The effect of attractant production factors on the income of curly red chili (Capsicum annuum L.) farming (case in Pasirwangi District, Garut Regency)

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Abstract. Curly red chili (Capsicum sp) is one of the commercial horticultural commodities that has a major obstacle in its cultivation, namely the attack of Plant Pest Organisms. One type of pests that often damages chili plants is fruit flies (Bactrocera spp) which can be controlled using an attractant. This study aims to analyze the factors that influence the production of curly red chili in farm with attractant utilization and without it and also their effect to farmers’ income. This research was conducted in Pasirwangi District, Garut Regency using a survey method on 72 farmers of red curly chilies. Data were analysed using multiple regression of a production function where one of the dummy production factors was the usage of attractant and non-attractant. The results showed that the production factors including land area, seeds, NPK fertilizer, organic fertilizer, labor and attractants had a positive effect on the production of curly red chilies. Partially, the production factors such as urea, Za fertilizer, KCl fertilizer and pesticides did not have any effect on the production of curly red chilies. The income of attractant users was higher than those who were not using attractants.

1. Introduction
Red chili (Capsicum sp) is a commercial horticultural commodity that can be consumed in fresh or processed form. Red chilies also contain many nutrients and vitamins such as calories, protein, fat, carbohydrates, calcium, vitamins A, B1, and C [1]. Most of the chili is used as a cooking spice for both household and food industry purposes. Besides that, it is also used as an ingredient in medicine and beverages. Therefore, according to Hastuti and Sinaga [2] the role of the chili commodity is quite large to meet domestic needs as an export commodity and the food industry. The export volume of fresh chilies reached its peak in 2010 amounting to 1500 tons, but then decreased until 2018 into 15.29 tons. The export volume of processed chili was higher than the export volume of fresh chili. In the same period there was an increase in export volume of 30.24% per year, greater than the increase in export volume of fresh chilies [3].

Chili production centers in Indonesia are located in several provinces in Java and outside Java. Based on the average production for 2014-2018, West Java contributed 23.03% to the total production of chili in Indonesia, Central Java 15.57%, North Sumatra 14.40%, East Java 8.80%, West Sumatra 7.04% and Aceh 4.84%. The distribution of chili production centers in West Java Province are in Garut, Cianjur, Bandung, Tasikmalaya, Ciamis, Majalengka, and Sukabumi. During the period 2011-2018, the development of chili planting areas in West Java fluctuated and ranged from 15.850 ha - 17,903 ha. Garut Regency was the main production center for chilies in West Java Province with a
production in 2018 of 911.35 thousand tons or 33.26% of the total production of chili in West Java, followed by Cianjur Regency at 13.34% and Bandung Regency 18.12%. Other regency only contributed 10% to West Java chili production [3].

Pasirwangi Subdistrict has been a center for vegetable production in Garut Regency for a long time, but its cultivation is still carried out using a semi-traditional system, especially in the implementation of pest and disease control management. According to Meilin [4], in general the pests found in chili plants in Indonesia are *T. parvispinus*, fruit flies (*Bactrocera sp.*), whitefly (*Bemisia tabaci*), peach aphids (*Myzus persicae*), aphids (Aphididae), and mites (*Polyphagotarsonemus latus* and *Tetranychus sp.*). In Pasirwangi, there are several types of fruit flies, namely *Bactrocera latifrons*, *B. cucurbitae*, and *B. papayae*, which have been identified as associated with Chili Plants. Fruit flies and tryps are types of dominant insect pests and causes serious damage to crops in the field.

Many efforts to control fruit flies (*Bactrocera spp.*) have been carried out including using mechanical, technical, and biological methods, but these efforts have not yielded significant results because there are many obstacles including: there is no way to control fruit flies that is appropriate and economical. In addition, excessive use of chemical pesticides can have a negative impact on natural enemies of pests, the environment and consumers and have an impact on the high cost of control, which causes farmers' income to decrease [5, 6, 7].

Environmentally friendly pest control has recently become a trend in the development of chili farming with the aim of reducing the use of synthetic pesticides. Pest control by considering environmental sustainability has a small risk, does not cause pests to become immune and is safe for human health and the environment. This is in accordance with Law no. 12/1992, PP No. 6/1995, and Law no. 13/2010 concerning Horticulture, which implies that plant protection is carried out in accordance with an integrated pest control system (IPM). Integrated pest control system is a way of securing production from pest problems by combining several control methods through an approach that prioritizes the role of agro-ecosystems. In addition, IPM is a very strategic step in responding to the demands of the world community for products that are safe for consumption, environmental sustainability, and sustainable management of natural resources.

The application of environmentally friendly pest control on chili plants provides benefits in the form of (1) increasing chili productivity on an ongoing basis; (2) environmental sustainability; (3) security and safety of farmers; and (4) consumer safety. Indicators of success in implementing environmentally friendly pest control are: (1) the balance of the ecosystem is maintained; (2) biodiversity remains sustainable; (3) minimal pesticide residue; and (4) production costs can be reduced [8].

One of the control measures that is safe for the environment and quite effective in suppressing the fruit fly population is the usage of methyl eugenol. Methyl eugenol is a compound that attracts insects, especially fruit flies. This substance is volatile and releases a fragrant aroma. Methyl eugenol can be obtained in the market under the name attractant at an affordable price and its use is quite easy.

The attractant leaves no residue on the fruit and is easy to apply to large areas. Because it is volatile, the range or radius is quite far, reaching hundreds or even thousands of meters, depend on the direction of the wind. The catchability of the attractants varies depending on the location, weather, commodities, and the condition of the fruit in the field. Several studies have shown that the use of methyl eugenol attractant can reduce the intensity of fruit fly attacks on mangoes by 39-59% [9,10]. The attractant with the active ingredient methyl eugenol is classified as a food lure, meaning that male flies are attracted to eat, not sexually. Furthermore, methyl eugenol is processed in the body of male flies to produce sex pheromones which are needed during mating to attract female flies [11].

Pest control using attractants is thought to reduce production costs and ultimately increase the income of chili farmers. In Hawaii, fruit fly control combines several control techniques, including attractants in traps, which can reduce the use of synthetic chemical pesticides by 75-95% [12]. Therefore, this study aims to analyze the factors that influence the production of curly red chilies in Garut Regency by including the dummy variables using and not using attractants.
Sustainable agriculture is the right choice to meet food security needs and address the challenges of climate change [13], one of which is by applying integrated pest control technology. Integrated Pest Management (IPM) is the right solution in answering the problems faced by farmers, because IPM is an ingredient of compatible control technologies by considering various aspects (economic, ecological, and social), so that environmentally friendly, safe, and economical [14, 15]. Furthermore, according to Pedigo [14], in IPM there are 4 interrelated components, namely: (1) information and knowledge (biosystematics and bioecology); (2) means decision making (method monitoring and action thresholds); (3) combination of control techniques; and (4) human resources, namely, direct actors IPM in the field and supporting actors. The fourth point in the IPM component is a very important basic point as a determinant of successful implementation or IPM implementation. Farmers are the main actors of farming in the field.

2. Research methods
The research was conducted in Pasirwangi District, Garut Regency with the consideration that it is the center for the development of the largest chili production in Garut. The approach in this study was designed quantitatively with a survey method.

This study used the Cobb-Douglas function model which analyzes the factors that influence the production of curly red chilies using and not using attractants as dummy variables. The Cobb-Douglas model is a model commonly used in agricultural economic research because of its practical nature and is easily transformed into a linear form [16]. The form of the Cobb-Douglas production function is as follows:

\[ Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3} \ldots X_n^{b_n} e^u \]

If the model is transformed into a linear form, the mathematical formulation will take the form:

\[ \ln Y = \ln b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + \ldots + b_b \ln X_b + d + e \]

To determine the effect of production inputs on production simultaneously, the F test is used. Statistical hypothesis:

- Ho: bi = 0, there is no influence of production factors on production
- H1: bi ≠ 0, there is at least one factor of production that affects production

The t test was used to show how much influence one production factor individually can explain production variations with the following hypothesis:

- Ho: bi = 0, the factor of production has no significant effect on production
- H1: bi ≠ 0, the factors of production have a significant effect on production

The types of data used in this study are primary and secondary data. Primary data were obtained through direct interviews with farmers using a questionnaire. The number of sample farmers was selected using proportional random sampling technique. The sample farmers who use attractants were 26 farmers and 42 people who did not use attractants.

3. Results and discussion
Fruit flies are one of the main pests for red chilies. As stated by Hasyim et al. [17], the losses caused by fruit fly attacks can range from 20-60%. Therefore, proper control is needed to reduce losses due to fruit fly attacks because by using chemical pesticides which most farmers do, in addition to increasing production costs it also damages the environment. Recently, 15-20% of chili farmers in Pasirwangi District have started to try using environmentally friendly pesticides (attractants).

The results of interviews with curly red chilies farmers showed that the application of attractant use in controlling fruit flies was quite effective where the use of attractants was able to reduce the rate of fruit fly attack by up to 75%. The reduced rate of fruit fly infestation affects the production and quality of the results obtained. To test the effect of production factors on the yield of curly red chilies with and
without using attractants in Garut Regency, an analysis with multiple regression models was used by
testing the fulfillment of the model's assumptions. Sukirmo [18] stated that production is a series of
processes in the use of existing production factors to produce goods or services (output). The
relationship between the factors of production and the level of production created is called the
production function.

The factors identified that can affect the production of curly red chilies are the land area, seeds,
Urea, Za fertilizers, KCl fertilizers, NPK fertilizers, organic fertilizers, pesticides, and labor. The F test
is a simultaneous test to determine whether the variable area of land, seeds, urea fertilizer, Za
fertilizer, KCl fertilizer, NPK fertilizer, organic fertilizer, pesticides, labor, and labor simultaneously
have a significant effect on the amount of curly red chili production. The analysis results can be seen
in Table 1.

Table 1. Simultaneous test results (Test F)

| Model      | Sum of Squares | df | Mean Square | F       | Sig |
|------------|----------------|----|-------------|---------|-----|
| Regression | 18.733         | 10 | 1.873       | 215.749 | .000* |
| Residual   | .530           | 61 | .009        |         |     |
| Total      | 19.263         | 71 | 19.263      |         |     |

From Table 1, it can be seen that the calculated F value was 215.749 with a significance value of
0.000. Thus the p-value (0.000) < α (0.05) means that H0 was rejected and H1 was accepted. So there
was an influence of production factors on the production of curly red chilies with and without using
attractants in Pasirwangi District, Garut Regency. Similar research was also conducted by Diarawati
[19] which shows that simultaneously the independent variables in the regression model, namely land,
seeds, fertilizers, pesticides and labor have a significant effect on the production of cayenne pepper.
Similarly, the research of Kusumaningsih [20] shows that the production factors which in the form of
land area, labor, seeds, manure, phonska fertilizer, prevaton insecticide, and bonstick paste all affect
cabbage production.

Furthermore, to see the effect of production factors partially on production yield, t test were used.
The significance can be estimated by comparing the value of t- table with t-count. Based on the results
of the t test in Table 2, the regression model equation of the red chili production function at the level
farmers in the study area generally can written as follows:

Production = 5.876 + 0.405 land + 0.123 seeds + 0.123 NPK + 0.242 organic fertilizer + 0.180 Labour
+ 0.069 Dummy Attractant

The coefficient of determination (R²) describes how far the model is able to explain the variation in
the dependent variable. The coefficient of determination which is close to one of the independent
variables explains almost all the information needed to predict the dependent variable. The R Square
value of 0.973 meant that the production yield could be explained by the factors of production land,
seeds, NPK, Organic fertilizer, labor and attractant by 97.3%. Meanwhile, the remaining 2.7% was
explained by other variables that were not included in the model and were thought to have influenced
the variation in the production of curly red chilies, including: climate, soil acidity, humidity, and
garden sanitation.
### Table 2. Estimation results of regression analysis parameters between independent variables and dependent variables in curly red chili farming in Pasirwangi, Garut Regency, 2018

| Model | Unstandardized Coefficients | Standardized Coefficients | t | Sig |
|-------|-----------------------------|---------------------------|---|-----|
|       |                             |                           |   |     |
| 1     | (Constant)                  | 5.876                     | 1.060 | 1.060 | 5.544 | .000 |
|       | Land                        | .405                      | .061 | .356 | 6.637 | .000 |
|       | Seeds                       | .123                      | .053 | .128 | 2.342 | .022 |
|       | Urea                        | .042                      | .061 | .039 | 688   | .494 |
|       | Za                          | .001                      | .055 | .001 | .027  | .979 |
|       | KCl                         | .015                      | .046 | .011 | .315  | .754 |
|       | NPK                         | .123                      | .042 | .130 | 2.932 | .005 |
|       | Organic Fertilizer          | .242                      | .062 | .249 | 3.924 | .000 |
|       | Pesticide                   | -.042                     | .076 | -.037 | -628  | .532 |
|       | Labor                       | .180                      | .074 | .155 | 2.422 | .018 |
|       | Dummy (Atractan)            | .069                      | .031 | .066 | 2.218 | .030 |
|       |                             |                           |   |     |       |     |
| R    | R Square                    | .986a                     | .973 | .968 | .09318 |     |

#### 3.1. Land
The results of the tests conducted show that the land area factor partially has a significant effect on the amount of curly red chili production. Land as the factory of agricultural product is one of the factors which has a significant contribution to farming. Currently, the average land area cultivated by curly red chili pepper farmers in Pasirwangi District is still below 0.5 ha due to limited land ownership. The size of the production from farming is influenced by the size of the land used that supported by the opinion of Mosher [21] that stated land productivity can affect the amount of farm production.

#### 3.2. Seed
The seed production factor shows a significant effect on chili production. Almost all curly red chilli farmers in Pasirwangi District used hybrid seeds. Generally, farmers use curly red chili hybrid seeds, including Magma and Bianca brands. These seeds are widely used by farmers with the consideration that these chili seeds are very adaptive, can be planted in high and low lands, have high productivity, relatively uniform fruit size, have lots of seeds, have a spicy taste and have a relatively long shelf life. The number of red chili seeds used without attractants per hectare minimum is 200 grams. The recommendation for the use of curly red chili seeds ranges from 200 gr - 300 gr/ha. To increase the productivity, increasing the number of seeds used per unit is one of the options. In addition, improvement of red chili seeds quality can be improved as the majority of seeds bought by the farmers come from kiosks without appropriate package so that there is no information regarding the seeds production and expiration date. Therefore, it is possible to increase the production of farmers if they change their seeds with a guaranteed quality seeds. In this study, seeds determine the superiority of a commodity, superior seeds tend to produce good quality production. The results of this study are in line with the results of research conducted by Sukiyono K [22] that stated the seeds have a significant positive effect on the amount of chili production.

#### 3.3. NPK fertilizer
The results of the analysis show that NPK had a significant effect. The utilization of NPK fertilizer by the respondents in Pasirwangi District is quite influential for red chili production because this fertilizer
can accelerate the plant growth with a healthy and strong condition and more practical in the application as it is cost-effective, time-saving, and the dosage is more measured. According to Saribun [23], the use of NPK fertilizers is expected to provide ease of application in the field and can increase the nutrient content needed in the soil and can be used directly by plants. In line with the opinion of Sutedjo [24] that stated the proper application of inorganic fertilizers to the soil can increase the fast nutrient availability for plants. The dosage of NPK fertilizer used by red chili farmers at the research location ranged from 491 to 507 kg/ha, while the recommendations from the Balitsa Research Institute ranged from 250-270 kg/ha. The farmers used higher NPK dosage because the application was carried out by the leak system since day 14 after plantation. The time interval for leak was once every 10 days that implemented until the plant harvested.

3.4. Organic fertilizer
Organic fertilizers have a significant effect on increasing production of curly red chilies. Organic fertilizer utilization in addition to nutrients supplementation also improves the physical properties of soil and maintains its temperature stability that increases the ability of plant to absorb available nutrients [25]. From the analysis results, in production process, the addition of organic fertilizer to the curly red chili farming at the research location significantly increased production. At this time the used of organic fertilizers by farmers at the research location was only in the range of 13.20 – 15.07 tons/ha. When this amount is compared to the recommended dosage (around 20 tons/ha), it is still insufficient. Thus, increasing the dosage of organic fertilizer is absolutely necessary.

3.5. Pesticides
Based on the results of the analysis, pesticide did not have any effect on the production of curly red chilies. The utilization of pesticide was intensive with excessive dosage at the research location, so that it is recommended to reduce the amount. In the implementation of pest control measurement, the average farmer did not take into account the attack threshold, but they controlled it on a scheduled basis using various types of pesticides at once.

Farmers who used mixed pesticides have opinion that mixed pesticides can control pest attack effectively even though the inappropriate use can cause health problems, environmental pollution, and the disturbance of ecological balance. Harsi Ke [26] stated that pesticide residues in soil and water have a positive correlation with pesticide residues in products. In addition, Hidayat et al [27] explained that the level of knowledge of farmers on pesticide management in accordance with the precautionary principle is still low and dependence on pesticides is still high.

3.6. Labor
The results of the analysis show that the number of workers had an effect on chili production at the research location. This results indicate that the increasing number of worker has a significant effect on the increasing of curly red chilies production. During the production of red chili, the cultivation from start to finish including preparation, harvest, and post-harvest cannot be separated from the need for labor. It is in line with the opinion of [28] which stated that labor has a significant effect on the production of red chillies in Sigi Regency. Generally, the labor in curly red chili farming is provided from family labor (family members) or outside the family labor. The availability of labor closely relates to the area of land being cultivated. Usually, the more labor available, the land area that is salted will be wider. The average land owned by the farmers that was used for cultivation of curly red chilies in study location was less than 0.5 ha.

3.7. Dummy (Applying attractants and not applying)
Based on the comparison between the farmer who applied attractant and farmer who did not apply it, the utilization of attractant had an effect on the production of curly red chilies. The survey results in the research location show that the utilization of attractant to control fruit fly was able to reduce the costs for synthetic pesticides or in other words, farmer use attractant to save production costs. The
reduction of pesticides cost is due to the fact that the cost of buying attractants is much cheaper than using synthetic pesticides (Table 3).

**Table 3.** Farming analysis of curly red chilies per planting season per hectare in Pasirwangi District, Garut Regency, 2018

| Description | With Attractant | Without Attractant |
|-------------|----------------|--------------------|
| Cost (Rp)   | 75,533,623     | 76,600,013         |
| Revenue (Rp)| 179,424,595    | 162,260,511        |
| Income (Rp) | 103,890,972    | 84,717,408         |
| R/C         | 2.37           | 2.12               |

Farming using attractant is more profitable (RC 2.37) than without it (RC = 2.12). Generally, farmers that utilize attractant have less frequency of spraying interval compare to farmers who only use synthetic pesticides. According to Kardinan [29], by utilizing attractants to control fruit fly pests, the use of synthetic insecticides can be reduced by 62%, fruit damage can decrease by 35% and farmers’ income can increase by 73%. However, there are not many farmers that has adopted attractants utilization due to lack of socialization about the techniques and benefits of attractants. Therefore, farmers are more likely to use excessive pesticides as they fear of crop failure. From the data in Table 3, it can also be seen that the cost of farming red chilies is very high so that many farmers need outside capital (loans), but based on the R/C, the farmers should be able to payback the loan. According to Karyani [30], the supply chain financing model is more recommended to be applied to chili agribusiness.

4. Conclusion
The production factors that affected the production of curly red chilies in Pasirwangi District, Garut whether the farmer used attractant or not were land area, seeds, urea fertilizer, Za fertilizer, KCl fertilizer, NPK fertilizer, organic fertilizers, pesticides and labor. Meanwhile, partially, the production factors such as urea, Za fertilizer, KCl fertilizer and pesticides did not have any effect on the production of curly red chilies. The usage of attractants was more profitable than not using attractants, but not many farmers had adopted it due to a lack of socialization about the techniques and benefits of attractants. In addition, more in-depth research is needed to find why many farmers are still reluctant to adopt attractants in chili cultivation.

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