Yield Gap in Cayenne Pepper Production in South Kalimantan

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Abstract. Swampy land is potential land for the development of cayenne pepper. However, there is a yield gap between swamp and dry land plants. The gap in the yield of cayenne pepper plants between dry and dry land is caused by the acidity of the soil in the swamp land which results in low cayenne pepper production

Introduction

Chilli is the most consumed horticultural commodity by the Indonesian people compared to other horticultural commodities [1] and is a horticultural commodity that influences national inflation [2, 3]. This aligns with Presidential Regulation No. 71 of 2015, which designates chili as a staple and essential commodity that affects pricing [3]. One way to prevent chili inflation is by increasing the planting area and production of chili in suboptimal land. The utilization of suboptimal land and the expansion of planting areas, including wetlands, is a strategic choice [4]. The potential of wetlands is vast because the wetland area in Indonesia is approximately 34.12 million hectares, consisting of tidal wetlands covering 8.92 million hectares and swampy wetlands covering 25.20 million hectares [5]. Wetlands are distributed across four islands: Papua (6.31 million hectares), Kalimantan (3.58 million hectares), Sumatra (2.79 million hectares), and Sulawesi (0.61 million hectares). The opened and usable wetlands are in Kalimantan (359,623 hectares), which is the largest area, followed by Sumatra (167,585 hectares), Sulawesi (46,666 hectares), and Papua (5,060 hectares). The largest chili planting area in Kalimantan is located in South Kalimantan Province. 6] report that chili commodities, particularly cayenne pepper (*Capsicum frutescens* L), frequently drive economic inflation in South Kalimantan. The highest planting area for cayenne pepper in Kalimantan is in South Kalimantan Province.

The potential of cayenne pepper in South Kalimantan

The data presented in Table 1 indicates that the production and harvested area of cayenne pepper in South Kalimantan have increased over the last 20 years, in line with the growing population. The average consumption of cayenne pepper per capita per year ranges from 0.8 to 0.9 kg [7]. The increased production of cayenne pepper in South Kalimantan has contributed to the overall national production of cayenne pepper, even though South Kalimantan is not among the top ten provinces for cayenne pepper production at the national level.

Table 1. Data of harvested area (ha), production (ton), population and consumption of cayenne pepper in South Kalimantan

No	Year	Harvested area (ha)	Production (tons)	Population (people)
1	2021	2.070	11.757,7	4.122.576
2	2020	2.329	17.476,3	4.073.584
3	2019	2.428	13.768,0	4.244.096
4	2018	2.462	12.670,6	4.182.695
5	2017	2.456	11.849	4.119.794
6	2016	2.617	1.139	4.055,500
7	2015	1961	4.789	3.989,800

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8	2014	811	3.606	3.922.790
9	2013	728	2.624	3.854.485
10	2012	590	2.184	3.790.071
11	2011	659	2.504	3.695.124
12	2010	768	3.191	3.626.116
13	2009	820	3.606	3.496.125
14	2008	1.103	5.833	3.446.631
15	2007	722	6.126	3.396.680
16	2006	668	4.436	3. 250.100
17	2005	423	2.441	3. 250.100
18	2004	600	1.870,7	3.219.398
19	2003	1.140	4.428	3.201.962
20	2002	1.249	1.706	3.054.129

Source of data : Kalimantan Selatan Province in Figures 2002-2021[8]

The potential for dry land in South Kalimantan is approximately 2.65 million hectares. The suitable dry land for agriculture is 688,032 hectares, which accounts for about 18.34[9]. Out of this, 1,450 hectares are designated for bird's eye chili cultivation, and the rest is allocated for food crops (such as corn, upland rice, soybeans, cassava), plantations (rubber), and other uses. The dominant uses of dry land are for food crops and plantation commodities.
On the other hand, South Kalimantan has approximately 1.1 million hectares of wetland, with swampy wetlands covering about 47.66% of this area, spread throughout the region (see Table 2). Noorginayuwati & Rina (2006) [10]mention that swampy wetlands can be an alternative land for agricultural use. The utilization of swampy wetlands is highly strategic, especially considering the shrinking agricultural land due to paddy field conversion and the increasing demand for food and other agricultural products driven by the growing population.

Table 2. The potential area of South Kalimantan swamp land based on land type and district/city

	District/City	**Swampland area (ha)**			**Persentation (%)**
		Tidal swamp	**Swampy**	**Total**	
1.	Barito Kuala	226.904,1	1.017,7	227.921,8	20,69
2.	Tapin	37.295,4	118.197,4	155.492,8	14,11
3.	Kotabaru	141.067,1	5.026,2	146.093,3	13,26
4.	Banjar	74.275,6	62.244,3	136.519,9	12,39
5.	Hulu Sungai Selatan	-	103.893,0	103.893,0	9,43
6.	Tanah Laut	56.431,4	30.936,3	87.367,7	7,93
7.	Hulu Sungai Utara	-	85.469,6	85.469,6	7,76
8.	Tanah Bumbu	39.291,4	16.315,5	55.606,9	5,05
9.	Hulu Sungai Tengah	-	51.823,8	51.823,8	4,70
10.	Tabalong	-	23.223,1	23.223,1	2,11
11.	Banjarbaru	-	13.462,5	13.462,5	1,22
12.	Balangan	-	12.622,8	12.622,8	1,15
13.	Banjarmasin	1.387,9	346,9	2.184,8	0,20

Kalsel Persentase (%)	*576.652,9 52,34*	*525.029,0 47,66*	*1.101.681, 9 100,00*	

Source of data : Mawardi *et al* (2019)[11]

The Gap in cayenne pepper production in swampy land vs dry

Cayenne pepper cultivation in dry land is carried out during the rainy season while cayenne pepper cultivation in swampy land is carried out during the dry season. Planting cayenne pepper in the dry season and rainy season can prevent chili production from being abundant in one season and scarce in another. However, when viewed from the value of productivity, there is a fairly deep gap between the productivity of cayenne pepper in dry land and swampy land (Table 3).

Table 3. Harvested area (ha), Production and Productivity of Cayenne Pepper base on Land Type in South Kalimantan Selatan in 2021-2022

Land Type	Harvested area (ha)	Production (tons)	Productivity (ton ha^{-1})
Swampy lands	274.3	1097.49	4.00
Tidal swamp land	137.9	284.39	2.06
Dryland	1450.07	9002.2	6.2
Irrigated land	6.45	15.09	2.34

Source of data : result of author survey

The results of a study of the gap in production and productivity of cayenne pepper between the swamp land and the dry land are thought to be caused by soil acidity (Table 4). This soil acidity causes flower loss due to infertile pollen. Soil acidity causes nutrients to become less available [12]

Tabel 4. a. Soil pH in swampy lands in South Kalimantan and Central Kalimantan

Locations	Pulau Damar	Rawa Belanti	Danau Panggang	Sungai Duriat	Kalumpang	Tawar
pH (H2O)	4,50	4,30	4,20	4,10	4,40	4,73

Source : Arifin *et al* (2006)[13]

Tabel 4. b. Soil pH in swampy lands in South Kalimantan

Locations	Panggang Marak*	Muning**	Hiyung[1]	Hiyung [2]	Hiyung [3]
pH/year	2016	2015	2014	2022	2022
pH (H2O)	4,37	3.84	3,84	3,15	4,83

Sumber :
*Yasin *et al*. (2019). [14]
** Pramudyani and Pramesti (2016). [15]
Hiyung 1 : Pramudyani *et al* (2019)[16]
Hiyung 2 & 3 : soil tes result by author in soil laboratory of BSIP swamp land

Tabel 4. c. Soil pH in dry land of South Kalimantan

Locations	Tampunang[1]	Kunyit[2]	Karangrejo[3]	Harapan Masa[4]	Sabah[5]	Asam randah[6]	
pH/year	2014	2015	2015	2016	2016	2019	2019

pH (H2O)	5,19	4,82	5,75	5,12	5,55	5,37	6,89

Sources :
[1,2,3] Pramudyani *et al* (2019). [16]
[4]Pramudyani *et al*. (2020). [17]
[5]Sabur *et al*. (2021)[18]
[6]Pramudyani *et al*. (2019). [19]

Tabel 4. d. Profile of conditions above ground swampy land vs dryland

	Swampy land	**dryland**
Water sources	Rain	Rain
Planting time	Affected by water condition	Affected by water condition
Land contour	Like a plate	flat
Weeds	many	many
Cropping system	Monoculture/polyculture	Monoculture/polyculture
Farmer behavior	diverse	diverse

Soil acidity (soil pH) has an effect on ion solubility and potential for phytotoxicity [20]The availability of micronutrients and toxic ions present in soil solution as cations, for example Al^{3+}, Mn^{2+} and Fe^{2+} increases with increasing soil acidity [21,22], while the availability of anions MoO_4^{2-}, CrO_4^{2-}, SeO_4^{-}, SeO_3^{-} and $B(OH)_4^{-}$ increase with increasing soil pH [23,24]. The results of the soil test (Table 3) showed that the pH of the soil in swampland was 3.15 – 4.83 with a very acid to acidic level, while the pH of the soil in dry land tended to be neutral (Table 4). Manganese oxide dissolves at pH 5.5 and releases Mn^{2+} into the soil solution [25]; [21]. The Fe^{2+} cation becomes the dominant ion in the soil at a pH of less than 3.8. Soil pH less than 3.2 causes H^{+} and Fe_2^{+} ions to be the main ions that can be exchanged [24]. Fe toxicity can occur only in highly acidic soils (pH<3.2) or soils contaminated with Fe-containing waste materials or under anaerobic conditions [26, 22]. Manganese toxicity occurs at soil acidity (pH 5.5) if sufficient amounts of Mn are present in the soil and also at higher pH in poorly drained soils where reducing conditions prevail [25,21,22]. Cayenne pepper planting was carried out using a surjan system and in non-flooded conditions so that the possibility of Fe, Mn and Al toxicity was very small. Decreasing soil pH conditions causes the availability and mobility of Cu metal ions to increase, but Cu ions are immobile in plants and tend to be deposited in roots [27]. Cu toxicity in plants promotes changes in root cell membrane permeability, expression of membrane phosphorus (P) transporters, volume, and root area, which results in lower P uptake [28]. Cu toxicity is not directly related to flower abortion or flower pollen growth. Micronutrients related to pollen growth are boron and silica. Growth of the pollen tube takes place through elongation of the tip and can be affected by many factors, including temperature, the osmolarity of the medium and the availability of calcium, zinc and boron [29,30]The pollen tube is a system that grows fast and is sensitive to boron deficiency [31]. Boron deficiency affects the distribution of acid pectin. Because pectin acid can increase tube strength and decrease extensibility by aggregating Ca^{2+} [32,33] Accumulation of pectin acid at the pollen tube end can increase rigidity and decrease the extensibility of the pollen tube wall, causing a slowdown or complete stop of pollen tube elongation. From the results of this study it was concluded that chili flower loss is caused by a deficiency of boron nutrients. Boron availability for plants decreases with increasing soil pH, especially above pH 6.5. However, in very acid soils (pH less than 5.0) boron availability is low due to absorption of boron onto the surface of iron and aluminum oxides from soil minerals. The results of the soil test (Table 5) showed that the boron content in the lebak swamp soil was low.

Tabel 5. Level of silica and boron in swampy land Hiyung village Tapin District

Soil sample	Nutrition	Unit	simplo	duplo	Criteria
Soil sample	Silika (SiO_2)	%	4,17	4,23	Low
	Boron (B)	mg kg^{-1}	1,28	1,24	Very low

Soil sample	Silika (SiO_2)	%	1,86	1,89	Low
	Boron (B)	mg kg^{-1}	1,85	1,87	Very low

Source: soil test result by author in Laboratory Saraswati Indo Genetech (2022)

Summary

Swampland has considerable potential for developing cayenne pepper and increasing national cayenne pepper production. The gap in cayenne pepper production between the swampy land and the dry land is caused by the acidity of the soil in the swampy land. Efforts to increase the production of cayenne pepper in lebak swamp land can be done by improving the soil to reduce the adverse effects of soil acidity.

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