Increasing added value of living standards on pepper growth and production towards sustainable agriculture

E Karmawati, Siswanto and M Syakir
Indonesian Centre for Estate Crops Research and Development
Jalan Tentara Pelajar No 1, Bogor 16111 Indonesia

Corresponding author email: elnakarmawati@gmail.com

Abstract. In recent years, the productivity of pepper in Indonesia has decreased due to various problems in pepper farming, both on-farm and off-farm, so the contribution of Indonesian pepper to the world declined. One of the problems farmers face in cultivating pepper is the use of non-living standards in several production areas, especially in Bangka Belitung and West Kalimantan. The use of non-living standards requires more inputs. Moreover, in the current pepper price situation, farmers have less profit. Observations on the growth of pepper on several types of living standards, namely Albizia, Gliricidia, coconut, and kapok, in Sukamulya, Pakuwon, and Muktiharjo. The experiment was conducted in 2015, 2016, and 2017. At each standard, 1, 2, and 4 pepper seedlings were planted. A sampling of 10 plants of each type of standard for observation of growth and yield had been conducted from each plot. The results showed that the alive climbing pole that could be attached for pepper were Albizia and Gliricidia. Productivity of fresh weight at the third year was 1.90 kg per standard used 4 seedlings and 1.87 kg per standard used 2 seedlings.

Keywords: Albizia, coconut, Gliricidia, kapok, Piper nigrum L.

1. Introduction
Estate crops are essential commodities and are the primary source for Indonesia's national income and foreign exchange because has the highest contribution to Gross Domestic Product, compared to other agricultural, livestock, labor, and agricultural services sectors. In 2016, total plantation exports reached US$ 28.1 billion or equivalent to Rp. 393.4 trillion [1].

Pepper (Piper nigrum L.) is one of the estate crops that produces a real contribution as a source of foreign exchange, employment, and income for farmers. Pepper is known as the King of Spices, because other types of spices cannot replace its usage Pepper product is exported in powder and granular form, both for white pepper and black pepper. White pepper is famous as Muntok White Pepper and is mainly produced in the Province of the Bangka Belitung Islands, while black pepper is known as Lampong Black Pepper, because most of it is produced in Lampung. These two production centers have remained the largest pepper areas in Indonesia in the last ten years. In 2018, the contribution of each region (Bangka Belitung and Lampung) to Indonesia's total production was 38.02 and 16.65%, respectively [1].

Pepper area has been increasing every year, however its productivity is decreased every year. The average decline is 2.29% per year, and a sharp decline occurred between 2014-2015, which was 10% [2] and reached the lowest productivity of 798 kg/ha. There are many problems faced by pepper farmers in the field, including the lack of proper cultivation and processing technology practice, pepper prices
that are constantly fluctuate, pest and disease attacks, lack of maintenance of pepper standards, and climate change [3]. One of the characteristics of pepper cultivation in Bangka-Belitung is the use of high-priced non-living standards [4]. Farmers who own limited capital will undoubtedly have less profits; hence a solution is needed to replace the pepper standards. One of them is the use of living standards, which is one component in developing environmentally friendly and efficient cultivation. So, the efforts to increase national pepper productivity can be achieved as well the sustainability. Other technological components that have been produced are the plant material selection, soil structure improvement, irrigation construction, plant propagation, seedling technology, cultivation technology, utilization of ground cover mulch, cultivation of pepper shrubs, plant maintenance, fertilization technology, cropping patterns, and plant-livestock integration [5].

The purpose of the study is to observe the pepper growth and yield of several types of living standards in three locations to determine the best types of standards for pepper production. For each type of standard, 1, 2, and 4 seedlings were planted.

2. Methodology
The decreasing interest in farmers for pepper cultivation in Bangka-Belitung is influenced by a number of factors, namely the high cost of production due to the use of non-living standards and high doses of fertilizers and pesticides. Therefore, it is necessary to have demonstration plots with various living standards, superior pepper seedlings, and the use of more than one seedling per standard so that the input is lower and the productivity increases. It is expected that using more seedlings produces a higher yield compared to the previous system and production costs can be reduced.

The superior varieties used were those that have been released and are widely used by farmers, namely Natar 1, with potential productivity of around 4 tons/ha [6]. This production will exceed the potential productivity if there is no initial pruning of the vines. For fertilizers and pesticides use, balanced fertilization was applied according to the recommendations, and control does not use chemicals to make it more affordable for farmers and safer for the environment.

The activity was conducted in 3 locations, namely at KP Pakuwon and KP Sukamulya in West Java, and KP Mukthiharjo in Central Java, in the form of a demonstration plot that started in the rainy season in 2014 and ended at the end of the rainy season in 2017. The living standards chosen were Gliricidia and albizia in KP Sukamulya, coconut in KP Pakuwon, and kapok randu in KP Mukthihardjo (Central Java) all of which are suitable for the growth of the living standards, and pepper plants are made to attach easily.

As much as 20 plants of each living standard type were planted in the first row with one seedling at each standard. In the second row, two seedlings of pepper planted each of 20 living standards. And 10 samples per row were observed every month for five variables on growth (plant height, number of tendrils, number of nodes, number of branches, branch length) and yield per standard.

3. Results and discussion
3.1. Growth
Observations on growth were taken for three years. The growth of pepper plants on several types of living standards that were kapok, coconut, Albizia and Gliricidia showed good performance. Based on the observation, the best pepper growth obtained by using Albizia standard, followed by Gliricidia, coconut, and kapok. The pepper growth is supported by data obtained from all observation parameters, namely plant height, number of tendrils, number of segments, number of branches, and branch length. The growth of pepper plants with various living standards is positively correlated with time. Thus, the older the pepper plants, the higher the values of the five parameters. Therefore, the comparison of plant growth between living standards used can use linear correlation values between plant height, number of tendrils, number of segments, number of branches, branch length, and time increment. Better plant growth is indicated by a positive correlation and slope value (r and b). The higher the r-value, the better the pepper growth and the more suitable the climbing used. This correlation value is consistent with the obtained slope b-value. The value of b shows the increase in the value of plant height, number of tendrils,
number of nodes, number of branches, and branch length each month. The values of r and b at each location are presented in Table 1 and grouped for one seedling, two seedlings, and 4 seedlings per standard because each group of seedlings has a different growth effect on each standard, indicating that there is an effect between the living standards and the number of seedlings per climbing pole.

Pepper growth at Albizia standard showed similar performance with the growth at Gliricidia standard, therefore they were combined in data processing, the difference was only in the plant height. Albizia is taller than Gliricidia plants, so that the probability for pepper to climb upwards was higher. The average height of pepper plants in Albizia is more than 4 m, while the maximum height of Gliricidia is 4 m (see picture). Pepper growth at Albizia and Gliricidia was quite better compared to coconut and kapok because the environmental conditions under Albizia and Gliricidia were more suitable for pepper than KP Pakuwon and KP Mukthibaro. Likewise, the condition of kapok and coconut plants has a somewhat slippery bark and shallow roots, so that pepper plant cannot penetrate into the lower soil, and its roots are difficult to get nutrients. Based on the growth parameters, it is suggested to plant Gliricidia as poles of pepper.

| Number of seedlings | Albizia/Gliricidia | Coconut | Kapok |
|---------------------|--------------------|---------|-------|
|                     | r      | b      | r      | b      | r      | b      |
| Plant height        |        |        |        |        |        |        |
| 1                   | 1.00   | 15.36  | 0.99   | 12.71  | 0.87   | 0.72   |
| 2                   | 1.00   | 13.98  | 0.77   | 11.21  | 0.98   | 4.75   |
| 4                   | 1.00   | 12.35  | 0.82   | 12.06  | 0.98   | 2.87   |
| Number of tendrils  |        |        |        |        |        |        |
| 1                   | 0.99   | 2.17   | 0.96   | 0.66   | 0.36   | 0.17   |
| 2                   | 0.99   | 9.42   | 0.99   | 0.45   | 0.67   | 0.87   |
| 4                   | 0.99   | 3.24   | 0.99   | 0.54   | 0.52   | 0.25   |
| Number of nodes     |        |        |        |        |        |        |
| 1                   | 0.99   | 1.24   | 0.91   | 0.93   | 0.65   | 0.56   |
| 2                   | 0.99   | 9.24   | 0.92   | 1.43   | 0.82   | 0.70   |
| 4                   | 0.99   | 9.30   | 0.94   | 1.29   | 0.92   | 0.54   |
| Number of branches  |        |        |        |        |        |        |
| 1                   | 0.99   | 1.16   | 0.97   | 1.09   | 0.60   | 0.16   |
| 2                   | 0.99   | 1.30   | 0.88   | 0.94   | 0.53   | 0.18   |
| 4                   | 0.99   | 0.42   | 0.92   | 1.05   | 0.57   | 0.13   |
| Branch height       |        |        |        |        |        |        |
| 1                   | 0.99   | 5.06   | 0.86   | 1.99   | 0.93   | 1.25   |
| 2                   | 1.00   | 1.53   | 0.96   | 1.57   | 0.86   | 0.95   |
| 4                   | 0.99   | 0.58   | 0.59   | 0.54   | 0.88   | 1.18   |

Living standards provide a greater probability for pepper growth and extend life because living standards can reduce stress, especially in the dry season, because the plant requires about 50-75% sunlight [7]. In Lampung, pepper plants can live more than 15 years old. It was suggested that living standard should have the following characteristics: a) Longevity, b) Allows pepper roots to attach firmly, c) Has no negative effects on pepper plants, such as competition for nutrients, water, and CO2, allelopathic effect, d) Easy and fast to grow and resistant to pruning, e) Economical and easy to obtain. Also, the stem diameter should not be too large, relatively resistant to pests and diseases [8], not a host for pests and diseases of pepper, from the Leguminosae family, and have deep roots. The living
standards provide shade so that the microclimatic conditions below are affected, which results in all agronomic aspects of the plants underneath. Therefore, from the four living standards tested, Albizia and Gliricidia can be selected as pepper standards, with the condition that stem borer pests on Albizia plants might be controlled. Popular standards are Gliricidia or gamal (Gliricidia maculata) and dadap cangkring (Erythrina fusca) plants because they are tolerant to pests and diseases that attack pepper plants.

Pepper plants can grow at a temperature of 10-40°C, and the ideal temperature is 23-32°C [8], but due to the hot temperature throughout the third year > 30°C in Muktiharjo, the sunlight penetrated more than 70 %, so the plants became dry and could not bear fruit. Nutrients can increase plant resistance to environmental stresses. Several researches had proven that nutrients play an important role [9, 10]. In contrast to growth in KP. Pakuwon, pepper growth in KP. Muktiharjo was not encouraging (Figure 1). Since January 2016, the number of plants have decreased, almost 50% of the plants have died, so replanting is necessary. The b-value obtained for the growth criteria is the smallest compared to the other 2 locations. Generally, the plant height decreased at the beginning of the third year. The maximum growth value was obtained in February, then in March all decreased. The correlation value from April to November 2016 looks positive but the increase every month is slowly shown by the b value obtained every month (Table 1). As previously explained, rainfall in 2014 and 2015 was very low, less than required. Seedlings in polybags are also quite good, but after being moved to the field, pepper plants started to stunt. There are several possibilities. The first is the presence of allelopathic substances from kapok roots or shallow roots of the kapok plant so that pepper roots did not develop.

In general, the number of pepper seedlings per climbing pole has an effect on growth. The growth of pepper from 1 seedling per standard was worse than 2 seedlings per standard, as well as 2 seedlings per standard had better growth than plants from 4 seeds per standard. It seems that for 4 seedlings per standard, there is competition in taking nutrients from the soil because the dose of fertilizer applied is the same for all living standards.

![Pepper plant using Gliricidia as standard in Sukamulya.](image)

**Figure 1.** Pepper plant using Gliricidia as standard in Sukamulya.
Figure 2. Pepper plant using Albizia as standard in Sukamulya.

Figure 3. Pepper plant using kapok as standard in Muktiharjo.

Figure 4. Pepper plant using coconut as standard in Pakuwon.
3.2. Yields
The yields obtained at the end of the third year are presented in Table 2. Pepper plants in KP. Pakuwon (Figure 1) were planted later than KP Sukamulya but have begun to bear fruit because they are more than two years old. With the number of seedlings of 4 plants per standard, pepper plants have the opportunity to bear more fruit than those from 1 and 2 seedlings. The fresh weight of fruit per ten plants reached 257.2 grams, while the dry weight reached 110.70 grams or 43% (Table 2). Meanwhile, pepper planting with kapok standard could not produce, because of the environment.

In KP Sukamulya (Figure 1) was different. Pepper production per 10 plants from 2 seedlings per standard as Gliricidia was the highest, compared to production from 1 & 4 per standard, according to the growth values obtained in Table 1. Whereas in Albizia, 4 seedlings per standard gave the highest production compared to other treatments, namely 19 kg wet weight or 9.65 kg dry weight on 10 plants. Albizia and Gliricidia gave the best pepper growth and production, but Albizia has a weakness. It is susceptible to stem borer. Therefore, research on living standards for pepper was discontinued at the end of the third year. Some of the living standards had collapsed by stem borer pests. Observation of damage by stem borers until the beginning of the 4th year reached 40%.

### Table 2. Cummulative pepper yield based on poles type and number of seedlings plant.

| Standards | Number of seedlings/plant$^1$ |
|-----------|-----------------------------|
|           | 1  | 2  | 4  |
| Fresh weight (g/ plant$^{-1}$) | 296 | 1870 | 1321 |
| Dry weight (g/ plant$^{-1}$)   | 165 | 1040 | 653 |
| Glirisida | Fresh weight (g/ plant$^{-1}$) | 710.5 | 1355 | 1900 |
|          | Dry weight (g/ plant$^{-1}$)   | 350.5 | 676 | 965 |
| Albizia  | Fresh weight (g/ plant$^{-1}$) | 20.0  | 14.3 | 25.7 |
|          | Dry weight (g/ plant$^{-1}$)   | 9.7   | 6.6  | 11.1 |
| Coconut  | Fresh weight (g/ plant$^{-1}$) |       |      |     |
|          | Dry weight (g/ plant$^{-1}$)   |       |      |     |

3.3. Opportunity to increase the added value
Compared to production costs with non-living standards, living standards are more economical for pepper farming, and productivity will be higher because plant growth will take longer [13], along with the growth of living standards. However, the use of living or non-living standards has different consequences for farmers’ productivity and income. For example, pepper farmers in Lampung used to use Gamal, dadap, and kapok as living standards. Meanwhile, in Bangka Belitung, West Kalimantan and East Kalimantan, the farmers use non-living standards made of mendaru, ulin, and pelawan poles or sometimes made of concrete. The average productivity of pepper in Bangka is 1.3-1.4 t/ha, far more than the average pepper productivity in Lampung, which is only around 0.4-0.6 t/ha. It is estimated that organic and inorganic fertilizers are used by pepper and the climbing pole, while the dead climbing pole is not. BCR farmers’ income on living standards is sometimes higher, because the inputs for farming are much higher. Therefore, farmers in Bangka have started to use living standards or dwarf pepper plant [11] because non-living standards are very expensive and increasingly rare. Pepper farmers in Vietnam
used living standards and planted two cuttings/seedlings per planting hole with a length of 4-6 nodes [8, 12].

4. Conclusion
Observation of growth and production of pepper using 4 types of living standards in 3 different places resulted in 2 types of them having the probability of replacing nonliving ones. All growth variables of Albizia and Gliricidia resulted in greater growth values than coconut and kapok. The productivity of pepper at the end of the third year for Gliricidia was 1.87 kg per standard using 2 seedlings, and for Albizia was 1.90 kg per standard using 4 seedlings.

References
[1] Direktorat Jenderal Perkebunan. 2020. Statistik Perkebunan Unggulan Nasional 2019-2021. Direktorat Jenderal Perkebunan. Kementan. 1056 p.
[2] Damanik S 2020 Analisis penawaran dan permintaan lada indonesia di pasar internasional. Jurnal Penelitian Tanaman Industri. Indonesian Agency For Agricultural Research and Development (IAARD); Jul 15;7(4):113.
[3] Karmawati E, Ardana IK, Siswanto, Soetopo D 2020. Factors effecting pepper production and quality in several production center. IOP Conference Series: Earth and Environmental Science [Internet]. IOP Publishing; 2020 Jan 10; 418:012051.
[4] Siswanto S, Ardana IK and Karmawati E 2021 Peluang peningkatan produktivitas dan daya saing lada Opportunity for increasing productivity and competitiveness of pepper. Perspektif. Indonesian Agency For Agricultural Research and Development (IAARD); 2021 Feb 8;19(2):149.
[5] Karmawati E and Siswanto 2018 Teknologi budidaya lada ramah lingkungan dalam mendukung sistem perkebunan berkelanjutan. in Mewujudkan Pertanian Berkelanjutan. IAARD PRESS; 2018: 347-364.
[6] Saefudin 2014 Tantangan dan kesiapan teknologi penyediaan bahan tanam mendukung persiapan teknologi bahan pakan. Perspektif, Rev. Pen. Tan. Industri, 2014; 13(2) : 111-125.
[7] Syakir M 2018 Inovasi teknologi budidaya lada perdu mendukung peningkatan produksi dan daya saing lada nasional. Naskah Orasi Pengukuhan Profesor Riset Bidayda dan Produksi Tanaman, 15 Oktober 2018. IAARD Press. 57 p
[8] Daras U 2016 Strategi peningkatan produktivitas lada dengan tajar tinggi dan pemangkasan intensif serta kemungkinan adopsinya di indonesia. Perspektif. Indonesian Agency For Agricultural Research and Development (IAARD); 2016 Sep 28;14(2):113.
[9] Tjahyana B E, Daras U and Heryana N 2012 Formula pupuk berimbang tanaman lada di Lampung. Bull. Ris. Tan. Rempah dan Aneka Tan. Industri 2012; 3(3) : 239-244
[10] Ardana IK, Syakir M, Karmawati E, Siswanto S. 2017 Potensi dampak ekonomi penerapan teknologi pemupukan dan polikultur lada di kabupaten Purbalingga, Provinsi Jawa Tengah / Potential Economic Impact of Pepper Fertilization and Multiple Cropping Technology Application in Purbalingga Regency, Central Java. Jurnal Penelitian Tanaman Industri. Indonesian Agency for Agricultural Research and Development (IAARD); 2017 Dec 29;23(2):112.
[11] Syakir M, Ardana IK, Karmawati E. Kinerja teknis dan finansial budidaya lada perdu di daerah pengembangan baru kabupaten banyumas, jawa tengah / technical and financial performance of bushy-pepper cultivation in the new development area at Banyumas District, Centra Java. Jurnal Penelitian Tanaman Industri. Indonesian Agency For Agricultural Research and Development (IAARD); 2018 Sep 10;24(1):39.
[12] Ton NT. 2010 Research on varietal selection and advanced cultivation practices for a sustainable development of pepper industry. Final Report of Ministerial Research Project, MARD; 2010. Vietnam.
[13] Karmawati E, Ardana KE, Siswanto, Iwa MT and Gusmaini 2017 *Final Report of ICERD Pepper Research 2017*. 89p.