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Effects of mulching on weed growth and cucumber yield

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Abstract

Cucumber responses to mulching vary by season, region and mulching material. A field experiment, arranged in a randomized complete block design with four replicates, was established to assess the effect of organic mulches on weed growth and cucumber yield. Treatments consisted of no mulch, palm oil leaf litter mulch, rice husk litter mulch, blady grass litter mulch, coffee husk litter mulch, and black-silvered plastic mulch. Treatment effects were evaluated in terms of the dry weight of weeds (broad and narrow leaf) and yield of cucumber (fruit diameter, fruit length, fruit number plant^{-1}, fruit weight, total fruit weight plot^{-1}and weight of marketable fruits plant^{-1}). Results indicated that the use of mulches effectively reduced weed growth, increased growth and yield of cucumber. The effectiveness of black-silvered plastic, coffee husk litter, rice husk litter, palm oil leaf litter, blady grass litter mulches to control weeds were 98, 68, 58, 56 and 54 %, respectively. Cucumbers grown with mulch had increased fruit diameter, fruit weight, number of fruit plant^{-1}, weight of marketable fruits, and total fruit weight plot^{-1} that were 7, 91, 25, 78, 134, and 78 % higher than those grown without mulch, respectively. These findings provids a valuable technique for cucumber growers in the low altitude of equatorial areas.

Key words*:* Yield of cucumber, weed growth, organic mulch, plastic mulch

Introduction

Low yields of many vegetable crops, including cucumber (*Cucumis sativus* L.) could be attributed to the presence of weeds in the growing areas. Weeds are defined as unwanted plants that grow within the area of cultivated crops which bring about competition with the main crops to access water, nutrients, light and other growing supports as well as serve as host for many insects and pathogens. Such competition eventually reduce growth and yields (quantity and quality) of vegetable crops. Dittmar *et al.* (2018) summarized that yield reduction due to weed suppression on many vegetable crops ranged from 10 to 105 %. In addition, Mandeep *et al.* (2019) specifically reported that weeds brought about economic yield reduction in potato from 6 to 82 %, 25 to 30 % in peas, 70 to 80 % in carrot, 67 % in onion, 42 to 71 % in tomato and 61 % in cauliflower. Previously, Harsono (2012) concluded that weeds also decreased chili pepper yields as much as 80 %. Successful weed control should integrally employ various techniques, including preventive actions, cultural, biological, chemical and mechanical methods. The practice of mulching in vegetable production is a mechanical control strategy to prevent weed growth (Jodaugienė *et al.*, 2006).

Mulching is defined as applying any organic materials and/or synthetic materials to partially or fully cover soil beds (Fahrurrozi, 2018). According to Lamont (2005), mulch modifies the growing environment, especially in the rhizosphere, through conservation of soil moisture, preventions of nutrient leaching and soil compacting, reduction of pest and pathogen attacks and suppressing of weed growth and development. The effectiveness of weed control by mulch application is mostly determined by the type of mulching materials. The use of plastic mulches has been reported as the most effective mulching technique to control weed growth in cucumber production. Bobby *et al.* (2017) concluded that the use of plastic mulches (black-black, black-silver, black-white) was much more effective compared to organic mulches (paddy straw, paddy husk, ground nut shells) on controlling weeds in greenhouse cucumber seedlings. Research conducted by Akbar *et al.* (2014) reported that the use of rice straw mulch and rice husk mulch effectively reduced weed growth in soy bean cultivation and eventually increased crop yields. In addition, Osundare *et al.* (2019) reported that sawdust and wood shaving mulches reduced weed emergences under mulches and eventually increased yield (number of fruits) of cucumber. Such effective weed controls are attributed to the light reduction in the top soil under the mulch which eventually prevent weed growth and reduce germination of weed seeds (Fahrurrozi, 2018; Prasetyo *et al.*, 2014).

The use of mulches for cucumber production were previously reported using many different kinds of mulch materials. Fahrurrozi *et al.* (2010) concluded the use of rice straw and black silvered plastic mulches increased marketable cucumber yields by 44 and 72 %, respectively, compared to those grown without mulch. Research conducted by El-Shaikh and Fouda (2008) found that use of wheat straw, black plastic, transparent plastic and yellow plastic mulches increased yield of cucumber by 67, 109, 129 and 124 %, respectively, compared to no mulched cucumber. Recently, Ekwu *et al.* (2017) found that the use of rice hull produced higher marketable yield of cucumber than those grown with black plastic and white plastic mulches as well as non mulching plots.

With the growing concerns about using agricultural wastes in environmental friendly vegetable production practices, many agricultural wastes could serve as mulching materials. Cucumber responses to mulching effectiveness for modifying the growing environment could vary among seasons and regions. The benefits of agricultural wastes available in the surrounding production areas as a mulching material for cucumber production should be locally evaluated to provide a better growing environment and healthier products. However, relevant research in using local available wastes in the Province of Bengkulu, Indonesia, as mulching materials for cucumber production has been less reported. Results of this experiment will not only particularly benefit cucumber growers in this area, but also in other equatorial growing environments. This research aimed to determine the effect of mulch materials on weed growth and on yield of cucumber.

Materials and method

The experiment was conducted from January to May 2018 in Bengkulu (3°45'55.4" SL 102°18'38.0" EL) at 12 m above sea level on Ultisols and arranged in randomized complete block design with four replications. Treatments consisted of (1) no mulch, (2) rice husk litter mulch, (3) palm oil leaf litter mulch, (4) blady grass litter much, (4) coffee husk litter mulch, and (5) black-silvered plastic mulch.

Before the experimental site was planted with cucumbers, initial analysis of vegetation was conducted using squares method in each block and sampled five times. It was concluded that *Asystasia intrusa*, a broad leaf weed species, had the highest Summed Dominance Ratio (SDR). The comparison among the site replications in terms of community coefficient was I:II=79 %, I:III=82 %, I:IV=79 %, II:III=79 %, II:IV=75 %, and III:IV=81 %. Since the community coefficient in each replication was higher than 75 %, it was concluded that weed communities in the sampling site were homogenous and in highest succession level (Spurr, 1964). This site was, therefore, representative for the weed control experiment.

The experimental site was cleared, ploughed, harrowed, and fertilized with cattle manure compost (10 tons ha^{-1}). After a month of field incubation, 20 soil-beds of 1 m (width) x 4 m (length) x 0.15 m (height) were established. Each soil-bed was separated by 0.5 m within the block and 1 m between the blocks. One day before seed planting, organic mulches with 5 cm thickness were applied accordingly to cover the surface of soil beds. Plastic mulch was stretched over the soil beds and secured into the soil at the both end-edges of soil beds and pinched with bamboo sticks along the soil beds.

Cucumber seedlings (*cv*. Bandana F1) were directly transplanted into the soil beds at the planting holes at 2-3 cm depth and covered with top soil. Two cucumber seeds were planted in each planting hole and the worse plant was removed at three days after planting. Plant spacing was 0.6 x 0.5 m, arranged in double row planting, to make a total of 18 plants in each soil bed. Each planting hole was applied with 5 pieces of Furadan 3G, and fertilized with 100 kg ha^{-1} N, 72 kg ha^{-1} P_2O_5 and 120 kg ha^{-1} K_2O. At three weeks after planting, an additional 60 kg ha^{-1} N was applied. Fertilizers were applied next to planting holes and covered back with top soil and mulches.

Bamboo stakes (2 m height) were vertically installed at seven days after planting next to the planting holes and the top of the stake was connected with other stakes by using raffia. When there were no precipitations took place, cucumbers were manually irrigated every other two-day until the soil reached field capacity. Weeds were not controlled, but insects were chemically controlled by using insecticides (active compound of deltametrin 25 g L^{-1}, dosages of 4 mL L^{-1} and fungi were controlled by using fungicides (active compound propinep 70 %), dosages of 4 g L^{-1}. Before application, pesticides were mixed with surfactant (active compound alkilaril polyoksietelien glikol 440 g L^{-1} and alkilaril polyglicol ester 400 g L^{-1}.

Cucumbers were harvested (total harvests of five times), when fruits had a uniform color of whitish green, every five days by cutting the fruit stalks with the scissor. Treatment effects on weed growth were measured in terms of weed dry weight of broad leaf weeds and dry weight of narrow leaf weeds $plot^{-1}$. The effect of treatments on cucumber yield was observed on five sample plants in terms of fruit diameter, fruit length, fruit weight, number of fruit $plant^{-1}$, total fruit weight $plot^{-1}$ and weight of marketable fruits. Additional data on soil moisture and soil temperatures were also collected. Data were subjected to a homogenous test and then analyzed by using the Statistical Analysis System at $P<0.05$. Means of treatment effects were compared using Duncan's Multiple Range Test at $P<0.05$.

Results and discussion

Environmental condition: The average monthly rainfall during the experiment (March 10th to May 11th) as recorded in Meteorology, Climatology, and Geophysical Agency Bengkulu was 255 mm. This amount is considered sufficient since the water requirement for successful cucumber growing ranges from 200 to 400 mm $month^{-1}$. The average soil moisture contents under the treatments of no mulch was significantly lower than those of under rice husk litter mulch, palm oil leaf litter, blady grass litter, coffee husk litter, and black-silvered plastic mulches (Table 1). Meanwhile, the effect of mulches on average minimum and maximum soil temperatures during the experiment varied among the treatments.

Table 1. Effects of mulches on soil moisture, minimum and maximum soil temperature

Type of mulche	Soil moisture (%)	Minimum temperature (°C)	Maximum temperature (°C)
No mulch	28.75 d	28.40 d	32. 07 b
Rice husk litter	35.22 ab	29.01 c	30.43 c
Palm oil leaf litter	34.69 b	27.75 d	29.15 d
Blady grass litter	34.73 b	28.12 d	29.59 d
Coffee husk litter	37.44 a	29.78 b	31.46 b
Black-silvered plastic	31.42 c	31.23 a	33.56 a

Means of treatments in the same column followed by the same letter are not significantly different according to Duncan's Multiple Range Test at $P<0.05$.

The presence of mulches on soil surface increased soil moisture content under the mulches by preventing soil evaporation, returning the moisture back to the soil environment (Lamont, 2005). The use of organic mulches shortened the gap between minimum and maximum soil temperature. Soil temperature under plastic mulch was higher maximum temperatures compare to other treatments. Such effects on soil temperatures were related to the ability of mulch materials to create 'greenhouse effect' under the mulches.

Effects on weed growth: Results indicated that the use of mulches effectively controlled weed growth in cucumber plots. The presence of broad leaf weeds was very much higher than narrow leaf weeds. The effects of mulches on weed growth are presented in Fig. 1. It appeared that black-silvered plastic mulch was most effective in controlling broad leaf weeds, followed by organic mulches (coffee husk litter, palm oil leaf litter, blady grass litter and rice husk litter) and no mulch. The average reduction of broad leaf weeds due to mulch application was 68.2 % lower than weeds in the unmulched plots. The effectiveness of plastic mulch to control weeds in vegetable production is extensively reported (Schonbeck, 1998; Mahajan *et al.*, 2007). Such reduction was related to blockage of sun light by mulch surfaces into the soil environment under the plastic mulch, resulted in the prevention of weed germination and or very poor growth of weeds due to lack of sun light in the soil environment (Fahrurrozi, 2018). In addition, the interaction of high soil temperatures and high moisture are more harmful to young weeds since wet heat has more killing effects than dry heat. Further analysis on the ability of each mulching material to suppress weed growth compared to non-mulched plots indicated that the effectiveness of black-silvered plastic, coffee husk litter, rice husk litter, palm oil leaf litter, blady grass litter mulches were 98, 68, 58, 56 and 54 %, respectively.

Results also suggested that the use of mulches were more effective in suppressing narrow leaf weeds than broad leaf weeds. On a dry weight basis, the total weight of narrow leaf weeds in all cucumber plots was 485.39 g, while total weight of the broad leaf weeds was 6005.19 g. However, not all mulches effectively controlled growth of narrow leaf weeds in cucumber plots. Black plastic mulch was the most effective to control narrow leaf weeds, followed by rice husk litter and coffee husk litter mulches. Both blady grass litter and palm oil leaf litter mulches were less effective in controlling narrow leaf weeds than other mulches.

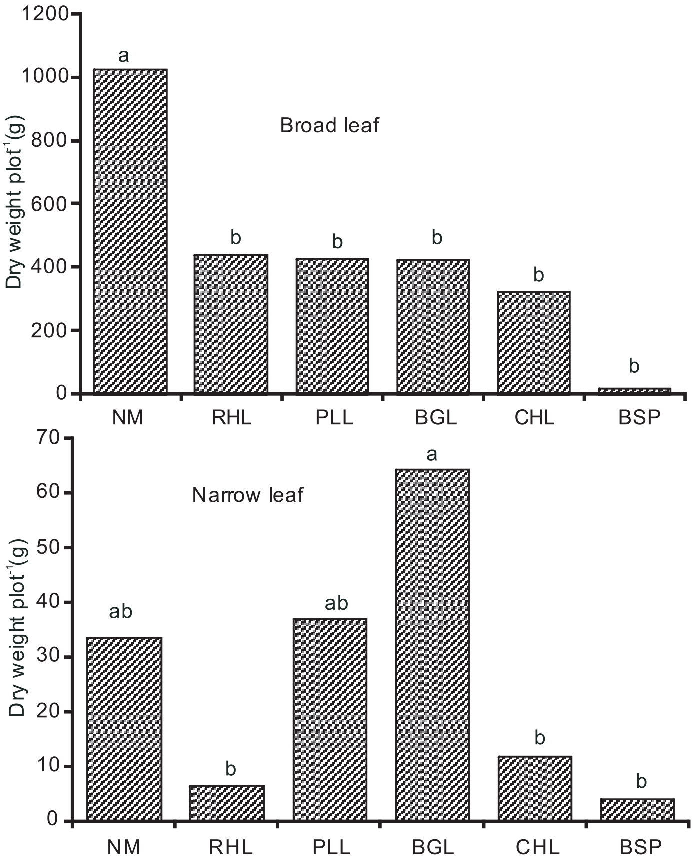

Fig. 1. Effects of no mulch (NM), rice husk litter (RHL), palm-oil leaf litter (PLL), blady grass litter (BGL), coffee husk litter (CHL) and black-silvered plastic (BSP) mulches on growth of broad leaf weeds and narrow leaf weeds in cucumber plots. (Means of treatments in the same weed followed by the same letter are not significantly different according Duncan's Multiple Range Test at $P<0.05$).

Effects on cucumber yield: The use of mulches increased fruit diameter (Fig. 2), fruit length (Fig. 3), fruit weight (Fig. 4), number of fruit plant^{-1} (Fig. 5), weight marketable fruits (Fig. 6) and total fruit weight plot^{-1} of cucumber (Fig. 7). On average, increase in fruit diameter, fruit weight, number of fruit plant^{-1}, weight marketable fruits and total fruit weight plot^{-1} of cucumbers grown with mulches were 7, 91, 25, 78, 134 and 78 %, respectively, higher than those of grown without mulch. Such increase might have resulted from the pronounced reduction of cucumber competition with weeds (Fig. 1).

Yields increases might have been also attributed to microclimate modification provided by the mulching. According to Bucki and Siwek (2019), mulching benefits to cucurbits by increasing water use efficiency, decreasing soil erosion and nutrient leaching in a deeper layer of the rhizosphere. Increase of cucumber yields might have also be related to increased carbon dioxide concentration

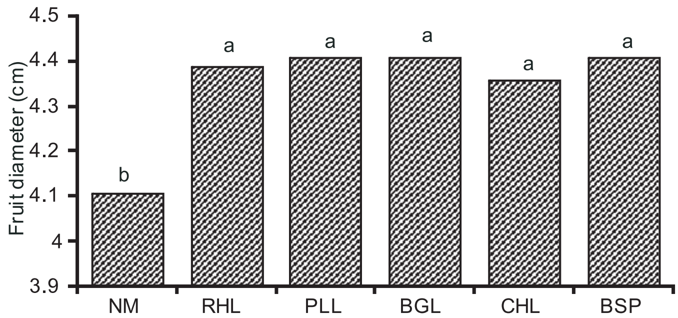

Fig. 2. Effects of no mulch (NM), rice husk litter (RHL), palm-oil leaf litter (PLL), Blady grass litter (BGL), coffee husk litter (CHL) and black-silvered plastic BSP) mulches on fruit diameter of cucumber (bars followed by the same letter are not significantly different according DMRT $P<0.05$).

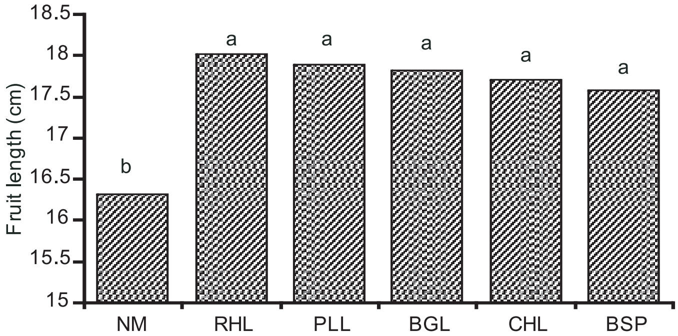

Fig. 3. Effects of no mulch (NM), rice husk litter (RHL), palm-oil leaf litter (PLL), blady grass litter (BGL), coffee husk litter (CHL) and black-silvered plastic (BSP) mulches on fruit length of cucumber (bars followed by the same letter are not significantly different according DMRT $P<0.05$).

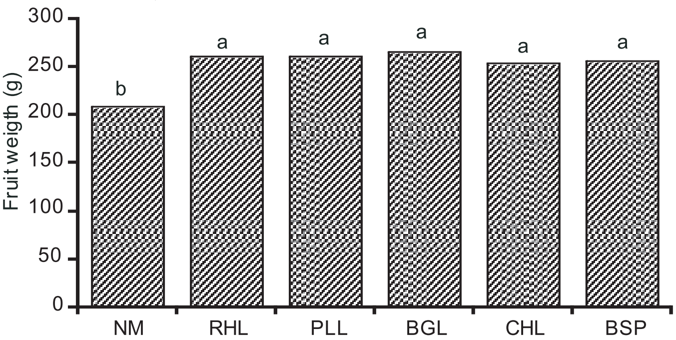

Fig. 4. Effects of no mulch (NM), rice husk litter (RHL), palm-oil leaf litter (PLL), blady grass litter (BGL), coffee husk litter (CHL) and black-silvered plastic (BSP) mulches on fruit weight of cucumber (bars followed by the same letter are not significantly different according DMRT $P<0.05$).

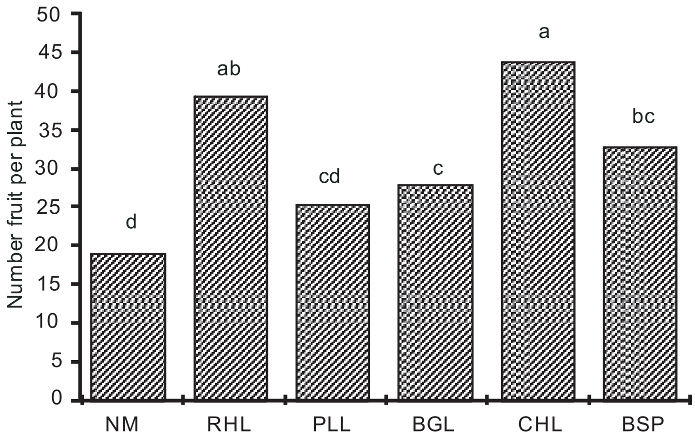

Fig. 5. Effects of no mulch (NM), rice husk litter (RHL), palm-oil leaf litter (PLL), blady grass litter (BGL), coffee husk litter (CHL) and black-silvered plastic (BSP) mulches on number of fruit plant^{-1}of cucumber (Means of treatments followed by the same letter are not significantly different according Duncan's Multiple Range Test at *P*<0.05).

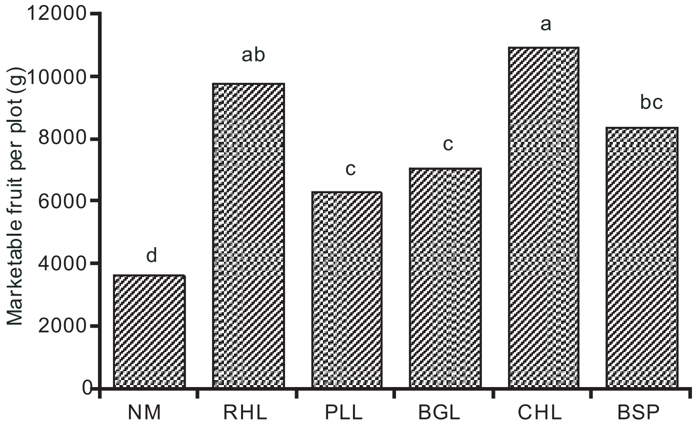

Fig. 6. Effects of no mulch (NM), rice husk litter (RHL), palm-oil leaf litter (PLL), blady grass litter (bgl), coffee husk litter (chl) and black-silvered plastic (bsp) mulches on weight marketable fruits plot^{-1} of cucumber (means of treatments followed by the same letter are not significantly different according Duncan's Multiple Range Test at *P*<0.05).

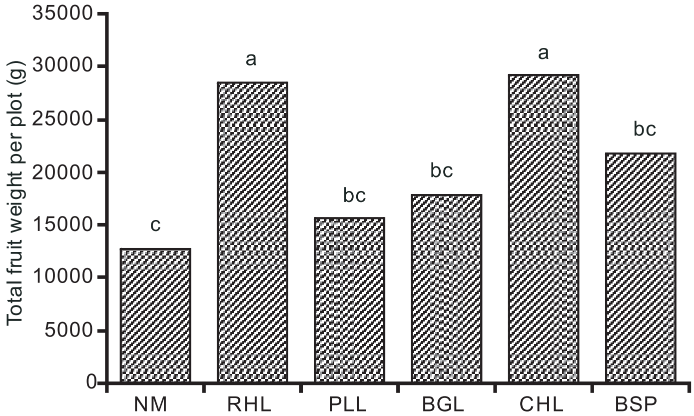

Fig.7. Effects of no mulch (NM), rice husk litter (RHL), palm-oil leaf litter (PLL), blady grass litter (BGL), coffee husk litter (CHL) and black-silvered plastic (BSP) mulches on total fruit weight plot^{-1}cucumbers (Means of treatments followed by the same letter are not significantly different according Duncan's Multiple Range Test at *P*<0.05).

around the cucumber canopies of mulched plants. This experiment also revealed that soil moisture content of mulched soils was 21 % higher than the non-mulched plot. Such increase benefitted cucumber growth and yield by improving nutrient availability and absorption. In addition, the presence of mulches also slowed down carbon dioxide released.from the soil to the atmosphere and then increased carbon dioxide release through planting holes (Aziz *et al.*, 2001). Research conducted by Soltani *et al.* (1995) indicated that carbon dioxide was released from the planting holes of mulched plants reached 560 ppm. Such increase exposed the cucumber seedlings to high carbon dioxide concentration to have more photosynthesis and eventually increased yield of cucumbers. Amongst yield components, marketable yield of cucumber might be the most important trait for farmer's point of view. In general, the use of mulches increased marketable yields by 138 % compared to non-mulched cucumbers. Cucumber grown with coffee husk litter had the highest marketable cucumber (10.851 kg plot^{-1}), followed by those grown with rice husk litter mulches (9,734 kg plot^{-1}). The lowest marketable yield was found in cucumber grown without mulch (3.603 kg plot^{-1}).

In addition to effect of mulching on microclimate modification of the growing environment such as excellent weed control, higher soil moisture under mulches, preventing of nutrient leaching (Bucki and Siwek, 2019), increased marketable yields of mulched cucumber was also resulted from the reduction of soil-surface splashing due watering or rainfall (Lamont, 2005). The presence of mulches prevented such splashing and produced cleaner cucumbers and eventually increased marketable yield of cucumbers. Increased fruit diameter, fruit length, fruit weight, number of fruit plant^{-1}, and total fruit weight plot^{-1} of cucumbers might have also contributed to the increase of marketable yield of cucumbers. Similar results were reported by Fahrurrozi *et al.* (2010). Recently, Ekwu *et al.* (2017) reported that plastic mulch increased marketable yield of cucumber. In addition, Ajibola and Amujoyegbe (2019) concluded the use of both plastic and organic mulches increased marketable cucumber fruits.

In conclusion, the use of mulches reduced weed growth in cucumber plots. The average reduction of broad leaf weeds due to mulch application was 68.2 % more than the weeds in the unmulched plots. Mulching was found to be more effective in suppressing narrow leaf weeds than browadleaf weeds. In addition, the use of mulches increased fruit diameter, fruit length, fruit weight, number of fruit plant^{-1}, weight marketable fruits and total fruit weight plot^{-1} of cucumbers. The use of coffee husk litter and rice husk litter mulches produced the best marketable cucumbers yield. These results are useful for cucumber growers in the low altitude of equatorial land, like the Province of Bengkulu, Indonesia.

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