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Implementing *Proliga* Technology and Using Superior Varieties to Increase Red Chili Productivity in South Sumatra

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ABSTRACT

South Sumatra's red chili productivity remains significantly lower than the national average. The major location of red chili development, such as Ogan Ilir Regency, has red-yellow podzolic soil lacking in P, K, and organic matter, as well as pest and disease attacks. Therefore, efforts are needed to increase the yield of red chili in South Sumatra. This study aims to use Proliga technology to increase red chili productivity in South Sumatra. The investigation was conducted on a farmers' field with a demonstration plot of ± 6000 m2. The study used a non-factorial Randomized Block Design, with four treatments and five replications. Three chili varieties (Tanjung-2, Lembang-1, and Ayu) were treated with Proliga technology, whereas one control plot used the Ayu variety (an existing variety) with the farmer technique (conventional). The results showed that using Proliga red chili technology resulted in higher red chili productivity than existing farmer technology. The increase in red chile productivity applying Proliga technology reached from 48.44 to 167.19%. This highlights that Proliga technology is more effective in increasing red chili production on red-yellow podzolic soils when using locally adapted varieties.

Keywords: Conventional, Proliga, productivity, red chili, superior varieties

Introduction

The productivity of red chili in South Sumatra from 2018 to 2023 decreased by 18.6%, with a production range of 6.39 t/ha (BPS Provinsi Sumatera Selatan, 2018), and around 5.2 t/ha (BPS Provinsi Sumatera Selatan, 2023). This productivity is still much lower than the national productivity of 10.2 t/ha (Murdhiani et al., 2021). The potential yield of red chili can reach 20-40 t/ha (Sari et al., 2018). Marpaung et al. (2016) stated that one of the causes of low chili productivity in South Sumatra is the characteristics of chili planting areas, which are dominated by red-yellow podzolic soil types. Other problems faced by farmers include relatively low farmer knowledge, limited capital, narrow cultivated land, and a lack of farmer skills.

Lands dominated by red-yellow podzolic soils have low soil fertility as indicated by low organic matter, low macronutrient content such as phosphorus and potassium, and pest and disease infestation (Berihun et al., 2017). Some of the problems in using red-yellow podzolic soils for crop production are low CEC values (Hale et al., 2020; Maftu'ah & Indrayati, 2013), low soil pH (4.1-4.8) (Hale et al., 2020; Mamondol & Meringgi, 2022; Ramadhani et al., 2015), low essential nutrient content, low availability of P and Mo (Mamondol & Meringgi, 2022; Ramadhani et al., 2015), high solubility of Al, Fe and Mn, dominated by kaolinite clay minerals, Fe oxides and Al so

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that the soil has poor properties, low cation exchange capacity and high mineral content, when dissolved, cause cation saturation which is toxic to plants, while the anions are easily fixed so that they are not available to plants (Ramadhani et al., 2015). Acidic soils can reduce crop production by 30-40% (Brown et al., 2008), and as much as 24-59% (Berihun et al., 2017). The low productivity of red chili is not only caused by natural factors, but also by production risk factors, namely the use of production inputs that are not by recommendations, as well as pest and disease attacks (Hiskia, 2021). As a result, the productivity achieved varies and tends to be suboptimal. The application of lime to acid soils significantly increases soil pH and suppresses Al^{3+} concentrations (Hale et al., 2020).

Various efforts have been made to improve cultivation technology to increase the productivity of red chili, including the use of superior and adaptive varieties (Kusmana et al., 2019; Basuki et al., 2014), the application of balanced fertilization between the use of chemical and organic fertilizers (Hapsoh et al., 2017; Dermawan et al., 2019; Yassi et al., 2020), the addition of amendments (Haryati et al., 2020), innovation in irrigation technology (Gencoglan et al., 2006), and integrated pest and disease management (Daryanto et al., 2017). The Agricultural Research and Development Agency has assembled an innovation in red chili cultivation technology, known as the double production technology innovation (*Proliga*). The *Proliga* technology has five technological components that are expected to increase red chili productivity, including: 1) use of superior varieties, 2) increasing plant population by implementing a 2:1 zig-zag planting system, 3) healthy nurseries, 4) management of fertiliser, water and soil, and 5) integrated control of plant pests and diseases. This technology can be applied to optimal and suboptimal soils (Murdhiani et al., 2021).

Several research results show that the application of *Proliga* technology can increase red chili productivity up to 20 t/ha (Atman et al., 2020), 15.81 t/ha to 22.98 t/ha (Triastono et al., 2023). The increase in red chili production is expected to be followed by an increase in farmers' income and welfare. Therefore, the aim of the study is to determine the productivity of red chili in South Sumatra using *Proliga* technology and superior varieties.

Material and Methods

Demplot

Red chili cultivation was carried out by creating a demonstration plot of *Proliga* red chili technology on 0.6 ha of farmer's land in Tanjung Pering Village (3°14'07.9"S 104°38'28.8"E), Indralaya District, Ogan Ilir Regency - South Sumatra. Annual rainfall in Ogan Ilir Regency in 2020-2023 is around 1,953-3,250.8 mm/year.

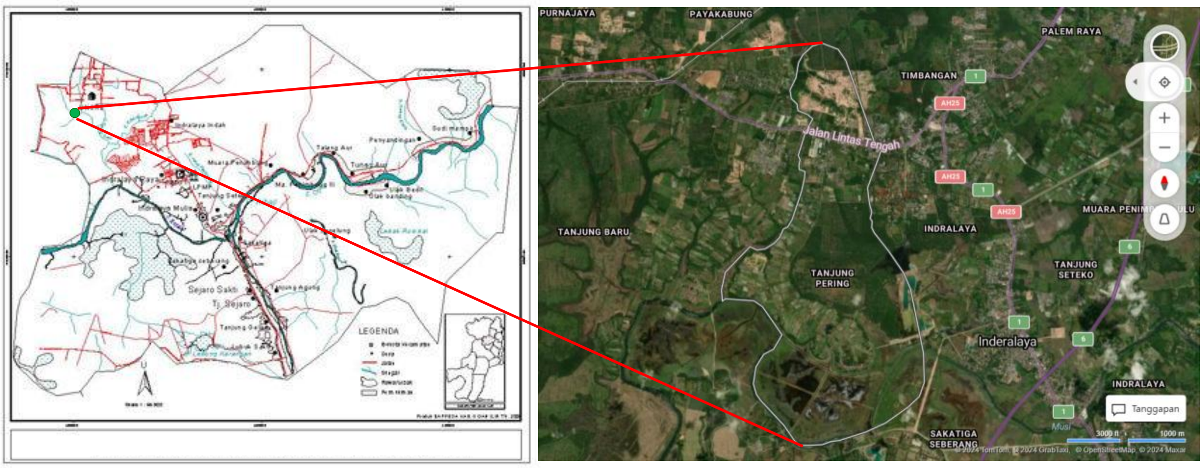


Figure 1. Administrative map of Indralaya District, Ogan Ilir, South Sumatra (left) and Tanjung Pering Village (right)

The study used a non-factorial Randomized Block Design, with four treatments: 1) farmer's existing technology with Ayu varieties (F-A), 2) *Proliga* technology with Ayu varieties (P-A), 3) *Proliga* technology with Tanjung-2 varieties (P-T2), and 4) *Proliga* technology with Lembang-1 varieties (P-L1), and five replications. Three chili varieties (Tanjung-2, Lembang-1, and Ayu) were treated with *Proliga* technology (Table 1), whereas one control plot used the Ayu variety (local superior variety) with the farmer's existing technology (Table 2).

Table 1. Components of Proliga red chili cultivation technology (Atman et al., 2020)

No.	Component	*Proliga* technology
1.	Varieties	Superior varieties
2.	Nursery	
a	Healthy seedlings	Nursery sterilization by spraying insecticide spirotetramat + imidacloprid (1.0 ml/l). The nursery media contains a mixture of soil and manure (1:1). Yellow traps are installed to control *Bemisia tabaci*. Soaking chili seeds for 1 hour in a solution of propamocarb hydrochloride fungicide (1 ml/l). The nursery bed is given a nylon or cotton cover with a density of 50 mesh/cm^2.
b	Chili seedlings	Seeding the chilies was done about 10 days after planting the corn (after the corn seeds had germinated and grown).
3.	Soil, nutrient, and water management	
a	First tillage	The soil is loosened by hoeing/tractor to a depth of 30-40 cm, then exposed to sunlight for 2 weeks. Prepare a 1 m wide area for the bolder plants (corn) surrounding the land. The distance between the corn bolder and chili plants is 1 m.
b	Bolder plant (corn)	Selected corn varieties that are long-lived and tall posture. Planting distance 20 cm x 20 cm with a zig-zag pattern, so that the 1 m wide bolder plant contains 4-5 rows of plants.
c	Second tillage	Make beds 1 m wide and a distance between beds of 50 cm.
d	Liming	Liming is done 30 days before planting. 3 t dolomite ha^{-1} (based on soil analysis) is spread evenly over the bed, then stirred with a hoe, and 2 lines are made along the bed, the distance between lines is 50 cm.
e	Base fertilizer	Applying basic fertilizer into each line. The composition of base fertilizer is 20 t of chicken compost/ha + 500 kg of NPK fertilizer (16:16:16)/ha + 200 kg of ZA/ha.
4	Mulching	Installation of black silver plastic mulch is carried out after applying base fertilizer and closing the lines.
5	Making planting holes	Planting holes are made with a planting distance of 70 x 50/60 x 50 cm with a zig-zag double-row pattern. Mulch holes are made 2 weeks after mulch installation.
6	Planting chili seeds	Chili seedlings were planted 3 days after making the planting hole, done in the afternoon (around 15.00) with a pattern of 2-1-2 seedlings per hole. The population of chili plants increases to 30,000 plants/ha.
7	Shoots pruning	Shoots pruning is done when the plant is 2-3 weeks old after planting.

To be continued…

8	Supplementary fertilization	Supplementary fertilisation composition: 1) 500 kg NPK 16:16:16/ha by dripping, applied after the plant is 1 month old. The fertilizer is dissolved in water (1 kg/100 lt) and then poured into the planting hole about 200 ml per plant. Follow-up fertilizer is done every 10 days. 2) Red KNO_3 fertilizer is dissolved in water (0.25 kg/100 lt water) given 2 times at 30 and 50 DAP. While white KNO_3 is dissolved in water (0.25 kg/100 lt water) given 2 times at 60 and 80 DAP. 3) Allwin Top (2 gr/lt water) is sprayed onto the leaves 4 times: 20, 35, 50, and 65 DAP.
9	Pest and disease control	1) Corn Bolder around the chili field to block *B. tabaci*. 2) Sanitation 3) Removing plants infected with the yellow virus 4) Bio insecticide ATECU is applied once a week and alternated with chemical insecticides such as: Integrate 40 WG and Endure 120 EC 5) Use of pest repellents in the form of a) citronella oil 2 ml/l, sprayed once a week on chili and corn plants, b) camphor: 10 grains per bottle of 500 ml aqua, as many as 40 bottles/ha. 6) Application of Kojo 300 SC, Bion M, Amistar Top fungicides

Table 2. Farmer's existing technology component (Suparwoto & Waluyo, 2022)

No.	Component	Farmer's existing technology
1	Varieties	Local varieties
2	Nursery	Chili seed sowing is done at the same time as soil cultivation
3	Soil, nutrient, and water management	
a	Soil tillage	The soil is loosened by hoeing/tractor to a depth of 30-40 cm. Make beds ± 80 cm wide and a distance between beds of 50 cm.
b	Liming	Liming is done 7 days before planting. 500 kg dolomite/ha is spread evenly over the bed, stirred with a hoe, and made 1 line along the bed.
c	Base fertilization	Base fertilizer was applied to each line. The composition of basic fertilizer is 10 t of chicken manure/ha + 100 kg of NPK/ha + 150 kg Urea/ha + 150 kg SP-36/ha + 500 kg KCl/ha.
4	Mulching	Installation of black silver plastic mulch is carried out after applying basic fertilizer and closing the lines.

To be continued…

5	Making planting holes	Planting holes are made with a planting distance of 70 x 50 cm, with 2 rows in 1 bed. Mulch holes are made 1 week after mulch installation.
6	Planting chili seedlings	Chili seedlings are planted 2 days after making the planting hole, done in the morning (before 09.00) and afternoon (after 15.00), 1 seedling per planting hole.
7	Pest and disease eradication	1). Herbicide spraying 2). Spraying chemical insecticides 3). Application of fungicide

The parameters observed include plant height, fruit number per plant, fruit weight per plant, weight of 100 fruits, yield, soil physical properties (texture), soil chemical properties (pH, soil organic C (SOC), total N, P and K, base saturation (BS), CEC, available P and K, and exchangeable Al)

Data analysis

The data obtained were analyzed using analysis of variance (ANOVA) and continued with the Honestly Significant Differences (HSD) test at 5%, to compare the effect of each treatment. Correlation analysis to see the closeness of the relationship between the parameters analyzed. Data analysis was performed using SAS 9.1.3. Portable.

Results and Discussion

Fertility level of red-yellow podzolic soil at the research site

Based on the results of soil analysis (Table 3), the fertility of red-yellow podzolic soil in Ogan Ilir Regency has a sandy loam texture and has a low fertility level (BS <35%) with limiting factors of available K content, total K, and soil pH. On the other hand, Borchard et al. (2014) found that acidic soils in tropical areas generally have low pH, high available Al^{3+} content, and low cation exchange capacity (CEC), which are the main factors inhibiting plant growth. According to Cai et al. (2015) stated that low soil pH (acidity) can also be caused by excessive and intensive N fertilization.

Table 3. Nutrient conditions in red chili fields in red-yellow podzolic soil

Parameter	Unit	Value	Criteria
Texture			Sandy loam [1]
- Sand	%	65	
- Silt	%	14	
- Clay	%	21	
pH		5.32	Slighly acid [1]
Cation exchangeable capacity	c mol (+) kg^{-1}	18.63	Moderate [2]
Base saturation	%	26.63	Low [2]
Total P	%	53.9	High [2]
Total K	%	6.72	Low [2]
Soil organic Carbon	%	3.78	High [2]
Total N	%	0.21	Moderate [1]
Available K	c mol (+) kg^{-1}	0.16	Low [1]
Available P	mg kg^{-1}	64.53	Very high [1]
Exchangeable Al	%	1.13	Very low [1]

Note: [1]= Eviati; et al. (2023), [2]= Sulaeman & Karolinoerita (2022)

Low pH and total K in the soil can be addressed by returning the remaining rice crop to the land in the form of straw to increase K nutrient levels in the soil, and by applying agricultural lime or other amendments to increase soil pH. The results of the study by Hale et al. (2020) showed that the addition of lime to acid soils significantly increased soil pH. The application of biochar is also very significant in increasing soil pH (Cornelissen et al., 2018; Berihun et al., 2017; Nigussie & Kissi, 2011).

The effect of liming can also overcome phosphorus deficiency caused by iron and aluminium oxide fixation in acidic soils (Yao et al., 2019). The addition of biochar significantly increases total C, N, and K as well as available P and K (Bhattarai et al., 2015). If there is potential for abundant empty oil palm bunches, they can also be used to increase K nutrients in the soil. The very dominant K content in empty oil palm bunches reaches 46.332 mg/kg (Nabila et al., 2023). The supply of NPK fertilizer and compost from empty oil palm bunches can also increase the weight of chilies (Hapsoh et al., 2019).

Growth and red chili productivity

The results of the study showed that the application of *Proliga* technology and the use of superior varieties did not affect the growth of plant height and length of red chili fruit (Figure 1). The average growth of red chili plant height reached 69-79.8 cm, and red chili fruit length reached 12.0-12.7 cm. The results of the correlation analysis also showed that plant height and red chili fruit length did not affect red chili production.

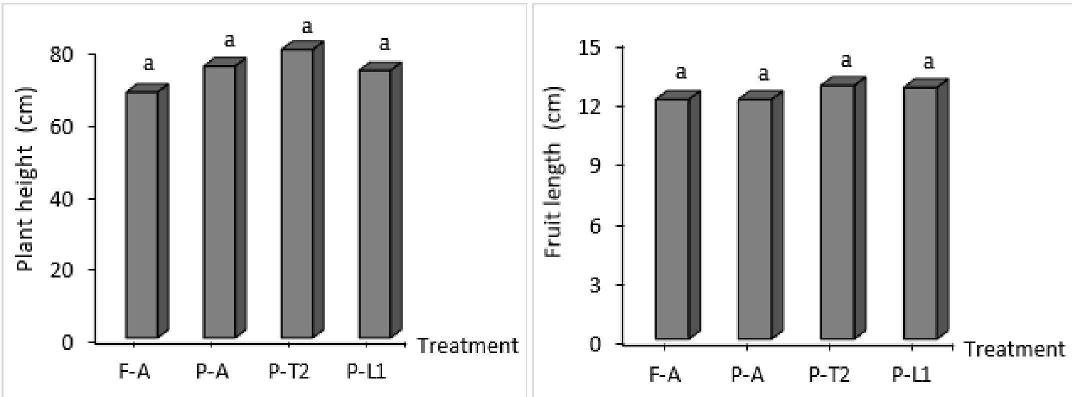
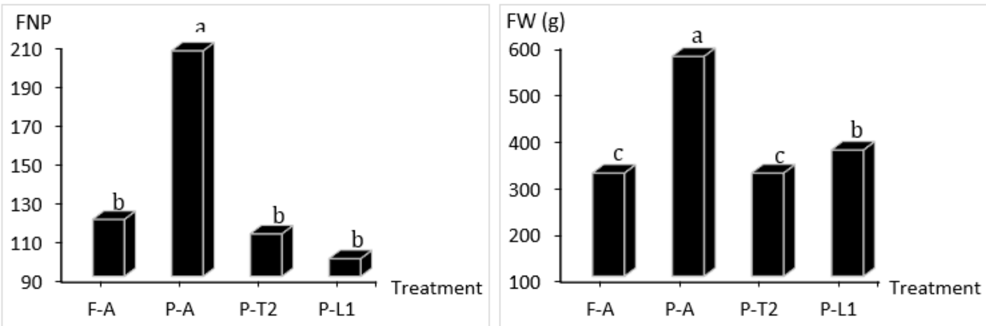


Figure 1. Growth in plant height (left) and fruit length (right) of red chili plants

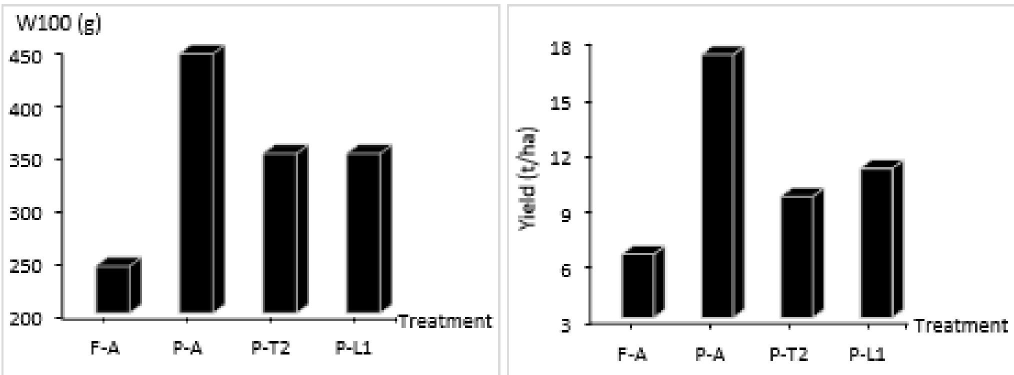


Remark: FNP= Fruit number per plant, FW= fruit weight per plant

Figure 2. Fruit number per plant (left) and fruit weight per plant (right) of red chili plants

The treatment of using superior local and national varieties with *Proliga* technology has a significant effect on the number of fruits per plant, fruit weight, weight of 100 fruits, and red chili production. In Figure 2 and Figure 3, it can be seen that the application of *Proliga* red chili technology using local superior varieties gives the highest results compared to other superior varieties. The farmers' existing technology gives the lowest results compared to other treatments. The application of *Proliga* technology and the use of local superior varieties resulted in red chili production reaching 17.3 t ha^{-1}, while the farmers' existing technology produced 6.3 t ha^{-1}. The results of the study by Sumarno et al. (2021) showed that the superior Dewata F1 chili variety that applied the farmers' existing technology provided a productivity of 6.65 t/ha, while those using *Proliga* red chili technology produced 9.84 t/ha.

The application of *Proliga* technology and the use of superior local varieties can increase the productivity of red chili by 167.19% compared to existing farmer technology. Meanwhile, the application of *Proliga* technology and the use of superior national varieties can increase the productivity of red chili by 48.44-71.88%. This shows that the use of superior local varieties cultivated with the right technology is more capable of increasing the productivity of red chili by 55.45-80.0% compared to the use of new/national superior varieties. The results of the study Triastono et al. (2023) and Rambe et al. (2021) showed that the use of *Proliga* technology was able to increase chili productivity by 87% compared to the existing technology of farmers in Rembang Regency, Central Java, and Batam City, Riau Islands.



Remark: W100 = weight of 100 fruit

Figure 3. Weight of 100 fruits (left) and yield (right) of red chili

Red chili productivity was very significantly positively correlated strongly with fruit number per plant, and very strongly with fruit weight per plant and weight of 100 fruits, with R values respectively of 0.70599; 0.94635; and 0.96016, respectively. Plant height was very significantly positively correlated strongly with sand, silt and clay fractions, total P, available P, cation exchange capacity, and base saturation, with R value of 0.6429-0.6453, and very significantly positively correlated very strongly with soil organic C, total N and K, available K, and exchangeable Al, with an R-value of 0.9930-0.9986 (Table 4). All observed soil parameters are positively correlated with each other, ranging from strong to very strong, with an R-value of 0.6449-0.9996.

Table 4. Correlation analysis between observed parameters

Parameter	FNP	FW	W100	Sand	Silt	Clay	SOC	total N
Yield	0.70599**	0.94635**	0.96016**	ns	ns	ns	ns	ns
FNP		0.79455**	ns	ns	ns	ns	ns	ns
FW			0.83386**	ns	ns	ns	ns	ns
PH				0.6442**	0.6453**	0.6429**	0.9978**	0.9986**

To be continued…

Parameter	total P	total K	available P	available K	CEC	BS	exchangeable Al
Yield	ns	ns	ns	ns	ns	ns	ns
FNP	ns	ns	ns	ns	ns	ns	ns
FW	ns	ns	ns	ns	ns	ns	ns
PH	0.6431**	0.9969**	0.6449**	0.9930**	0.6398**	0.6522**	0.9981**

Remark: **=very significant, ns=not significant, FNP= Fruit number per plant, FW= fruit weight per plant, W100=weight of 100 fruit, SOC=soil organic C, CEC=cation exchange capacity, BS=base saturation, PH=plant heigh

Conclusion

Using *Proliga* red chili technology as well as the cultivation of superior varieties could increase red chili productivity, which has the potential to increase red chili productivity in South Sumatra than existing farmer's technology, reaching 48.44-167.19%. This highlights that *Proliga* technology is more effective in increasing red chili production on red-yellow podzolic soil when using locally adapted varieties.

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