Technology package of land preparation with solarization and biofertilizer on chili

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Abstract. Intensive land use without regard to soil fertility and health can reduce crop productivity. The purpose of this research was to compare yields of various packages of land preparation technology that can support soil fertility and health. The study was conducted in Cianjur Regency, West Java, Indonesia from June until November 2019. The study used a randomized block design with four treatments and six replications. The technology packages tested were the solarization of mulch installation, the use of biofertilizers, and chemical fumigation. Data were analysed by analysis of variance and followed by Duncan's test at the 95% confidence level. The results showed that there was no difference in fruit weight and number of fruits per plant, as well as weight per fruit in all treatments. However, the treatment of delaying planting for two weeks after mulch installation and the use of biofertilizer has the potential to be studied further because they were significant at several harvests. The weight per plant was 30.34-46.67 g higher than other treatments at the 4th harvest, the number of fruits was 3.2-11.67 higher at the 3-4th harvest, and the weight per fruit was 0.31-0.65 higher in the 2nd-5th harvest.

1 Introduction

Chili is not a staple food but the need for this spice cannot be replaced by other food sources [1]. This is what makes chili economically very profitable and requires an increase in productivity, especially for countries that are in the economic recovery phase after the covid-19 outbreak, such as Indonesia. Indonesia was ranked fourth in the world for chili production after China, Mexico and Turkey which was reached 20.42 t ha^{-1} [2]. This number has the potential grow if the production problems can be solved properly. Several obstacles, such as decreasing soil fertility [3] and disease infestation [4] cannot be overcome by applying excessive chemical fertilizers and synthetic pesticides commonly used by farmers, since they actually damage soil condition and the balance of nature [5]. Biological agents and solarization are considered as a solution to these problems. However, not many farmers in Indonesia are aware of these two alternative solutions. This research can give the comparison between the chili yield obtained by farmer's usual method and by the application of solarization and biofertilizer. Therefore, the purpose of this study was to compare yields of

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various packages of land preparation technology, including the application of solarization and biofertilizer.

Soil solarization is a soil heating technique by covering the soil with mulch, so that solar heat radiation is trapped in the soil [6]. This technique is useful for controlling soil-borne diseases so as to increase growth, harvest, and quality of agricultural crops [6]. Its ability to increase soil productivity is due to its synergistic nature with organic fertilizers that can help increase crop yields [7] increasing soil organic matter, releasing allelopathic mixtures, and increasing nutrients availability by increasing the amount of microorganism in the soil rhizosphere [7]. Soil solarization will only kill pathogens but not their antagonists, thereby increasing the systemic resistance of plants and save for the environment [8].

Two biological agents capable of suppressing soil-borne pathogens are *Gliocladium* sp. and *Trichoderma* sp. Both are able to suppress *Fusarium* and increasing plant growth on chrysanthemums [9] and garlic [10]. *Gliocladium* sp. also known to increase the yield of several shallot varieties [11] and suppress plant diseases caused by other pathogens, such as, *Pythium* sp., *Ganoderma boninense*, *Ralstonia solanacearum*, and *Rhizoctonia solani* in horticultural crops [8]. *Gliocladium* sp. available in the form of a biological fungicide issued by the Indonesian Ornamental Plants Research Institute under the trade name *Gliocompost*. The advantages of this *Gliocompost* can be combined with chemical fertilizers and other fungicides for better results [12]. *Trichoderma* sp. reported to be more effective on reducing disease caused by *Phytium* sp. compared to *Gliocladium* [13]. It can also delay the infestation of potato blight [14]. The sinergism of these two biofertilizers was reported to be able to supress *Fusarium* on shallots [15]. Therefore, this research is expected to provide the same benefits to chili when combined with land preparation.

2 Materials and methods

The study was conducted in Cianjur Regency, West Java, Indonesia from June until November 2019 at -6.8461, 107.01293, 1200,0 m, 339. The research soil was characterized by moderate acidity (pH 5.6), very high of organic C (6.5%), high total N (0,6%), moderate of CN ratio (10,8), moderate K (35,7 mg/100g), and very high of P (431 ppm).

Experimental plot was a randomized block design with four technology packages and six replications. The technology packages tested were the solarization of mulch installation, the use of biofertilizers and chemical fumigation (Table 1).

Table 1. The component of technology packages of treatments.

Treatments	A	B	C	D
Solarization of mulch installation	No	Yes, two weeks by silver black plastic	Yes, two weeks by transparent plastic	No
Biofertilizer	No	*Trichoderma* *Gliocompost*	*Trichoderma* *Gliocompost*	- *Gliocompost*
Chemical fumigation	No	No	No	Basamide

The size of the beds used in this study was about 90-100 cm with a spacing of 30-40 cm. Silver black mulch was used to cover the beds with black on the inside and silver on the outside of the beds. Treatments of A and D were without solarization, so that after mulch was installed, the mulch was perforated and then chili seeds were planted immediately without any time lag. *Trichoderma* was sprayed onto the land to achieve water field capacity and then mulched for at least two weeks in the solarization treatment (treatments B and C). For this solarization treatment, the cover layer in treatment B used silver, black mulch and in treatment C used transparent plastic with a thickness 0,3 mm. For treatment B, the mulch could be perforated immediately after two weeks of solarization, but for treatment C, the transparent plastic was removed and replaced with silver black mulch. In this solarization treatment (B and C), 10 g of *Gliocompost* per hole was applied with 5 kg per 200 kg of manure covering an area of 1 ha. For chemical treatment D, 200-300 g/m^2 basamide was used before mulching and then *Gliocompost* was applied after mulch perforating.

The chili variety used in this study was Kencana. Fertilizer was given as much as 25 tons ha^{-1} of manure and 1.25 tons of NPK (16:16:16) at the time of land cultivation. Supplementary chemical fertilizer was given after one month of planting by 5 kg NPK per 200 L with 200 ml per hole at 1, 2, and 3 months after planting. Methyl eugenol traps were installed to control fruit fly pests, when the plants began to flower. Pesticides were only applied after the pest exceeds the economic control threshold. The first harvest was carried out more than 75 days after planting, after the fruit were fully ripe. The second and subsequent ones was carried out every 5-7 days after the previous harvest. Each harvest was done in sunny weather, by carefully picking chili.

Yield components were measured by fruit weight per plant, number of fruits per plant and weight per fruit. Twenty-five plants for each treatment were sampled. The data were then analyzed by analysis of variance and followed by Duncan's test at the 95% confidence level.

3 Results and discussions

The differences in technology packages did not affect the total fruit weight per plant, the total number of fruits per plant and weight per fruit of chili (Table 2). This showed that the different types of solarization, the application of biofertilizer or chemical fumigation did not affect the chili harvest components, although treatments of B and C seemed superior. Land preparation treatments such as the type of mulch cover for solarization and the application of biofertilizer or chemical fumigation gave varied effects, resulting in a fairly high coefficient of variance, so we did logarithmic transformation of the data (Table 2). This high data variation took time to prove it by an annual data series. It took at least three consecutive years to obtain conclusive data on the effect of solarization [16] and biofertilizers [17] on crop, due to the long-term effects of these two technology components. The impact on soil fertility and health will be more visible in the next growing seasons.

Table 2. Total of fruit weight total per plant, number of fruit total per plant and weight per fruit of chili

Treatments*	Fruit weight total per plant (g)	Number of fruit total per plant	Weight per fruit (g)
A	313.60	89.64	11.71
B	341.88	105.08	12.74
C	348.44	100.00	13.28
D	324.32	99.52	12.74
CV (%) **	(24.95)	(23.46)	(25.77)

Notes: *
A: Without solarization and without biofertilizer, B: Solarization with silver black plastic and biofertilizer (*Trichoderma* and *Gliocompost*), C: Solarization with transparent plastic and biofertilizer (*Trichoderma* and *Gliocompost)*, D: Without solarization but with basamide and *Gliocompost*
** the numbers in brackets have been transformed logarithmically

Solarization had a long-term effect on the availability of beneficial microorganisms and suppressed pathogens and weeds. Soil bacterial communities were found to accumulate in solarized soils, thereby increasing the impact on eggplant and wheat growth [18]. Within a year, solarization could reduce soil resistance to *Fusarium oxysporum* but after that, its

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combination with compost could support the opposite in melons [19]. Repeated solarization loops combined with bio fumigation could also suppress soil-borne pathogens and weeds, and lead to increased tomatoes yield [20]. It took two weeks for each solarization season to produce an adequate temperature profile to inactivate various pathogens [21].

Biofertilizers play a very important role in improving soil fertility by fixing N balance in the soil, increasing the number of micro-organism, and accelerating microbial processes which important for the availability of plants nutrient. Its use in the long-term use was not only eco-friendly, but more efficient and productive [22]. The use of biofertilizer for nine season of rice production has increased the availability of N and P in the soil, better than the use of chemical fertilizer [23].

To explore further, observations were made for each variable at each harvest (Tabel 3). Treatment of B was significantly different from treatment of A and D at the fourth harvest for fruit weight per plant, at the third and fourth harvest for the number of fruits per plant and at the second harvest for the weight per fruit. Meanwhile, treatment C was almost always the same as treatment B, even better for the weight per fruit at the fourth and fifth harvests. This showed that the combination of solarization and biofertilizer treatment could increase fruit weight and number of fruits at a certain harvest time, especially at peak harvest, at 2nd-5th harvest (Table 3).

Table 3. Fruit weight per plant, number fruit per plant, and weight per fruit of every harvest time of chili.

Treatment*	Harvest						
	1	2	3	4	5	6	7
Fruit weight per plant (g) **							
A	84.60 a	76.00 a	94.50 a	57.00 a	48.40 a	48.80 a	29.40 a
B	70.48 a	97.50 a	114.50 a	94.67 b	51.80 a	49.00 a	29.00 a
C	83.64 a	99.00 a	89.00 a	103.67 b	55.00 a	46.20 a	26.20 a
D	79.52 a	99.00 a	101.50 a	64.33 a	52.00 a	44.20 a	29.80 a
CV (%) ***	(35.17)	(20.91)	29.55	(26.13)	32.01	26.30	26.66
Number of fruits per plant **							
A	15.25 a	27.90 a	32.50 a	21.00 a	18.92 a	20.32 a	12.04 a
B	10.12 a	29.70 a	40.30 b	32.67 b	19.12 a	21.92 a	12.36 a
C	18.60 a	32.40 a	30.80 a	31.53 b	17.76 a	20.24 a	11.72 a
D	19.20 a	36.20 a	37.10 a	23.73 ab	19.52 a	19.68 a	12.32 a
CV (%)	(30.85)	36.46	25.50	(28.78)	28.54	24.17	24.70
Weight per fruit (g) **							
A	4.62 a	2.71 a	2.97 a	2.74 a	2.57 a	2.42 a	2.46 a
B	4.38 a	3.33 b	2.87 a	2.89 ab	2.72 a	2.31 a	2.36 a
C	4.67 a	3.07 ab	2.94 a	3.30 b	3.08 b	2.28 a	2.27 a
D	4.24 a	2.68 a	2.98 a	2.79 a	2.77 a	2.27 a	2.44 a
CV (%)	17.44	19.83	18..69	23.97	20.81	19.57	17.23

Notes: *
A: Without solarization and without biofertilizer, B: Solarization with silver black plastic and biofertilizer (*Trichoderma* and *Gliocompost*), C: Solarization with transparent plastic and biofertilizer (*Trichoderma* and *Gliocompost*), D: Without solarization but with basamide and biofertilizer (*Gliocompost*)
** Numbers following by the same letter are not significant according to Duncan test at 95 % confidence level ($P < 0.05$).
*** the numbers in brackets have been transformed logarithmically

The combination of the use biofertilizers and mulch had also been reported to increase the yield of other crops. There was a study conducted in Bangladesh which comparing the yield components of tomatoes and cauliflower between the practice of mulching and indigenous microorganism (IMO) and the practice of no mulch and no IMO. The results showed that the first practice was higher in yield and gross margins than the second [24]. In Peas, mulch and biofertilizers (*Rhizobium*) had a very good impact on seed germination, the temperature provided by mulch was suitable for growth. The combination of those promoted faster mobilization of photosynthetic components that were essential for the vegetative and reproductive phases of peas [25].

The treatment of biofertilizers, especially the combination of *Trichoderma* and *Gliocompost* was very important in determining the success of this research. This was because treatment D which only used *Gliocompost* had a lower yield component than treatments B and C (Table 3). It meant that Basamide could not replace the role of solarization and *Trichoderma*. Basamide as a biofumigant which was expected to support the provision of land was unsuccessful or Basamide could suppressed soil-borne pathogens, but did not increase plant growth, even had been supported by *Gliocompost*. *Trichoderma* determined not only to work as a biological agent but also as a Plant Growth-Promoting Rhizobacteria (PGPR) [26]. It is also reported that the combination of soil solarization and *Trichoderma* could increase chili production [27].

Treatments B and C were not significantly different. This indicated that the use of different plastic types for solarization had no significant effect on the results of this study since transparent mulch and silver black mulch were only slightly different at number of fruits at third harvest and weight per fruit at fourth harvest. This was presumably because the weather conditions during solarization were quite hot, so that plastic coverings with different types still resulted in high temperatures in the plastic. The best plastic for solarization was by polyethylene, but this was greatly influenced by environmental conditions. Heat in solarization effected over a temperature threshold of about 37 ^{O}C for mesophylic organisms [28].

The superiority of treatments B and C over other treatments was also not evident in the total harvest (Table 1), but it was seen in the second and fifth harvests (Table 3), thus looking trends for every harvest was interesting. The trend line of fruit weight per plant from the first to the seventh harvest was different between treatment B and C and treatment A and D (Fig. 1). The treatment equation B and C tend to be quadratic, while others tend to be more-straight. Further research was needed to confirm this difference, because for other parameters (number of fruits per plant and weight per fruit), the curve shape was similar for all treatments (Figure 2 and 3).

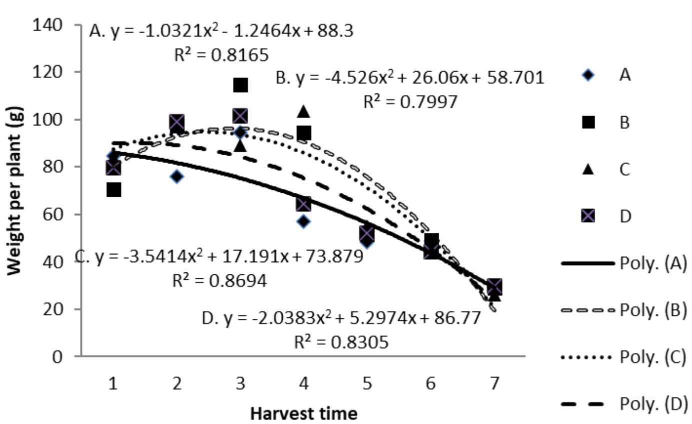

Fig. 1. Fruit weight per plant in seven consecutive harvests of chili

A: Without solarization and without biofertilizer, B: Solarization with silver black plastic and biofertilizer (*Trichoderma* and *Gliocompost*), C: Solarization with transparent plastic and biofertilizer (*Trichoderma* and *Gliocompost)*, D: Without solarization but with basamide and *Gliocompost*.

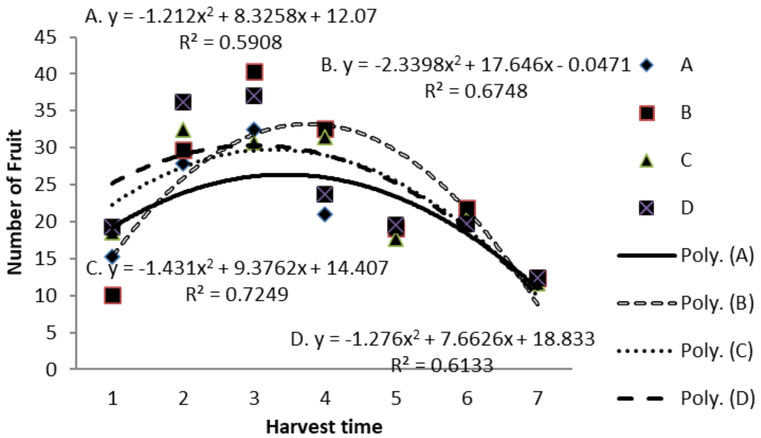

Fig. 2. Fruit per plant in seven consecutive harvests of chili

A: Without solarization and without biofertilizer, B: Solarization with silver black plastic and biofertilizer (*Trichoderma* and *Gliocompost*), C: Solarization with transparent plastic and biofertilizer (*Trichoderma* and *Gliocompost*), D: Without solarization but with basamide and *Gliocompost*.

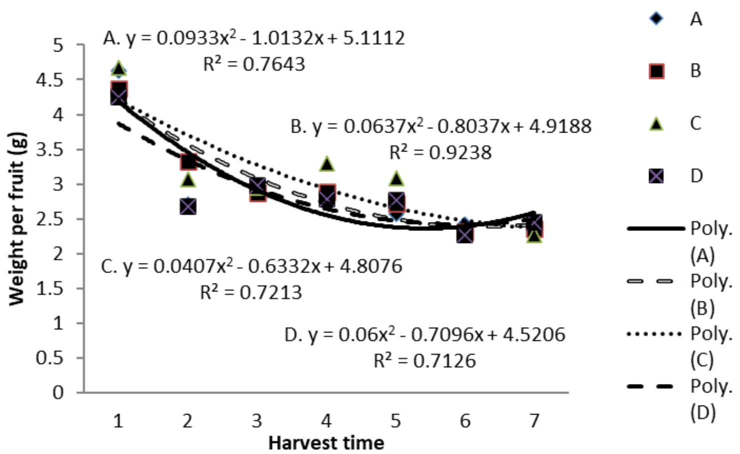

Fig. 3. Weight per fruit in seven consecutive harvests of chili

A : Without solarization and without biofertilizer, B : Solarization with silver black plastic and biofertilizer (*Trichoderma* and *Gliocompost*), C : Solarization with transparent plastic and biofertilizer (*Trichoderma* and *Gliocompost*), D : Without solarization but with basamide and *Gliocompost*.

4 Conclusion

There was no difference in fruit weight and number of fruits per plant, as well as weight per fruit in all treatments. However, the treatment package of delaying planting for two weeks after mulch installation (Solarization) and the use of biofertilizer (*Trichoderma* and *Gliocompost*) had the potential to be studied further because they had highest fruit weight (94.67-103.67), number of fruits per plant (31.53-40.30), and weight per fruit (3.08-3.33) at several harvest. The weight per plant was 30.34-46.67 g higher than other treatments at the

4th harvest, the number of fruits was 3.2-11.67 higher at the 3-4th harvest, and the weight per fruit was 0.31-0.65 higher in the 2nd-5th harvest.

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