

1 **PHYSIOLOGICAL RESPONSES OF WEEDS**
2 **SUBJECTED TO BLACK PLASTIC MULCHING, AN**
3 **ALTERNATIVE PREPLANT WEED CONTROL**

4 **Running head: Black plastic mulch as an alternative non-chemical preplant**
5 **weed control**

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17 **Abstract**

18 **Weed is a crucial problem in agricultural system, as well as the non-cropland**
19 **region. Enormous amount of herbicides has been used to control weeds, causing**
20 **environmental, health and herbicide resistance problems. Mulching has been used**
21 **as an alternative non- chemical weed controls. Plastic mulching has been**
22 **commonly used as a covering material throughout the growing season. However,**
23 **there is no report of using the black plastic mulching as a preplant weed control.**
24 **In this study, we therefore evaluating the potential of 3 types of black plastic**
25 **mulching as a preplant weed control. The evaluation was based on the**
26 **physiological responses of weeds subjected to different types of the mulches, the**
27 **weed controlling ability 1-month after mulching, and soil parameters. The results**
28 **were indicated that black plastic film and the black woven plastic were the most**
29 **effective plastic mulches for preplant weed control. After mulching for 4 weeks,**
30 **the plastics were removed, weed density were collected. At 30-day after mulch**
31 **removal, the plots subjected to the black plastic film and the black woven plastic**
32 **had a significant lower weed density of only 5.1 g DW m⁻² and 51.1 g DW m⁻²,**
33 **which were 1.4% and 14% of the control (no mulching), respectively. The**
34 **controlling effects was mainly due to the inhibition of weed photosynthesis,**
35 **transpiration and the degradation of chlorophyll, without any changes in soil**
36 **properties. As an preplant non-chemical weed control, black plastic mulching still**
37 **need the evaluation in various soil condition and weed population.**

Keywords: weeds, plastic mulch, physical weed control, non-chemical weed control

Introduction

Weeds are undesirable plants growing in an area. Many weeds are capable of rapid growth and reproduction. Weeds often cause yield losses in crop field and other negative effects i.e., itchiness and habitats for pests and poisonous animals (Chauhan, 2020). Weeds also possess the high variation, leading to the difficulty in controlling. Chemical weed management methods are widely used because they are quick and effective to destroy weeds, as well as more cost effective (Zhang, 2003). The inappropriate herbicide usage led to the environmental toxicity, health problems, herbicide resistance weeds, and the residues in the soil (Damalas and Eleftherohorinos, 2011). Preplant weed control were mostly depended on the combination of mechanical methods, like tillage, and uses of herbicides, such as paraquat, glyphosate, dicamba, atrazine 2,4-D and diuron (Ikley, 2020). The safety and side effects of these herbicides are remained controversial in many countries around the world (Mallory-Smith and Roma-Burgos, 2020).

The alternative non-chemical weed control recently gets more attention. Plastic mulches are widely used because of its ability of maintaining soil moisture, prevent weed growth and soil degradation from inclement weather (Qin et al., 2018). Moreover,

plastic cover reduced labor cost in weed controls and the use of chemical herbicides, as well as increased soil temperatures in cold countries (Schonbeck and Evanylo, 1998). However, the soil temperature increment by black plastic film is less than white plastic film because of its lower light transmission and heat radiation trapped under the plastic sheet (Moreno and Moreno, 2008). To our knowledge, the black plastic mulch promoted the germination and productivity of crop plants such as potato, maize, muskmelons, watermelons, eggplants and tomatoes (El-metwally and El-wakeel, 2019; Lament, 1993; Qin et al. , 2018). All the studies on black plastic mulches were based on their efficacies in weed controls during growing seasons and the productivity of crop plants under those mulching. Interestingly, using the plastic mulches as the preplant weed control, together with the physiological responses of weeds during mulching, has been under the attention. However, the price of each type of plastic mulch is also another factors on farmer's technological implementation. Therefore, the purpose of this study is to evaluate the efficiency of different types of plastic mulches for pre-planting weed control and the physiological response of weeds to identify the most effective plastic mulch in cost and controlling ability in preplant weed controls.

Materials and Methods

The experiment was conducted at the organic farm, Suranaree University of Technology between July - September 2020. The experimental plots were placed near the water reservoir where the soil moisture content is high year-round. Three types of plastic used in this experiment were 1) Sun shade net that can filter the light up to 50%, the main material is PE, and cost ~5 Baht/m² (SH-02, Fonte, Thailand); 2) Black woven plastic sheet that can filter the light more than 99%, the main material is PE, and cost ~24 Baht/m² (99, Thailand); 3) Black plastic film with high flexibility but low water infiltration, and cost ~2 Baht/m² (marine fish, Thailand).

The experimental design was RCBD with 4 treatments: 1) Control (no mulch), 2) Sun shade net, 3) Black woven plastic sheet, and 4) Black plastic film with 3 biological replications (plots). In each plot, each plastic sheet was cut in to the size of 1x 2 m² and bound to the ground with wood sticks at the corners of the rectangles. Before the experiment, 9 species of weeds were found in the area as shown in Table 1. Each type of plastic sheet was placed in the selected area, kept each treatment 50 cm apart, with random order of treatments in each replication. Before mulching and every week during mulching, the physiological responses were collected. Soil parameters were also recorded on the day of the plastic removal.

Physiological response of weeds

The net photosynthetic rate, stomatal conductance, and transpiration rate were measured from 10.00 am – 1.00 pm, when the average light intensity was 1,335 $\mu\text{mol m}^{-2} \text{s}^{-1}$, using ADC photosynthesis meter, model LCI-5 (Bio Scientific, UK). The measurements were randomly measured on 3 waterkanon (*Ruellia tuberosa* L.) plants per replicate. The waterkanon was chosen due to its large leaf, which was more convenient to measure by the photosynthesis meter. The SPAD values were also collected with Leaf Green meter, model SPAD 502 (Konica Minolta, JAPAN), together with the other parameters from the photosynthesis meter.

Soil parameter measurement

Soil temperature was measured using a digital thermometer, model 4180CC (Traceable® Products, U.S.A) equipped with the TP-K02 probe at the depth of 5 cm from soil surface. The soil moisture content was measured by moisture meter, model HH2 (Delta-T Device, UK), acquiring data in the unit of percent volumetric soil water content (%). Three values were obtained from each plot. After 4 weeks of mulching, the top 15 - 20 cm of soil profiles in each plot were collected for electrical conductivity (EC) and pH measurements.

Soil samples were dried indoors until they can be ground and sieved through a 2 mm soil sieve. Soil samples were weighed 10 g, add 90 mL of distilled water, placed into a

114 plastic bottle and shook at 160 rpm for 30 minutes. The soil solutions were retrieved
115 from the bottles and measured with an EC/ pH meter (WTW, inoLab, Germany).

116

117 **Weed density**

118 Weed densities were randomly collected from the middle part of the plots with a 50 x
119 50 cm² quadrat. One sampling per plot. All samples were dried at 70 degree Celsius.
120 Dry weight of each sample was used to calculate weed density, which are reported in
121 the unit of g DW m⁻².

122

123 **Statistical analysis**

124 The data were analyzed by one-way ANOVA and Duncan's test at the 95%
125 confidence level ($P \leq 0.05$) using the SPSS 14.0 program for Windows.

126

127 **Results and Discussion**

128 **Physiological response of weeds**

129 Plastic mulches directly control weeds by reducing the amount of light
130 transmitted to weeds (Bitomský et al., 2018), led to the reduction in photosynthetic rate
131 (Niu et al., 2019). This notion supported the continuously decrease in photosynthetic
132 rate from before mulching until 4-week after mulching (Figure 2a). Different types of
133 the mulches gave the different physiological response of weeds with high correlation

134 the light penetration efficiency. From our preliminary results, the double-layer of sun
 135 shade net let light pass only 4.3% (only $54 \mu\text{mol m}^{-2} \text{s}^{-1}$ from full sun light of $1,335$
 136 $\mu\text{mol m}^{-2} \text{s}^{-1}$), but the black woven plastic and the black plastic film let the light pass
 137 only 0.5 and 0.4%, respectively (Figure 1). Surprisingly, only about $54 \mu\text{mol m}^{-2} \text{s}^{-1}$
 138 was enough to maintain the leaf greenness (Figure 2d) and slightly reduced the
 139 photosynthetic rate at $1355 \mu\text{mol m}^{-2} \text{s}^{-1}$, with no significant difference from that of the
 140 control. This might implied that the weeds would be killed only when there is light less
 141 than 1 percent and it needed at least 3 weeks to let the photosynthesis to be fully
 142 inhibited (Figure 2a). The black woven plastic and black plastic film were the fastest
 143 and most effective mulch to reduce weed photosynthesis and inhibit weed growth
 144 (Figure 3 and 4). El-metwally and El-wakeel (2019) also found that the black plastic
 145 mulching was more effective than the organic mulches, herbicide, and hoeing.
 146 Moreover, the reduction in photosynthetic rate may result from carbon dioxide shortage
 147 from the effect of stomata closure (the decrease in stomatal conductance; Figure 2b)
 148 and the lack of high energy compounds, resulting from light limitation (Hidayati and
 149 Anas, 2016). The lower stomatal conductance also caused less transpiration (Figure
 150 2c), which might benefit the soil water conversation in some circumstances.

151 To evaluate the persistence of controlling effects, after 4-week mulching the
 152 plastics were removed, allowing the remaining of weeds to expose to the light. Thirty
 153 days after the plastic removal, weeds can grow again at the different density in all
 154 treatments (Figure 3 and 4). Weed density after 30 days of the mulching with the black
 155 woven plastic and black plastic film revealed the significant lower weed density,

156 compared to the control and sun shade net (Figure 3 and 4). The weed species collected
 157 from each treatment were identified. The finger grass, creeping panicgrass and
 158 waterkanon, which are the dominant species in the area, were able to emerge and grow
 159 in all treatments (Table 2). At the end of mulching, there is no alive weed under black
 160 woven plastic and black plastic film (Figure 4), but after 30 days of the plastic removal
 161 some small weed seedling were found. This might be due to the fact that plastic
 162 mulches usually destroy only the meristems, leaves and roots of weeds, but were unable
 163 to damage seeds (Mashingaidze et al., 1996). The new seedlings can germinate from
 164 the seed accumulated in the soil or dispersed from the nearby weeds when obtaining
 165 the appropriate light, temperature, and moisture (Mashingaidze et al., 1996).

166

167 **Soil parameters**

168 The pH of soil in each treatment were between 7-8, soil conductivity and soil
 169 moisture were between 110 – 152 $\mu\text{S cm}^{-1}$, soil temperature for all treatments was
 170 between 33 - 29°C, and soil moisture content were between 13-15%. There was no
 171 significant difference among treatments on all measured soil parameters (Fig. 5a, b, c
 172 and d, respectively). Haque et al. (2018) also found that the black plastic mulch does
 173 usually not alter soil temperature and soil pH. In the coastal area, black plastic mulch
 174 reduce water evaporation, led to the lower soil EC (Haque et al., 2018), while in our
 175 experimental area, there was no sign of the salinity problem ($\text{EC} < 4 \text{ dS m}^{-1}$), so the
 176 EC was not affected by mulching. These findings supported our notion that the

177 inhibition effects were directly from the insufficient light, without any effect from the
178 alteration of soil properties.

179 Although the black plastic is expensive, with the method of application as
180 demonstrated in this study and the durability of the plastics per se, the plastic can be
181 reused many times, which potentially costs less than labor cost for manual and chemical
182 weed control (Vavrina and Roka, 2000). Moreover, black plastic mulches can be used
183 as a preplant weed control in the places that chemical are prohibited, like in organic
184 farming, the lands with severe herbicide resistance weeds, or other areas aim to reduce
185 the use of herbicides. From economic stand point, the black plastic film would be the
186 most appropriate mulching material for preplant weed control due to its affordable cost
187 of only ~2 Baht/m², and the most effective controlling ability (Fig.3).

188 **Conclusion**

189 Black plastic film was the most effective mulch that can be used as an
190 alternative method for preplant weed. The mechanism of weed control was directly
191 through the light limitation, without any alteration in soil properties. The duration of
192 mulching need to be until the target weeds were completely dead (with no
193 photosynthetic activity), which may different among weed species.

194

195

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 199 to maintaining the experimental plots and identifying weed species found in the
 200 experimental area.

201

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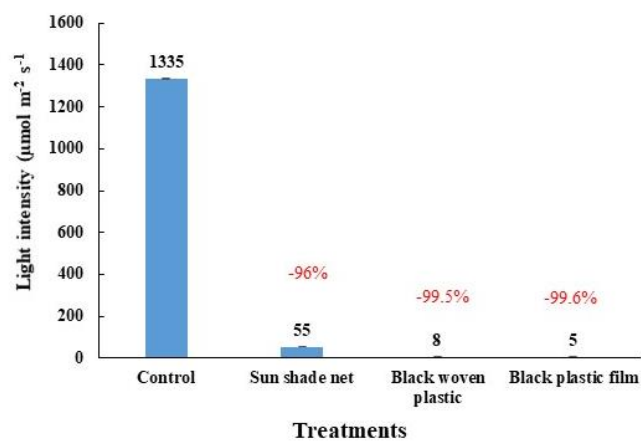
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Table 1 Weed species in the experimental area

ชื่อสามัญ	Common name	Scientific name	Family	Weed type	Life cycle
หญ้าคา	Blady grass	<i>Imperata cylindrica</i> (L.) Raeusch	Poaceae	Narrowleaf	Perennial
หญ้าชันกาด	Creeping panicgrass	<i>Panicum repens</i> L.	Poaceae	Narrowleaf	Perennial
หญ้าปากควาย	Crowfoot grass	<i>Dactyloctenium aegyptium</i> (L.) P. Beauv.	Poaceae	Narrowleaf	Annual
หญ้าปล้องข้าวนก	Finger grass	<i>Digitaria adscendens</i>	Gramineae	Narrowleaf	Annual
หญ้าตีนงู	Diannel flower	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	Broadleaf	Annual
หญ้าสตาร์	Star Grass	<i>Cynodon plectostachyus</i>	Poaceae	Narrowleaf	Perennial
ต้อยต่ง	Waterkanon	<i>Ruellia tuberosa</i> Linn	Acanthaceae	Broadleaf	Annual
ตีนตุ๊กแก	Mexican daisy	<i>Tridax procumbens</i> L.	Compositae	Broadleaf	Annual
โง้งหาง	Pygmy groundcherry fruit	<i>Physalis minima</i> Linn	Solanaceae	Broadleaf	Annual



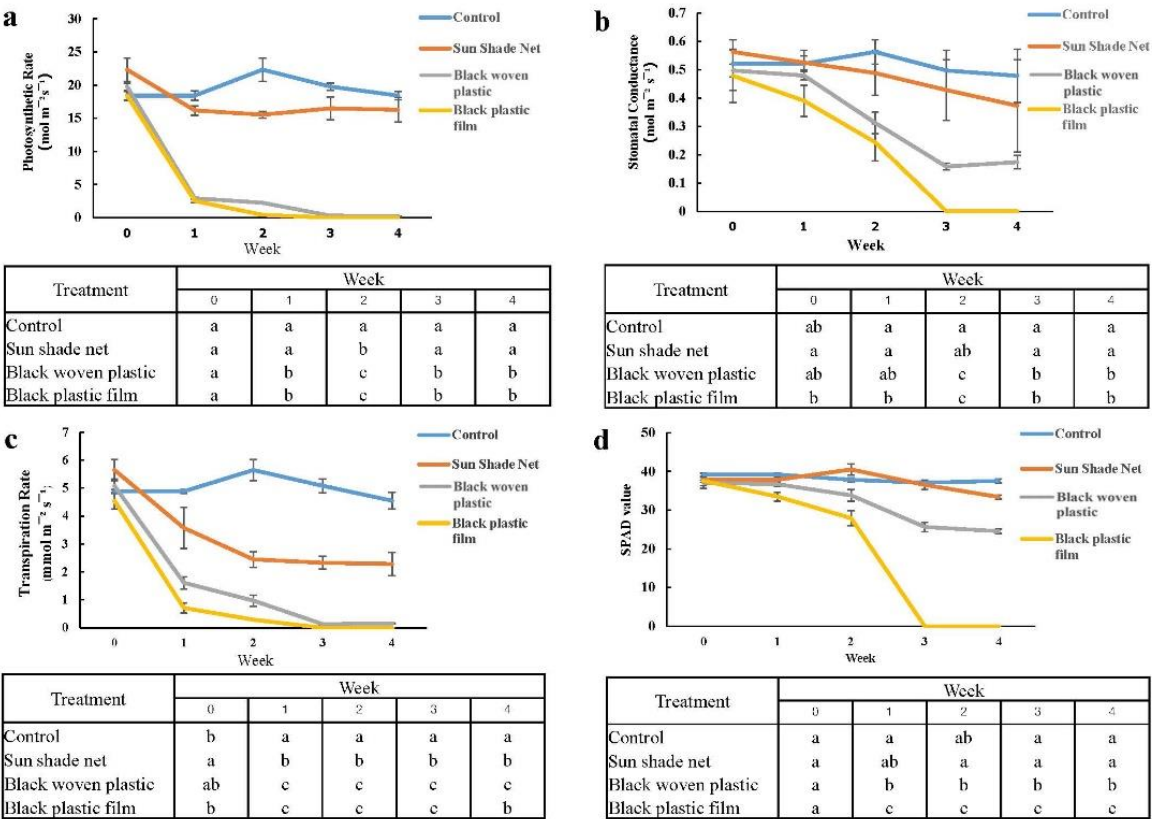
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260 **Figure 1.** Light intensity (Q) measured by the light sensor on the photosynthesis meter. Values
 261 are the Mean $\pm$ SE (n= 3). The red letters on the bars are the percent reduction of light intensity,
 262 compared the full sunlight in the control condition.

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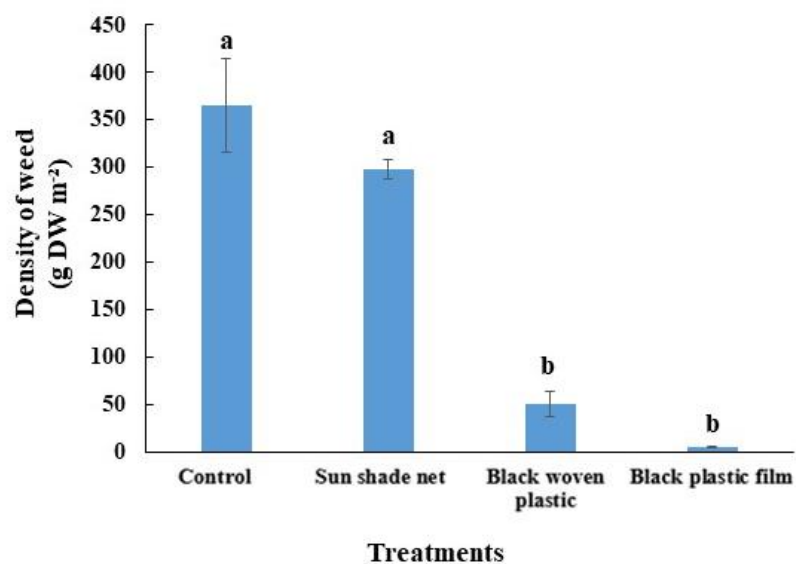
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267 **Figure 2.** Physiological responses: (a) Photosynthetic Rate (b) stomatal conductance (c)
268 transpiration rate (d) leaf greenness of waterkanon (*Ruellia tuberosa* L.) measured weekly
269 under different black plastic mulches. The 0 value in all measurement means there was no more
270 attached leaves to be measured. Values are the Mean $\pm$ SE (n= 3). The different letters in the
271 column indicate significant differences at the 95% confidence level ($P\leq0.05$).

272



273

274 **Figure 3.** Weed density at 30 days after the plastic mulch removal. Values are the Mean $\pm$ SE
 275 (n= 3). The different letters above the bar indicate significant differences at the 95% confidence
 276 level ($P \leq 0.05$).

277



Figure 4. The weekly changes of weed coverage in each plastic treatment and 30 days after the removal the plastic sheet.

Table 2 Weed species collected from each treatment 1-month after plastic mulch removal

Treatments	ชื่อสามัญ	Common name	Scientific name	Family	Weed type	Life cycle
Control	หญ้าชันกาด	Creeping panicgrass	<i>Panicum repens</i> L.	Poaceae	Narrowleaf	Perennial
	หญ้าปล้องจ้าววนก	Finger grass	<i>Digitaria adscendens</i>	Gramineae	Narrowleaf	Annual
	หญ้าเส้นงู	Diannel flower	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	Broadleaf	Annual
	หญ้าศุกร์	Star Grass	<i>Cynodon plectostachyus</i>	Poaceae	Narrowleaf	Perennial
	ตีนตุ๊กแก	Mexican daisy	<i>Tridax procumbens</i> L.	Compositae	Broadleaf	Annual
	หญ้าปลั่งควาย	Crowfoot grass	<i>Dactyloctenium aegyptium</i> (L.) P. Beauv.	Poaceae	Narrowleaf	Annual
	ค้อยคิง	Waterkanon	<i>Ruellia tuberosa</i> Linn.	Acanthaceae	Broadleaf	Annual
	หญ้าเลา	Blady grass	<i>Imperata cylindrica</i> (L.) Raeusch.	Poaceae	Narrowleaf	Perennial
Sun shade net	หญ้าชันกาด	Creeping panicgrass	<i>Panicum repens</i> L.	Poaceae	Narrowleaf	Perennial
	หญ้าปล้องจ้าววนก	Finger grass	<i>Digitaria adscendens</i>	Gramineae	Narrowleaf	Annual
	ค้อยคิง	Waterkanon	<i>Ruellia tuberosa</i> Linn.	Acanthaceae	Broadleaf	Annual
	หญ้าปล้องจ้าววนก	Finger grass	<i>Digitaria adscendens</i>	Gramineae	Narrowleaf	Annual
Black woven plastic	หญ้าเส้นงู	Diannel flower	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	Broadleaf	Annual
	หญ้าศุกร์	Star Grass	<i>Cynodon plectostachyus</i>	Poaceae	Narrowleaf	Perennial
	หญ้าเลา	Blady grass	<i>Imperata cylindrica</i> (L.) Raeusch.	Poaceae	Narrowleaf	Perennial
	ค้อยคิง	Waterkanon	<i>Ruellia tuberosa</i> Linn.	Acanthaceae	Broadleaf	Annual
	โสมเทพ	Pygmy groundcherry fruit	<i>Physalis minima</i> Linn.	Solanaceae	Broadleaf	Annual
	หญ้าชันกาด	Creeping panicgrass	<i>Panicum repens</i> L.	Poaceae	Narrowleaf	Perennial
	หญ้าปล้องจ้าววนก	Finger grass	<i>Digitaria adscendens</i>	Gramineae	Narrowleaf	Annual
Black plastic film	ค้อยคิง	Waterkanon	<i>Ruellia tuberosa</i> Linn.	Acanthaceae	Broadleaf	Annual

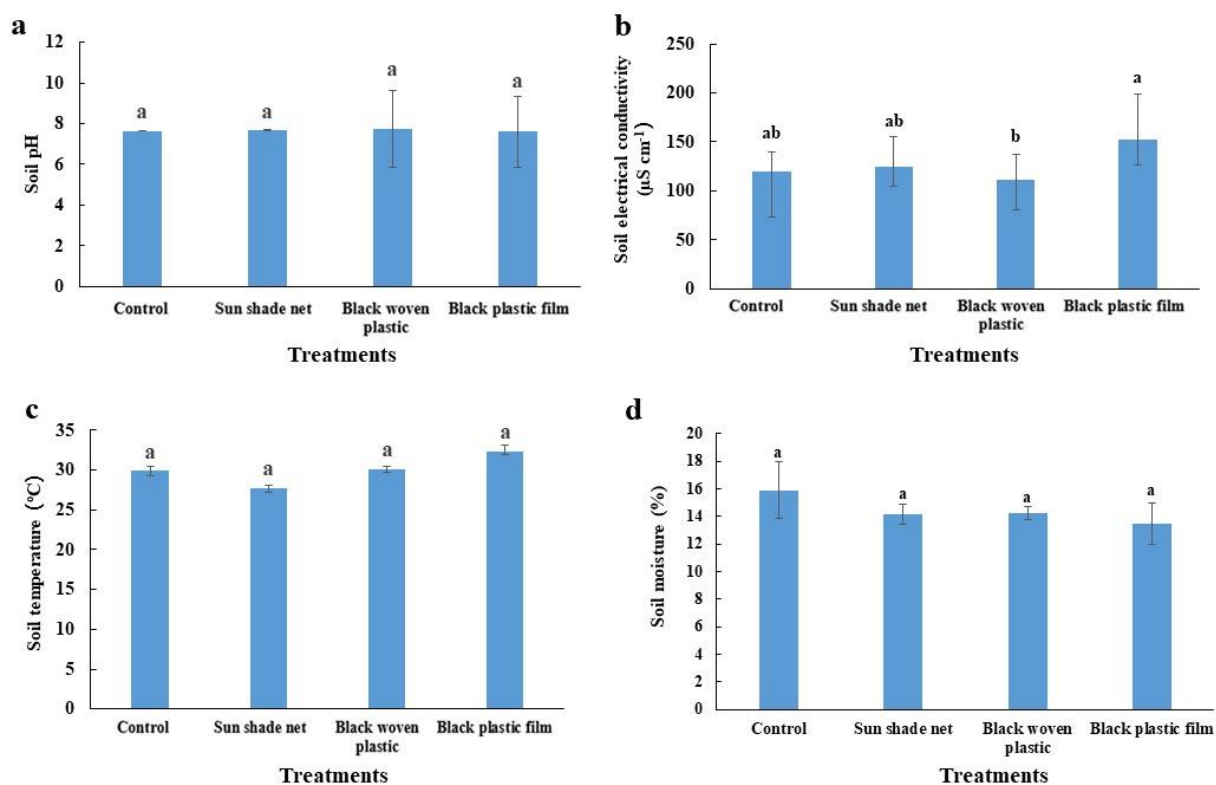


Figure 5. Soil properties (a) soil pH (b) soil electrical conductivity (c) soil temperature (d) soil moisture after each type of plastic mulching. Values are the Mean $\pm$ SE (n= 3). The different letters above the bar indicate significant differences at the 95% confidence level ($P \leq 0.05$).