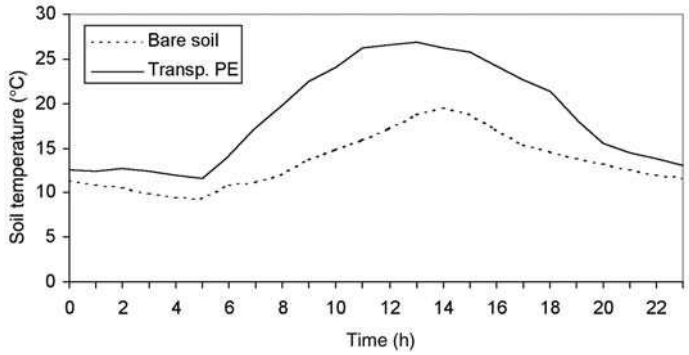

Fig. 1. Diurnal patterns of soil temperature at the 5 cm depth in the plastic mulch and bare soil plots.

Regardless of planting density, the number of days from transplanting to flowering was significantly lower in the mulched plots than in the bare soil. Increasing plant density resulted in early flowering. Mulching dramatically increased fruit yields in comparison to bare soil (Table 2). Fruit yield by July 30 in the transparent PE mulching treatment and in the bare soil over the three planting densities averaged 0.53 and 14.43 t/ha respectively. Plant density had almost no effect at this harvesting date. Cumulative yields by August 18 and by September 28 (total fruit yield) were significantly affected by the treatments tested; regardless of planting density, yields in the mulched plots were 58% and 56% respectively higher than in the unmulched plots. Irrespective of the mulching treatment, fruit yields significantly increased as in row spacing decreased. Mulch treatment and planting density significantly interacted. The increase in fruit yield due to PE mulching was significantly greater at the highest plant densities. Regardless of planting density, percentage of unmarketable fruits was

significantly higher in the unmulched plot as compared to the PE mulched plots. The majority of the unmarketable fruits in the unmulched plots were represented by unripened fruits.

Table 1. Flowering date, marketable yields and percentage unmarketable yield of 'Interpeller' tomato at different harvesting dates as affected by transparent PE mulch and planting density

Mulch	Plant density (plants/m^2)	Flowering date[†]	Marketable yield (t/ha)			Unmarketable yield (%)
			7/30/00	8/18/00	9/28/00	
None	0.74	46.7a	0.36c	13.26f	15.45f	25.0b
	1.1	44.8b	0.51c	15.45e	20.11e	26.0b
	2.2	40.6c	0.71c	17.68d	23.67d	28.0a
	Mean	44.0a	0.53b	15.46b	19.93b	26.3a
Mulch	0.74	27.3d	13.25b	20.54c	31.47c	6.0c
	1.1	25.6e	14.46ab	39.48b	45.33b	3.0d
	2.2	24.4f	15.57a	49.56a	58.64a	5.0c
	Mean	25.8b	14.43a	36.53a	45.15a	4.7b
Average	0.74	37.0a	6.8a	16.90c	23.46c	15.5a
	1.1	35.2b	7.49a	27.47b	33.0b	14.5b
	2.2	32.5c	8.14a	33.62a	41.15a	16.5a

[†]Days after transplanting.
[a,b,c,d,e,f]Values within columns that are followed by the same letter are not significantly different at P = 0.01 using Duncan's Multiple Range Test.

Table 2. Mean fruit weight of tomato 'Interpeller' at different harvesting dates as affected by transparent PE mulch and planting density

Mulch	Plant density (plants/m^2)	Mean fruit weight (g)		
		7/30/00	8/18/00	9/28/00
None	0.74	70.3c	63.9c	52.4b
	1.1	64.6e	63.9c	57.3d
	2.2	62.4f	57.3e	42.4e
	Mean	65.7b	63.2b	47.4b
Mulch	0.74	77.8a	75.2a	62.1a
	1.1	71.5b	69.7b	49.5c
	2.2	65.6d	60.7d	45.3f
	Mean	71.6a	67.9a	42.3a
Average	0.74	74.0a	71.8c	57.3a
	1.1	68.0b	65.9b	48.4b
	2.2	64.0c	59.0a	43.8c

[a,b,c,d,e,f]Values within columns that are followed by the same letter are not significantly different at P = 0.01 using Duncan's Multiple Range Test.

The lowest percentage of unmarketable fruits was obtained by planting 1.1 plants in the plots covered with transparent PE. Irrespective of the planting density, mean fruit weight in the unmulched plots at the final harvesting date was significantly lower than in the mulched plots. Regardless of mulch treatment, increasing plant density resulted in lower mean fruit weight. The highest mean fruit weight was recorded at the second and third harvesting date (77.8 and 75.2 g respectively) in the plots covered with transparent PE film and at a density of 0.74 plants/m^2.

Conclusion

Adverse climatic conditions during the fall interfere with regular fruit ripening and reduce the potential yields of tomato grown at 950 m elevation in the Sicilian hilly countryside. Beneficial effects

of transparent PE mulching for warm season crops cultivated in areas with a short growing season have been reported (Waterer, 2000). This study confirms that in those situations where the brevity of the growing season is a limiting factor, transparent PE mulch represents an efficient mean for increasing fruit yield in comparison to the bare soil. In this experiment, soil temperatures under the mulch were, during the growing season, constantly higher than on bare soil. In particular, soil temperature between 900 and 1700 was near optimal for tomato root mineral uptake and growth which, accordingly to Maletta and James (1987), is about 25 °C. Conversely, soil temperatures in the unmulched soil were always below optimal. This, in addition to other beneficial effects of transparent PE mulching, such as reduced evaporation, higher availability of water resources, more root development in the upper soil layer, and reduced nutrient leaching, induced growth stimulation and favored fruit ripening prior to fall adverse climatic conditions would prevent regular fruit ripening and reduce potential marketable fruit yields. Tomato population density is decided according to several factors: plant habit, environmental conditions, soil fertility, presence or absence of irrigation, plant management and fruit harvest (Atherton and Rudich, 1986). The present work suggests that under Sicilian countryside conditions optimal plant density is 2.2 plants/m^2.

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The authors contributed equally to this work.

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