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ALTERNATIVE WAYS ON ORGANIC PEPPER (*Capsicum annuum* L.) PRODUCTION IN TURKEY

Alev Kir* [1], Barbaros Cetinel[2], Hatice Sevim Turan[1], Erol Aydogdu[1]

[1]Ministry of Agriculture and Forestry (MoAF) of Turkey, Olive Research Institute (ORI),

[2]Ministry of Agriculture and Forestry (MoAF) of Turkey, Plant Protection Research Institute (PPRI), Izmir, Turkey

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Abstract: Contentious inputs in management of organic farming include the use of plastic for mulching in vegetable crops. The Horizon2020 project Organic-PLUS (GA774340) aims to develop and promote alternatives to fossil-derived plastic used for mulching. In Turkey, one promising alternative tested in field during 2019 was finely chopped pruning materials from olive (*Olea europaea* L.) branch, which performed well on organic growing of pepper (*Capsicum annuum* L.) in field. Olive material showed better weed suppression than biodegradable plastic mulch in irrigated pepper during summer in a field experiment in Izmir/Turkey. One reason for this is that the plastic foils degraded too quickly under Turkish field conditions with a pepper crop. Pruning materials for mulching is an interesting alternative, but practical method for producing and applying this material in field needs to be developed.

Introduction: The Organic-PLUS project provides scientifically informed decision support to assist national and regional policy makers, and other actors in the organic sector. Phasing out of some contentious inputs such as plant protection inputs, antibiotics, peat, plastics and animal-derived fertilizers is main objective of Organic-PLUS. The project identifies and evaluates contentious inputs currently used in organic production across Europe, and tests and develops specific technical solutions to minimize their use (Schmutz et al, 2018).

Fossil-derived plastic foil is often used for mulching in organic vegetable growing (Løes et al 2018), and biodegradable plastic foil is often not made from 100% renewable materials. In Organic-PLUS, an industry partner from Poland (Postawa et al, 2020) developed biodegradable plastic foils (CUT). Field experiments were carried out in Turkey and UK. In Turkey, chopped pruning material from olive was included as an alternative mulching treatment. The aim of the field experiment in Turkey during 2019 was to compare the performance of biodegradable plastic mulch, traditional fossil-derived plastic mulch and olive material mulch in organic growing of pepper in field, with irrigation. Weed suppression capability, yield levels and plant quality characteristics of pepper were recorded.

Material and methods: The replicated trial was carried out at the experimental organic field of MoAF (Figure 1) in Menemen (Izmir/Turkey) during the summer season of 2019. The experimental area has been managed organically since 2008. The area lies in the Mediterranean climate zone with an average annual rainfall of 700 mm and relative humidity of 60%. Pepper (*Capsicum annuum* L. cv Yalova Yaglik) (Figure 2) was grown as experimental crop, with surrounding hedges composed of ornamental and aromatic/medicinal of local species like mainly, marigold (*Tagates* spp.), cypress (*Cupressus* spp.), bay tree (*Laurus nobilis* L.), sage (*Salvia fructicosa*), yarrow (*Lycopodium annotinum* L.), peppermint (*Mentha piperita* L.), rosemary (*Rosmarinus officinalis* L.), ball thyme (*Origanum onites* L.), and lavandula (*Lavandula stoechos* L.) in the experimental area. The pre-crop grown in from October 2018 to at the end of March 2019 was a green manure (Common vetch (80%) +barley (20%)) and it was plugged in to the 20 cm depth of the soil during 25% flowering stage of green manure crop. Aerobic Compost made from chopped olive brunch, vegetable waste (broccoli, faba bean, maize, and artichoke), freshly cut grass, and farmyard manure in 2018 was applied to the plots 15 days before the plantation of pepper transplants to the experimental field. The compost used in the current study was mature according to its carbon to nitrogen ratio (C/N ratio), which was determined as 20. Transplants of pepper were raised indoor (greenhouse) and then planted to organically managed field on 28thApril 2019. The chosen variety is a non-hybrid standard variety that has been bred from domestic landraces. According to the description certificate, the variety is expected to give an average yield of 40 tons per hectare and average diameter 100 mm in conventional management.

Figure 1. Experimental organic field of MoAF (38°36'36.98" N, 27°6'10.09" E) (Izmir/Turkey)

Figure 2. *Capsicum annuum* L. cv Yalova Yaglik.

The experiment was designed to study the effects of mulching materials fossil-derived plastic (P), biodegradable plastic with 30% (by weight) filler material of $CaCO_3$ (CUT1), biodegradable plastic with no filler (CUT2), and olive pruning material (OP). Two controls, with (C) and without (CNW) weeding (by hand) were applied. Developed biodegradable plastic foils made from renewable and non-GMO materials. P, produced to use for 2-3 years in conventional farming. Pepper is a common vegetable crop in Turkey, and grown by farmers especially in Aegean, Marmara, and South East Regions. The experiment was conducted in randomized block design in 24 plots with 6 treatments and 4 replications, with 119 plants in each experimental plot. The distance between the experimental plots on all sides was 2.1 m and each plot size was 36.5 m^2 (6.4 m x5.7 m) with edge effect (Figure 3). Soil (0-10 cm and 10-30 cm) sampled twice before compost application and after last (4th) harvest of pepper for each plot and data was recorded. Compost made from chopped Olive (*Olea europaea*) branch pruning (6V/10V), aromatic and medicinal plants (3V/10V) (Oregano stem (*Origanum vulgare*), Sage stem (*Salvia officinalis*), Bay leaves (*Laurus nobilis*), and Thyme stem (*Thymus* spp.)), and horse manure (1V/10V) was applied to the plots 15 days before the plantation of pepper transplants. The parcel (3.5 x 5 m without edge effect) was covered with enough olive pruning material to cover the top layer by 5 cm. Olive pruning material was ground to a thickness of 0.5-1.5 cm. Totally, 420 mm irrigation water was applied, during growing period of pepper (April-September) in weekly periods. For the control of pest (only aphid was detected), not only an authorized pesticide (*Azadirachta indica* A. Juss) extract was used 3 times in the whole pepper growing season, especially in early transplanted stage of peppers to experimental field, but also all cultural precautions and usage of yellow sticky traps for observations of pests (aphid, white fly, and red spider mite) were performed. No any disease was detected in any plot. The weed coverage data were estimated by visual observation using the percentage of surface infested by weeds. The data on total weed count and coverage were recorded at 40 days after transplanting during the experimental year. The weed density and coverage area were determined randomly using a 1 m x 1 m = 1 m^2 quadrate twice in each experimental plot. Marketable fruit were weighed, counted, and graded by size following a diameter scale used: extra-large (diameter > 84.0 mm), large (76.0–

83.9 mm), medium (64.0–75.9 mm), and small (56.0–63.9 mm) (Jovicich et al., 2005). Soil pH (1:2.5 Soil:Water), EC (mS cm^{-1}), Lime (Scheibler Calcimeter, %), Organic Matter (Walkley-Black Method, %), Texture (Hydrometer Method), N (Dumas Method, %) and P (Olsen Method, ppm) were determined in the samples. N (%) was determined according to Dumas Method in the soil samples. K (ppm), Ca (ppm) and Mg (ppm) were determined in the filtrate with ICP-OES device in the soil samples. Fe, Cu, Mn and Zn (ppm) were determined in the filtrate with ICP-OES device in the soil samples. N (%) was determined according to Dumas Method in the leaf samples. P (%), K (%), Ca (%), Mg (%), Fe (ppm), Cu (ppm), Mn (ppm) and Zn (ppm) were determined in the filtrate by Microwave Digestion System and ICP-OES device in the leaf samples. Results were statistically evaluated by variance analysis (ANOVA) and significant differences between means were assessed by Tukey test using SAS (SAS version 9.1.3, SAS Institute, 2004).
Figure 3. Field plan of experiment.

Results: *Plastic foils:* P treatment was determined the most suppressed mulch material of weeds (Figure 4). CUT1 and CUT2 were quickly degraded, and about 2 months after planting, no trace of plastic material could be observed in field by eye, not even in the sides of the plot where the plastic was buried. The degradation of CUT1 was observed slower than observed for CUT2 both in Turkey and UK field trials (Rayns et al 2020). In spite of the complete and rapid degradation of CUT 1 and 2, these treatments showed higher yields significantly ($p \leq 5$ %) of pepper than fossil-derived plastic, and much better yields than in the non-weeded control. It was observed that after degradation of CUT1 and 2, the weed suppression effect maintained due to a strong and compact soil structure and not effected pepper yield negatively. So that data related to weed suppression of both CUT treatments, found successfully after OP treatment due to CUT degradations during open field and irrigated summer season of pepper production. As a result of the statistical analysis, mulch applications were the most effective in terms of reducing weed coverage area for organic pepper in summer season. Their weed coverage areas were found to be approximately 80% lower than the control applications. The average weed coverage rates and total weed fresh weight of plots from lowest to highest for this season were P (2.25%), OP (4.25%), CUT1 (5.25%), CUT2(15.25%), control weeded (55.30%), and control non-weeded (96.75%), respectively.
Pepper yields: Total pepper yields of OP (38 tons per ha), CUT2 (33 tons per ha) CUT1 (33 tons per ha), and P (32 tons per ha) showed approximately equal to average yield of the variety (40 tons per ha), significantly ($p \leq 5$ %). OP showed the highest marketable pepper yield, significantly ($p \leq 5$ %) (22.3 tons per ha).The weeded control and the mulched treatments all gave comparable yields, between 15 and 20 tons per hectare. This was significantly better than for the non-weeded control which only gave about 0,2 tons.
Figure 4. Weed suppression and yield performances of the treatments.
Soil and plant analyses: When the mean soil analysis results (0-10 cm and 10-30 cm depth) of the pepper experimental growing area are evaluated collectively; according to Akalan (1965), organic matter content (%) is at the low and very low level (0.18-1.79), according to Olsen and Dean (1965), P (ppm) content is medium and high (11.26-46.79), considering the limit values of Pizer (1967) K (ppm) content varies between high and very high (265.23-504.21), When the limit values are taken into consideration according to Loue (1968), Ca (ppm) content is high (3006.22-4394.46), Mg (ppm) content varies between high and very high (268.06-460.28), when considering the limit values of Follet and Lindsay (1970) 's analysis of the microelements; Fe (3.79-9.89 ppm), Mn (7.99-12.04 ppm), Zn (2.70-1.44 ppm), Cu (0.77-1.25 ppm) are sufficient. It is understood that the soil grown on pepper is at a very good level in terms of fertility. When the analysis results of the leaf samples of pepper plant are examined; according to the limit values reported by Reuter and Robinson (1986), P (%) content varies between sufficient and high (0.41-0.71), K (%) contents are adequate except for 3 samples

(2.51-4.01), Ca (%) contents are enough in 2 samples, others are low (0.58-1.36). Mg (%) contents vary between low and sufficient levels (0.18-0.30), Fe (ppm) contents are sufficient, high and very high (137.19-353.86), Mn (ppm) contents are sufficient in 4 samples, others are low (16.27-36.54), Zn (ppm) contents are low in 1 sample, others are sufficient (34.48-61.80), Cu (ppm) contents are low in 1 sample, others are sufficient (8.41-33.32). When the nutritional status of the leaves is examined in general, it was found at adequate level.

Discussion: Experiment of Organic Plus project in Turkey using pepper crop has promising results to phase out plastic. After OP chopped mechanically, it can be used for mulching in small-scale organic farms of Turkey. CUT1 and CUT2 can be used as sustainable solutions for weed suppression in OF instead P.

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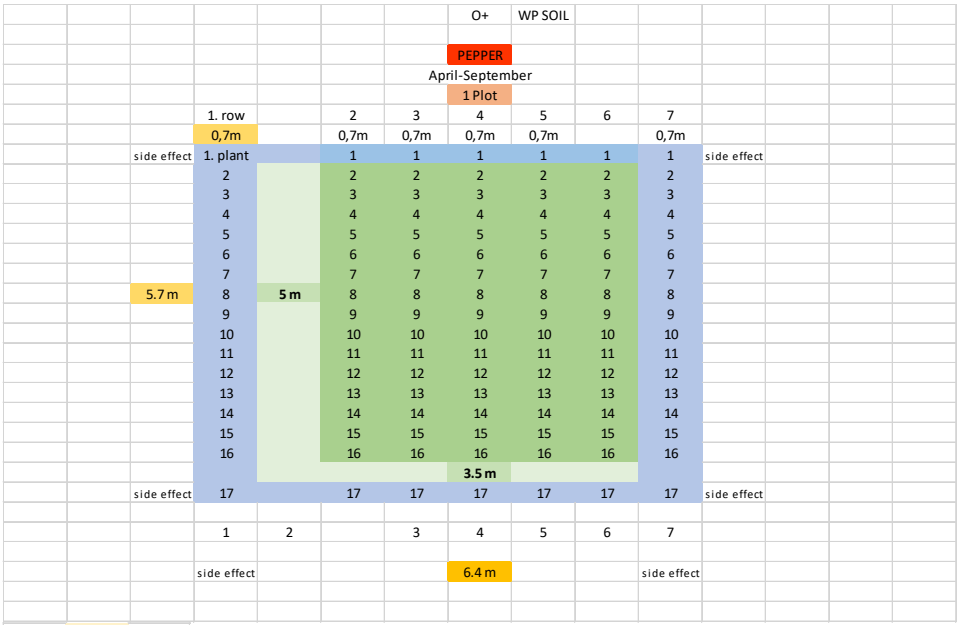
Figure 1: Experimental organic field of MoAF (38°36'36.98" N, 27°6'10.09" E) (Izmir/Turkey)

Figure 2: Pepper (*Capsicum annuum* L.)

Figure 3: Field plan of experiment



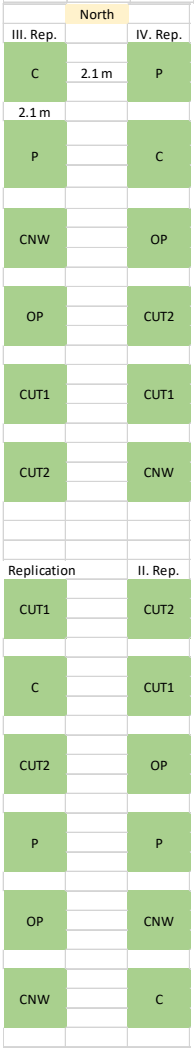
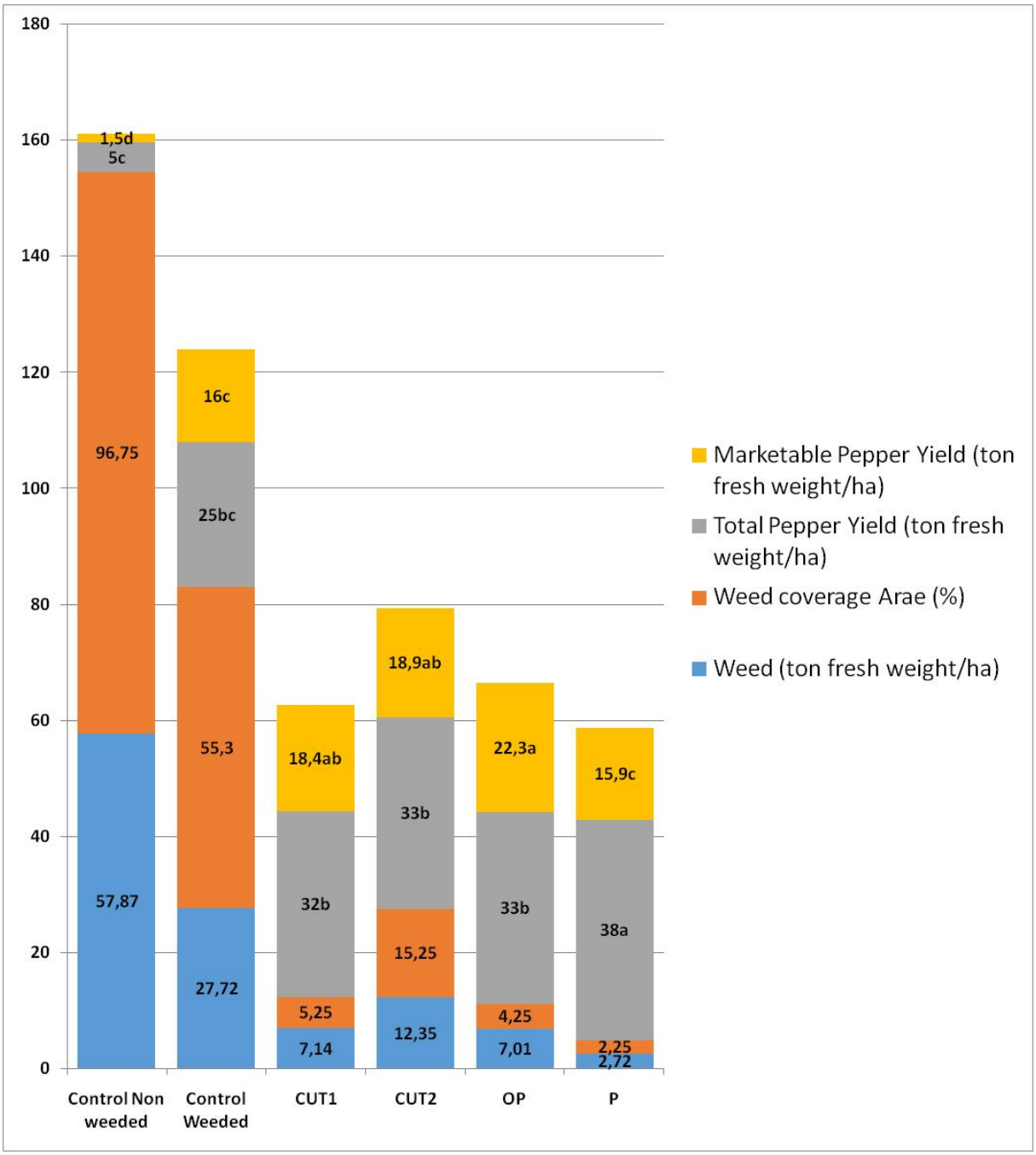


Figure 4: Weed suppression and yield performance of the treatments



Disclosure of Interest: None Declared

Keywords: Biodegradable plastic, olive branch prunings, organic farming, pepper (*Capsicum annuum* L.), weed suppression