Increasing productivity of red chilies using *Proliga* cultivation technology and high yielding varieties

Atman¹, C Indrawanto²*, Yuniarti¹, Y A Dewi² and F Hendrawan¹

¹Assessment Institute for Agricultural Technology (AIAT), Jl. Padang-Solok KM. 40 Sukarami, Kec. Gunung Talang, Solok Regency, West Sumatra Province, Indonesia.
²Indonesian Center for Assessment and Development of Agricultural Technology (ICATAD), Jl. Tentara Pelajar 10 Cimanggu Bogor, West Java, Indonesia.

E-mail: *indrawanto2001@gmail.com

Abstract. In Solok District, West Sumatra Province, farmers plant curly red chilies using the local variety Sukarami with simple cultivation technology. The resulting productivity is around 6-7 tonnes /ha. The Indonesian Agency for Agricultural Research and Development (IAARD) has introduced cultivation technology for red chilies namely 'Proliga' to increase productivity. The experiment was conducted in Sukarami Field Station in Solok Regency. Four treatments with Six replication have been applied, (1) Proliga cultivation technology using Kopay Variety (Proliga Kopay), (2) Proliga cultivation technology using Kencana Variety (Proliga Kencana), (3) Proliga cultivation technology using Sukarami Variety (Proliga Sukarami), (4) Farmer's cultivation technology using Sukarami Local Variety. The results show that the application of Proliga technology increases the yield. The largest increases were obtained through the application of Proliga technology using Sukarami local variety, with a revenue value of Rp. 209,448 million / ha or an increase of 57.44% compared to the Farmer's cultivation technology using Sukarami Local Variety. The R/C and MBCR values of the Proliga Sukarami technology are 1.51 and 2.36 respectively.

1. Introduction

Red chilies (*Capsicum annuum* L.) are widely used as food and as raw material of pharmaceutical industries. It has high economic value and is marketed in form of fresh, dry, powdered or paste. West Sumatra Province, is a center production for red chilies, contribute 11.5% to nasional red chilies production [1]. Red chilies production from West Sumatera is marketed not only in West Sumatra Province, but also in Riau, Jambi, and Bengkulu Provinces and It is also exported to Malaysia and Singapore [2].

Red chilies production in West Sumatra Province between 2015 - 2019 increased from 63,402 tons to 139,994 tons with an average productivity of 9.5 tons / ha, higher than the average national productivity of 8.7 tons / ha [3]. However, this level of productivity is still far below the potential productivity of 20 tonnes / ha. The poor application of red chilies cultivation techniques has resulted in low productivity and quality [4]. In addition, the low productivity of vegetables in West Sumatra is generally caused by the low quality of seeds, inappropriate dosage and timing of fertilization application, pests and diseases [5]. Pests and diseases that often attack Red chilies are thrips (*Thrips parvispinus*), mites (*Polyphagotarsonemus latus*), fruit caterpillar (*Helicoverpa armigera*), fruit flies (*Bactrocera sp*), anthracnose (*Colletotrichum spp*.), withered phici, withered caps (*Phytophthora*).
bacteria (*Ralstonia solanacearum*) and yellow virus disease, which can cause yield loss of 25 - 100% [6]. Moreover, red chili plants that have started producing require macro nutrients P and K as well as micro nutrients B, Mo, Cu, Zn, Fe and Mn to help ripen fruit, strengthen stems, and support generative [7].

Indonesian Agency for Agricultural Research and Development (IAARD) has introduced technological innovation namely ‘Proliga’ for red chili which has several advantages such as (1) increase the yield, (2) increase efficiency and (3) reduce yield loss cause by pests and diseases to <10%. These benefits can be gained by implementing recommended technology components: (1) using high yielding varieties, (2) using healthy seedling, (3) increasing plant population about 29-30 thousand/ha, (4) water, soil and nutrients Management by regulating the application of manure, chemical fertilizer, dolomite and water according to location conditions and can meet the needs of a population of 30,000 plants (5) pests and diseases controlling using a combination of biological, mechanical and chemical components of pests and diseases control [8,9].

In Solok Regency, West Sumatra Province, farmers grow a lot of curly red chilies of the Sukarami variety using local cultivation technology (farmer technology) and the productivity obtained is around 6 tonnes / ha. Another variety of curly red chilies that is widely used in West Sumatra is the Kopay variety, which originates from Payakumbuh City, West Sumatra. Another red chili variety is the Kencana variety which is widely grown in the medium plains. This study aims to compare the chili yields obtained from the Proliga cultivation technology using the Kopay variety, the Kencana variety and the Sukarami variety with the local cultivation technology (farmer technology) using the Sukarami variety.

2. Materials and methods

The experiment was conducted in Sukarami Field Station of Assessment Institute for Agricultural Technology, Solok Regency, West Sumatra Province, from May to December 2019. The altitude of Sukarami Field Station is 984 m above sea level (asl) with soil nutrients in research site were pH H$_2$O (5.4), pH KCl (4.97), C-organic (4.22%), N Kjeldhal (0.48%), P$_2$O$_5$ Bray I (19.7 ppm), K-dd (1.14 Cmol/kg) and C/N 8.79.

The experiment used On Farm Research (OFAR) approach. Four treatments with six replication were applied in random block design. Experiments were carried out on plots with a size of 35 x 1 m, distance between plots of 30 cm and distance between replications of 60 cm. The treatments are (1) Proliga cultivation technology using Kopay Variety (Proliga Kopay), (2) Proliga cultivation technology using Kencana Variety (Proliga Kencana), (3) Proliga cultivation technology using Sukarami Variety (Proliga Sukarami), and (4) Farmer’s cultivation technology using Sukarami Variety as control (Farmer’s Tech. Sukarami).

Variables observed were growth components (plant height, stem diameter, number of main branches per plant); chilies yield characteristics (fruit length, fruit diameter, number of fruit per plant); and chilies yield (kg/ha). These data were tabulated and analysed using variance analysis and advance analysis using Duncan’s Multiple Range Test (DMRT) at the 5% significance level. In addition, farming input and output data were also collected and analysed to assess the farming feasibility by Revenue Cost Ratio (R/C) and Margin Benefit Cost Ratio (MBCR) analysis [10].

Technology components applied in Proliga cultivation technology and in Farmer’s cultivation technology can be seen in table 1.
Table 1. Technology components applied in proliga cultivation technology and in farmers cultivation technology.

| Proliga cultivation technology                                                                 | Farmers cultivation technology                                                                 |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| 1. High Yielding Variety (Kopay Variety; Kencana Variety and Sukarami Local Variety)          | 1. High Yielding Variety (Sukarami Local Variety)                                            |
| 2. Healthy nursery using chiffon cloth covering, sterilization using insecticides, installation of yellow sticky traps to monitor the population of Bemisia tabaci (whitefly) until the population was zero, and at the age of 3 weeks pinching was finished | 2. Healthy nursery using chiffon cloth, sterilization using pesticide and installation of yellow sticky trap to monitor *Bemisia tabaci* (whitefly) population until zero |
| 3. Plant population around 30,000 plants/ha using zig-zag system with spacing 50 x 70 cm, in one hole 2 plants are planted, then the next hole is 1 plant. Zigzag planting method aims to prevent sun light from being obstructed and air circulation is not disturbed | 3. Plant population around 20,000 plants/ha with spacing 50 x 70 cm, one seed per planting hole |
| 4. Water, nutrients and soil management with basic fertilizer using cow manure (20 t/ha), dolomite lime (2 t/ha), NPK (16-16-16) (600 kg/ha) given two weeks prior to planting and covered with silver black plastic mulch. It then was followed by NPK fertilizer (16-16-16) about 300 kg/ha and given by cast (fertilizer dissolved in water about 10-20 g/l) and then poured into the planting hole as much as 100-200 ml/plant started in 4 weeks after planting at interval of every 10-14 days. | 4. Water, nutrients and soil management using basic fertilizer with cow manure (10 t/ha), dolomite (0.5 t/ha), NPK (16-16-16) (500 kg/ha) given two weeks prior to planting and covered with silver black plastic mulch. It was then followed by NPK fertilizer (16-16-16) (250 kg/ha) and given by cast (fertilizer dissolved in water about 10-20 g/l and then poured into the planting hole as much as 100-200 ml/plant started in 4 weeks after planting at interval of every 10-14 days |
| 5. Pest and diseases controlling by planting corn as a trap crop around the planting areas, installing yellow sticky traps, routine observation, removing plants attacked by systemic diseases alongside with applying chemical and biological pesticides based on control thresholds. | 5. Pests and diseases controlling using chemical pesticide application once a week. |

3. Results and discussion

3.1. Growth components
All of the growth components of Proliga Sukarami is higher than Farmers Tech. Sukarami, this proves that Proliga cultivation Technology improves performance of growth components (table 2). This is because the cow manure provision can improve soil chemical and physical so that the growth, components and crop yield increased [11]. Likewise, [12] mentioned that 2 ton/ha of dolomite can improve plant growth because of the improvement of soil ph and growth environment.

Performance of components growth of Proliga Kopay and Proliga Kencana are not significantly different with Farmers Tech Sukarami except for Number of Branches per Plant components, where Proliga Kopay is significantly lower and Proliga Kencana is significantly higher than Farmers Tech. Sukarami. This is because the Kopay variety can only adapt well at medium to high altitudes (400 - 814 m asl) [13] and the Kencana variety can only adapt well at medium altitude (510 - 550 m asl) [14].
Table 2. The performance of growth components.

| Treatments          | Plant height (cm) | Stem diameter (cm) | Number of branches per plant |
|---------------------|-------------------|--------------------|------------------------------|
| ‘Proliga’ Kopay     | 77.5 b            | 1.19 b             | 6.3 c                       |
| ‘Proliga’ Kencana   | 71.0 c            | 1.21 b             | 8.3 a                       |
| ‘Proliga’ Sukarami  | 88.1 a            | 1.37 a             | 8.2 a                       |
| Farmers Tech. Sukarami | 75.3 bc   | 1.20 b             | 7.4 b                       |
| KK (%)              | 4.66              | 10.46              | 7.63                        |

The numbers in each column followed by the same lowercase letter are not significantly different at the 0.05 DMRT level.

3.2. Chilies yield characteristics

Performance of chilies yield characteristics, the longest fruit and the largest fruit diameter were found in the Proliga Kopay treatment which was significantly different from other treatments. While the highest number of fruit per plant was obtained in the Proliga Sukarami treatment but it was not significantly different from the Farmers Tech Sukarami treatment. This is thought to be due to the dominance of the genetic influence of varieties on the yield components of red chilies.

The mismatch of the experimental land height for Kopay and Kencana varieties caused the two varieties to not develop properly. Performance components of fruit length and fruit diameter of Kopay varieties are lower than their potential, 28 - 33 cm for fruit length and 1.0 - 1.2 cm for fruit diameter [13]. While the Kencana variety has a performance component, the number of fruits per plant is lower than its potential 141 - 289 fruits [14].

Table 3. Characteristics of chilies yield.

| Treatments          | Fruit length (cm) | Fruit diameter (cm) | Number of fruits per plant |
|---------------------|-------------------|---------------------|----------------------------|
| ‘Proliga’ Kopay     | 20.87 a           | 0.968 a             | 52.17 c                    |
| ‘Proliga’ Kencana   | 13.56 c           | 0.854 b             | 71.00 b                    |
| ‘Proliga’ Sukarami  | 15.65 b           | 0.832 b             | 101.80 a                   |
| Farmers Tech. Sukarami | 15.89 b    | 0.851 b             | 85.83 ab                   |
| KK (%)              | 9.69              | 6.97                | 19.39                      |

The numbers in each column followed by the same lowercase letter are not significantly different at the 0.05 DMRT level.

3.3. Chilies yields

Proliga Sukarami treatment gave 57.4% higher yields than the Farmers Tech Sukarami treatment. This indicates that the Proliga cultivation technology is able to increase the production of red chilies. This is in accordance with the results of research conducted by [15] that the provision of manure ranges from 20 - 30 ton/ha combined with N fertilizer (150-200 kg/ha), P₂O₅ (100-150 kg/ha), and K₂O. (100-150 kg/ha) can increase the yield of red chilies. Likewise, giving lime as much as 2 t/ha can increase the yield of red chilies [12].

Table 4. The performance of chilies yield.

| Treatments          | Fruit yield (kg/ha) | Increasing of fruit yield (%) |
|---------------------|---------------------|-------------------------------|
| ‘Proliga’ Kopay     | 9,009 b             | 33.7                          |
| ‘Proliga’ Kencana   | 6,812 c             | 1.1                           |
| ‘Proliga’ Sukarami  | 10,605 a            | 57.4                          |
| Farmers tech. Sukarami | 6,736 c  | -                             |
| CV (%)              | 4.67                | -                             |

The numbers in each column followed by the same lowercase letter are not significantly different at the 0.05 DMRT level.
Proliga Kopay treatment and Proliga Kencana treatment also gave higher yields than Farmers Tech. Sukarami treatment. However, the production levels achieved by Kopay Proliga (9,009 tons/ha) and Proliga Kencana (6,812 tons/ha) are still below the potential production of the two varieties. The production potential of the Kopay variety is 18.21 tons/ha, while the Kencana variety has 12.1-22.9 tons/ha. This is due to the mismatch of the height of the experimental area (984 m asl) with the characteristics of the Kopay variety which is suitable at an altitude of 400-814 m asl and the Kencana variety which is suitable at an altitude of 510-550 m asl.

3.4. Technological feasibility analysis
All Technology, Proliga Kopay, Proliga Kencana, Proliga Sukarami and Farmers Tech. Sukarami, economically feasible with an R/C value above one. The largest income is obtained through Proliga Sukarami technology, amounting to IDR 70.36 million/ha with an R/C value of 1.51. The Proliga Sukarami cultivation technology compared to the farmers cultivation technology (Farmers Tech. Sukarami) gave an MBCR value of 2.36. This means each additional investment of IDR 1 on the Proliga Sukarami technology will result in an additional income of 2.36 IDR compared to farmers technology (Farmers Tech. Sukarami). Kopay Proliga cultivation technology compared to the farmers cultivation technology (Farmers Tech. Sukarami) also provides an MBCR value greater than one (1.32) but smaller than the Proliga Sukarami technology.

Table 5. Technological feasibility analysis.

| Treatments         | Farming input costs ( IDR 000/ ha) | Total revenue ( IDR 000/ ha) | Income ( IDR 000/ ha) | R/C  | MBCR |
|--------------------|------------------------------------|-----------------------------|------------------------|------|------|
|                    | Production inputs | Labors | Total                |                  |      |      |
| ‘Proliga’ Kopay    | 56,667               | 79,010 | 135,677              | 177,927           | 42,250 | 1.31  | 1.32  |
| ‘Proliga’ Kencana  | 55,167               | 73,900 | 129,067              | 134,537           | 5,470  | 1.04  | -0.88 |
| ‘Proliga’ Sukarami  | 56,367               | 82,720 | 139,087              | 209,448           | 70,361 | 1.51  | 2.36  |
| Farmers Tech. Sukarami | 43,117               | 73,200 | 116,317              | 133,036           | 16,719 | 1.14  | -     |

Annotation: The market price for red chili = 19,750 IDR/kg

4. Conclusions
The application of Proliga technology in red chilies farming in Solok Regency, West Sumatra Province increases the yield of chili products obtained compared to the cultivation technology applied by farmers. The largest increase in yields and income was obtained through the application of Proliga technology with the local variety Sukarami (Proliga Sukarami), with a revenue value of 209,448 million IDR/ha or an increase of 57.44% compared to the income from the cultivation technology applied by farmers with the local variety Sukarami (Farmers Tech. Sukarami). The R/C and MBCR values of the Proliga Sukarami technology are 1.51 and 2.36 respectively.

References
[1] Yanuarti and Afsari 2016 Profil Komoditas Barang Kebutuhan Pokok dan Barang Penting: Komoditas Cabai [Commodity Profiles of Basic Needs and Important Items: Commodities of Chili] (Jakarta: Kementerian Perdagangan)
[2] BPS 2020 Provinsi Sumatera Barat dalam angka [West Sumatera Province in figure] (Sumatera Barat: Biro Pusat Statistik [Central Bureau of Statistics])
[3] Ditjen Hortikultura 2020 Luas panen dan produksi cabai besar menurut provinsi tahun 2015 - 2019 [Harvested area and production of chili by province 2015 - 2019] (Jakarta: Direktorat Jenderal Hortikultura [Directorate General of Horticulture])
[4] Atman 2020 Teknologi Produksi Lipat Ganda (Proliga) Spesifik Sumatera Barat [Multiple Production Technology (Proliga) Specific to West Sumatra] (Sumatera Barat: BPTP Sumatera
Barat)  

[5] Nurnina N and Amran M 2011 Bioekologi dan pengendalian pengorok daun Liriomyza chinensis Kato (Diptera: Agromyzidae) pada bawang merah [Bioecology and control of Liriomyza chinensis Kato (Diptera: Agromyzidae) in shallots] J Litbang Pertan 30 4 pp 148–55  

[6] Setiawati W, Sumarni N, Koesandriani Y, Hasyim A, Uhan T S and Sutarya R 2016 Penerapan teknologi pengendalian hama terpadu pada tanaman cabai merah untuk mitigasi dampak perubahan iklim [Application of integrated pest control technology in red chili plants to mitigate the impacts of climate change] J. Hortik 2 3 2 pp 174  

[7] Wiryanta B T 2002 Bertanam Cabai pada Musim Hujan [Planting Chilies in the Rainy Season] (Jakarta: Agromedia Pustaka)  

[8] Sumarni N and Muharam A 2005 Budidaya Tanaman Cabai Merah [Cultivation of Red Chilies] (Bandung: Balai Penelitian Tanaman Sayuran [Vegetable Crops Research Institute])  

[9] BPTPAceh 2016 Petunjuk Teknis Cabai Merah [Red Chili Technical Instructions] (Aceh: Balai Pengkajian Teknologi Pertanian [Agricultural Technology Research Center])  

[10] Widyastuti D E, Ibrahim J T, A. Winaya and Sukorini H 2019 Financial feasibility analysis of red chili pepper seedling at Karanganyar, Poncokusumo, Malang INSIST  

[11] Pasang Y, Jayadi M and Rimanewsati 2019 Peningkatan unsur hara fosfor tanah ultisol melalui pemberian pupuk kandang, kompos dan pelet [Increase in ultisol soil phosphorus nutrients through the application of manure, compost and pellets] J Ecosolum 8 2 pp 86–96  

[12] Koesrini and William E 2006 Pengaruh pemberian bahan amelioran terhadap pertumbuhan dan hasil cabai merah (Capsicum annum L.) di lahan sulfat masam [Effect of ameliorant on growth and yield of red chili (Capsicum annum L.) in acid sulphate soils] Indonesian J. Agron 34 3 pp 153–9  

[13] Kementan 2009 Deskripsi Cabai Keriting Varietas Kopay [Description of the Kopay Variety of Curly Chilies] (Jakarta: Kementerian Pertanian [Ministry of Agriculture])  

[14] Kementan 2011 Deskripsi Cabai Keriting Varietas Kencana [Description of the Kencana Variety of Curly Chilies] (Jakarta: Kementerian Pertanian [Ministry of Agriculture])  

[15] Sumarni N, Rosliani R and Duria A 2010 Pengelolaan fisik, kimia, dan biologi tanah untuk meningkatkan kesuburan lahan dan hasil cabai merah [Physical, chemical, and biological management of soil to increase soil fertility and yield of red chilies] J Hortik 20 2