Vol. 4 No. 01 (2024)

Andalasian International Journal of Social and Entrepreneurial Development (AIJSED)

ISSN: 2808-6732 (Online)

Available at: http://aijsed.lppm.unand.ac.id/index.php/aijsed

DOI: https://doi.org/10.25077/aijsed.4.01.15-22.2024

Article

Land Suitability Analysis of Mung Bean Plants (Vigna radiate L.) by Growing Degree Days Method

Delvi Yanti*, Rian Ramanda, Imelda Safitri, Rusnam

Departement of Agricultural Engineering and Biosystem, Andalas University

Article Information

Received : 2024-01-23
Revised : 2024-02-27
Accepted : 2024-03-15
Published: 2024-04-24

Keywords

Keyword: Growing Degree Days, Green Mung Beans, Land Suitability, Scenario, planting

*Corresponding Author

delviyanti@ae.unand.ac.id

Abstract

Mung bean (Vigna radiate L.) is one of the most widely cultivated crops after soybean and peanut. Mung beans (Vigna radiate L.) became one of the crops that experienced a decline in production amid the increase in the area of harvested land in West Sumatra. The purpose of this study was to analyze the level of land suitability of mung bean crops using the Growing Degree Days method in West Sumatra Province. The research method used in this research is Scoring and Overlay using ArcGis 10.5 software. Land suitability analysis is carried out by giving scores to several parameters of land characteristics. The parameters used are slope, land use, rainfall, soil texture and soil pH. Growing Degree Days analysis was conducted by accumulating the daily temperature values of plants based on planting scenarios. These two analyses were combined with Overlay clustering. The results showed that the land area of West Sumatra whose GDD value is optimal for mung bean growth with the level of land suitability in physical characteristics in S1 class is 15,819.29 ha and in S2 class is 877,501.06 ha. Areas that are suitable in terms of physical characteristics and values with an area of > 100 ha are Lima Puluh Kota District, Pasaman District, Solok District, and South Solok District. The best planting time for mung bean based on the planting scenario is from December to March.

INTRODUCTION

West Sumatra Province is one of the central regions of food commodities in Indonesia. The contribution of the agricultural sector in West Sumatra Province, especially the food crop sub-sector, was the largest contributor, amounting to 6.38% in 2020 (BPS West Sumatra Province, 2021). This sub-sector includes rice and secondary crop commodities (corn, green beans, peanuts, soybeans, sweet potatoes and cassava) (BPS Provinsi Sumatera Barat, 2021). West Sumatra Province is a tropical climate area traversed by the equator. The average air temperature ranges from 19-35°C, making West Sumatra suitable for growing crops, one of which is mung beans. The high demand for mung beans, supported by climate and land conditions, means that mung beans have the potential to be exported.

Mung beans (Vigna radiate L.) is one of the most widely cultivated crops after soybeans and peanuts (Simbolon et al., 2019). Based on data on mung bean production in the last 3 years, namely in 2019 it was 340.96 tons, in 2020 it was 296.88 tons and in 2021 it was 241.00 tons with a harvest area in 2019 of 260.60 Ha, in 2020 of 335.70 Ha and in 2021 of 336.90 Ha (BPS West Sumatra Province, 2021). Mung bean production data shows a decrease. This is influenced by several factors, one of which is land suitability for mung bean plants. This condition is evidenced by the harvest area, which increases every year, which is unable to increase the production of mung beans (BPS West Sumatra Province, 2021). In an effort to fulfill the high needs of the community, mung bean production needs

to be increased.

Climate is one of the parameters of land suitability that cannot be improved. Climate has a great influence on plant growth and productivity. Climatic factors that affect the growth of mung bean plants are rainfall, temperature, solar intensity and air humidity (Salimah, 2013). Temperature greatly affects the growth of mung beans, where if the temperature is too high or too low, it will make the growth of mung beans damaged and eventually die. Climate change can cause land degradation (Utami, 2019). Land degradation causes soil nutrient depletion which results in a decrease in mung bean production. Land productivity or mung bean production capability is closely related to land suitability, so it is necessary to analyze land suitability.

Land suitability analysis is usually done by observing the physical aspects of the land (shape of the area, climate, soil type, soil fertility level, type and potential of mung bean plants, hydrology and drainage). Climate conditions that often change make land suitability analysis not sufficiently observed through physical aspects alone, further analysis needs to be done, one of which uses the Growing Degree Days method.

Growing Degree Days (GDD) is a method used to measure the effect of temperature on plant growth and development (Pertiwi, 2018). GDD is the number of degrees above a certain threshold base temperature at which an organism can grow. The data required for GDD analysis is in the form of daily temperature information used to analyze the land suitability of an area by looking at the relationship of temperature to plant growth.

Determining the GDD value of mung bean commodities in each region of West Sumatra is intended to improve effective and efficient management of crop cultivation. Obtaining temperature and accumulative GDD values can then be made spatially and temporally using geographic information systems. The data can be used as one of the bases in deciding the area and time suitable for mung bean commodity cultivation. Accuracy in the application of agricultural cultivation is one of the characteristics of precision farming. The purpose of this research is to determine the level of land suitability for mung bean crops in West Sumatra Province based on GDD spatially and temporally.

RESEARCH METHOD

Location and Time of Research

The research was conducted in West Sumatra Province. Data were processed and analyzed at the Laboratory of Agricultural Land and Water Resources Engineering, Department of Agricultural and Biosystem Engineering, Andalas University. The research was conducted from November 2022 to May 2023.

Research Tools and Materials

The tools used are a laptop that has installed Microsoft Office software, ArcGis 10.5, a smartphone that has installed Geotegging software, and GPS. The data used in this study are:

1. Secondary data in the form of climatological data (daily rainfall and daily temperature) of the West Sumatra region for the last 30 years (1990-2020) used for land suitability analysis and calculation of GDD values and mapping. The data was obtained from the website power.larc.nasa.gov with coordinate points referring to the Water Resources Management Agency (PSDA).
2. Administrative map of West Sumatra region used to determine the research boundaries obtained from website tanahair.indonesia.go.id
3. Slope map of West Sumatra region used for the land suitability analysis process obtained from DEM data processing and downloaded on the website tanahair.indonesia.go.id
4. Soil type map of West Sumatra region used for land suitability analysis process obtained from Indonesia-geospatial.com website.
5. Soil pH map of West Sumatra region used for the land suitability analysis process obtained from the Indonesia-geospatial.com website
6. Land use map of West Sumatra region used for the process of analyzing land suitability obtained from the website tanahair.indonesia.go.id

Research Procedure

The analysis of the land suitability of mung bean plants using the Growing Degree Days method is carried out in several stages, namely analyzing land suitability based on land characteristics, analyzing GDD based on planting time scenarios, and making land suitability maps based on GDD values.

1. Analysis of Land Suitability of Mung Bean Plants Based on Land Characteristics

Analysis of land suitability based on land characteristics is carried out using the matching method,

namely matching and comparing the growing requirements of mung bean plants with land suitability criteria based on MOA No. 79 of 2013. The land suitability class of mung bean plants is expressed in the level of very suitable (S1), suitable (S2), marginally suitable (S3), and unsuitable (N). The parameters analyzed include slope, land use, rainfall, and soil type. Parameter scoring values are in Table 1.

Table 1. Scoring of Land Suitability Parameters for Green Beans (Vigna radiate L.))

No	Variable	Range Variable	Score
1	Slobe (%)	< 3	4
		3-8	3
		8-15	2
		> 15	1
2	Land Use	Tegalan	4
		Rice Field	3
		Plantation	2
		No Variable	1
3	Rainfall (mm)/month	350-600	4
		600-1000	3
		> 1000	2
		< 250	1
4	Soil Texture	Fine, moderately fine, me	4
		Fine, rather fine, medium	3
		Somewhat coarse	2
		coarse	1
5	Soil pH	5,6-7,6	4
		5,4-5,6	3
		< 5,4	2
		No Variable	1

The parameters were given equal and balanced scores, as each parameter is assumed to have the same influence on determining land suitability (Killa, 2020). The parameters were put together by means of spatial superposition (overlay) analysis, which combines the base maps in the research material into a new map with comprehensive information. The range of values for each land suitability class was obtained from clarifying the interval geometry equation. The geometric interval equation (1) is based on Ekaputra, et al. (2021) and the calculation of intervals on land suitability scoring in Table 2.

$$X = \sqrt[n]{B/A} \quad \text{..... (1)}$$

Keterangan:
Description:
X = Variable interval
n = Number of class intervals used (land suitability class)
A = Minimum value of scoring
B = Maximum value of scoring

Tabel 2. Level of Land Suitability Based on Land Characteristics

Classification	Formula	Class
S1	$Ax^3 – Ax^4$	Very Suitable (S1)
S2	$Ax^2 – Ax^3$	Suitable (S2)
S3	$Ax – Ax^2$	Marginal Suitable (S3)
N	$A – Ax$	Not Suitable (N)

2. Analysis of Growing Degree Days (GDD) of Mung Bean Plants

Data processing is carried out to obtain the appropriate GDD value for mung bean plants with equation (2) to determine the GDD value and equation (3) to calculate the accumulated GDD value according to (Malik et al., 2018).

$$Growing\ Degree\ Days\ (°C) = \left[\left(\frac{T_{max}+T_{min}}{2}\right) - T_{base}\right] \quad \text{.....(2)}$$

Description:
GDD = daily growing degree
Tmax = daily maximum air temperature (˚C)
Tmin = daily minimum air temperature (˚C)
Tbase = base temperature of mung bean at 10˚C (Parthasarathy et al., 2013).

Accumulated GDD = ∑ GDD..... (3)

According to Irawati et al. (2021) crops are suitable for planting in the dry season - early rainy season. The age of mung bean plants based on the results of field surveys is ± 100 days. The results of the GDD value obtained are compared with the GDD value of mung beans in the literature. The GDD value that is suitable for mung bean plants according to (Malik et al., 2018) is in the range of 1155 - 1422.

3. Making a Map of Land Suitability for Mung Bean Plants Based on Growing Degree Days (GDD)

The results of the GDD data of mung bean plants obtained for each planting time scenario in the West Sumatra region, then continued with the creation of a GDD land suitability map for each scenario, namely 12 GDD scenario maps. The process of making a map of land suitability for mung bean crops based on GDD was carried out using ArcGis. Land suitability maps based on land characteristics were overlaid with GDD maps.

RESULT AND DISCUSSION

Land Suitability of Green Mung Beans in West Sumatra Province

Mung bean land suitability is divided into four classes, namely S1 (highly suitable), S2 (suitable), S3 (marginally suitable), and N (unsuitable). The results of the analysis of mung bean land suitability in West Sumatra Province are spatially shown in Figure 1 and the area is presented in Table 3.

Table 3. Green Mung Beans Land Suitability based on Land Characteristics

Land Suitability Class	Description	Area (Ha)	Percentage (%)
S1	Very Suitable	102.892,43	2,86
S2	Suitable	1.919.045,77	53,30
S3	Marginal Suitable	840.364,54	23,34
N	Unsuitable	737.851,26	20,50
Total		3.600.154,00	100,00

Based on Table 3, the available land (S1 and S2) for mung bean cultivation is 2,021,938.19 Ha. The level of land suitability in the West Sumatra region in class S1 (very suitable) for mung bean crops amounted to 102,892.43 Ha or 2.86% consisting of dryland agriculture and dryland agriculture mixed with shrubs, with gentle slopes and soil textures that tend to be smooth.

Class S2 (suitable) has an area of 1,919,045.77 Ha or 53.30%. Class S2 mostly consists of dryland agriculture, rice fields, shrubs and secondary dryland forests with soil textures that tend to be fine. Factors affecting the distribution of land suitability class S2 are slope, soil pH, and rainfall. Slope that is too high (sloping land) causes easy erosion or soil erosion, causing nutrients on the land to also erode. The lack of nutrients will cause the growth of mung bean plants to be less than optimal. Land suitability classes S1 and S2 indicate optimal land for mung bean cultivation.

Land suitability class S3 (marginally suitable) has an area of 840,364.54 Ha or 23.34%. The S3 land suitability class mostly consists of primary dryland forests and plantations with steep slopes and very acidic pH. The S3 level indicates that the land is quite suitable for planting mung bean plants, but has many or severe limiting factors that can affect the productivity and development of mung bean plants. Land suitability with class N (unsuitable) with an area of 737,851.26 Ha or 20.50%. This N land suitability class mostly consists of settlement land, swamps, and mangrove forests, with very steep slopes and very acidic pH and protected areas. Land suitability level N indicates that the land is not suitable for mung bean cultivation.

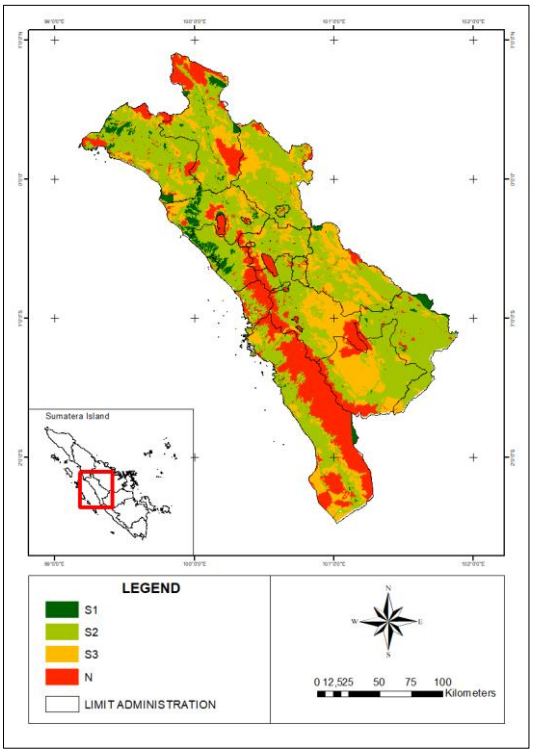

Figure 1. Map of Land Suitability for Green Mung Beans in West Sumatra Province

Table 3 shows that the most dominant land suitability class for mung bean crops in West Sumatra is class S2 (Suitable). Land with class S2 (Suitable) has limiting factors that can be handled without affecting the productivity of the land. Factors affecting the S2 (Suitable) class in mung bean plants such as steep slopes, land use that still includes protected areas (forests), coarse soil texture and acidic soil pH for mung bean plants. The land suitability class used for GDD analysis is S1 and S2 class land based on Regency / City in West Sumatra can be seen in Table 4.

Table 4. Land Suitability Class S1 and S2 for Mung Bean Crops by Regency/City in West Sumatra

District/City	Area (Ha)		Total Area
	S1	S2	
Agam	35.614,72	124.787,40	160.402,12
Bukittinggi	0,00	1.078,73	1.078,73
Dharmasraya	2.486,00	259.973,11	262.459,11
Pariaman City	2.078,06	3.479,07	5.557,13
Solok City	615,52	3.636,55	4.252,07
Lima Puluh Kota	0,65	210.720,97	210.721,62
Padang	263,50	27.495,14	27.758,65
Padang Panjang	0,00	1.347,79	1.347,79
Padang Pariaman	24.095,59	86.282,05	110.377,64
Pasaman	11.927,71	194.063,72	205.991,42
West Pasaman	20.583,05	245.388,71	265.971,76
Payakumbuh	0,00	6.933,79	6.933,79
Pesisir Selatan	3.115,57	188.174,62	191.290,20
Sawahlunto	0,00	17.392,38	17.392,38
Sijunjung	10,47	161.341,51	161.351,98
Solok	1.154,39	138.950,99	140.105,38
South Solok	887,20	166.407,18	167.294,38
Tanah Datar	59,99	81.592,05	81.652,05
Total	102.892,43	1.919.045,77	2.021.938,19

According to BPS (2021), the largest mung bean production in the West Sumatra region is in

West Pasaman Regency. This data is in accordance with the results of the analysis obtained, West Pasaman Regency has the largest suitable land area for mung bean plants covering 265,971.76 Ha. Other areas with a potential land area for mung bean development with an area of more than 200,000 ha are Dharmasraya Regency, Lima Puluh Kota Regency, and Pasaman Regency.

Analysis of Growing Degree Days of Mung Beans in West Sumatra Province

GDD analysis was conducted at each rain gauge station as the observation location because it is considered to be a divider of the area in West Sumatra Province. The GDD value is analyzed based on the beginning of planting time so that there are 12 scenarios analyzed for suitability. The GDD value that is suitable for mung bean plants according to Malik et al., (2018) is in the range of 1155 - 1422 with a harvest age of 100 days. The results of the analysis of the area distribution of the GDD value of mung bean plants can be seen in Table 5.

Table 5. GDD of Green Mung Beans in West Sumatra Planting Scenario (Month) GDD Value GDD Land Area (Ha)

Scenario	Planting Scenario (Month)	GDD Value	GDD Land Area (Ha)	
			Suitable	Not Suitable
Scenario 1	January-April	1.268,21- 1.682,21	1.104.972,00	2.495.182,00
Scenario 2	February-May	1.273,01- 1.680,72	926.084,16	2.674.069,84
Scenario 3	March-June	1.307,39- 1.726,50	204.228,45	3.395.925,55
Scenario 4	April-July	1.288,70- 1.709,70	391.031,35	3.209.122,65
Scenario 5	May-August	1.288,78- 1.717,26	473.247,74	3.126.906,26
Scenario 6	June-September	1.278,47- 1.697,69	1.004.993,84	2.595.160,16
Scenario 7	July-October	1.282,52- 1.681,67	1.142.169,37	2.457.984,63
Scenario 8	August-November	1.292,20- 1.671,64	1.042.029,47	2.558.124,53
Scenario 9	September-December	1.273,97- 1.641,58	1.657.090,55	1.943.063,45
Scenario 10	October –January	1.269,84- 1.647,92	1.646.123,76	1.954.030,24
Scenario 11	November - February	1.261,94- 1.660,92	1.658.172,32	1.941.981,68
Scenario 12	December - March	1.250,19- 1.660,95	1.891.694,22	1.708.459,78

In Table 5, it can be seen that each scenario based on the accumulated GDD value (one growing season) has a different suitable land area. Scenario 12, namely the planting period in December-March, is the best planting time with the largest area of land with GDD values compared to other planting times, which is 1,891,694.22 ha. Land that is suitable for physical characteristics but the GDD value is not suitable for mung bean plant growth is not recommended for mung bean planting.

Land Suitability of Green Mung Beans in West Sumatra Province Based on GDD (Growing Degree Days) Value

Analysis of the suitability of mung bean land based on the value of Growing Degree Days is focused on areas with land suitability classes S1 (very suitable) and S2 (suitable). The results of the analysis of mung bean land suitability based on GDD values can be seen in Table 6.

Table 6. Results of Analysis of Land Suitability of Green Mung Beans Crops Based on the GDD Value of Green Mung Beans Crops in West Sumatra

Scenario	Planting Scenario (Month)	Land suitability in GDD compliant areas (Ha)		Total GDD compliant land area (Ha)
		S1	S2	
Scenario 1	January - April	13.343,50	550.115,41	563.458,91
Scenario 2	February – May	11.378,30	463.754,66	475.132,96
Scenario 3	March - June	1.026,28	99.040,80	100.067,08
Scenario 4	April – July	2.936,09	177.781,13	180.717,21
Scenario 5	May - August	5.348,96	230.786,46	236.135,42
Scenario 6	June - September	13.089,61	498.805,02	511.894,63
Scenario 7	July - October	13.424,37	547.896,81	561.321,18
Scenario 8	August - November	12.373,25	501.552,53	513.925,78
Scenario 9	September - December	15.799,54	796.103,61	811.903,15
Scenario 10	October – January	15.585,57	758.026,78	773.612,35
Scenario 11	November – February	15.743,80	793.613,97	809.357,78
Scenario 12	December - March	15.891,29	877.501,06	893.320,35

The best planting recommendation for mung bean is based on the largest area of suitable land in terms of physical land characteristics and GDD. Large areas of suitable land indicate that the land has great potential for the growth and development of mung bean plants, so that it can increase production. The best planting recommendation is in Scenario 12 with a planting start of December - March. The distribution of S1 and S2 land based on the GDD value of scenario 12 can be seen in Table 7 and spatially in Figure 2.

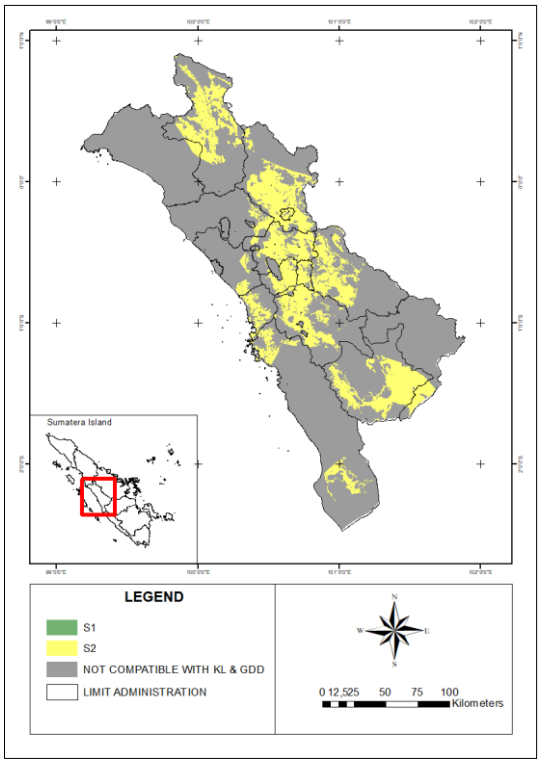

Figure 2. Map of the Best Green Mung Beans Planting Recommendations of West Sumatra Province (December - March Planting Season)

Table 7. Distribution of S1 and S2 Land based on GDD Value (Planting Month December - March)

District/City	Land Suitability in GDD Compliant Areas		Total (S1 & S2) (Ha)
	S1 (Ha)	S2 (Ha)	
Kab.Agam	2.825,52	17.965,87	20.791,39
Kota Bukittinggi	0	396,29	396,29
Kab.Dharmasraya	0	22.215,06	22.215,06
Kota Pariaman	0	0	0,00
Kota Solok	1.169,42	3.695,87	4.865,29
Kab.Lima Puluh Kota	0,66	137.777,26	137.777,92
Kota Padang	267,80	27.477,34	27.745,14
Kota Padang Panjang	0	1.107,29	1.107,29
Kab.Padang Pariaman	0	14.178,65	14.178,65
Kab.Pasaman	9.852,40	133.831,68	143.684,08
Kab.Pasaman Barat	0	9.171,33	9.171,33
Kota Payakumbuh	0	6.423,03	6.423,03
Kab.Pesisir Selatan	347,29	56.078,86	56.426,15
Kota Sawahlunto	0	17.425,58	17.425,58
Kab.Sijunjung	0,09	91.004,48	91.004,57
Kab. Solok	625,57	126.976,43	127.602,00
Kab.Solok Selatan	669,63	129.775,00	130.444,63
Kab Tanah Datar	60,90	82.001,05	82.061,95
Total	15.819,29	877.501,06	893.320,35

Not all areas in West Sumatra are at the level of land suitability in physical characteristics (S1)

and the GDD value is optimal for mung bean growth. The total land with the level of land suitability in physical characteristics in class S1 is 15,819.29 ha and in class S2 is 877,501.06 ha. The area that is not suitable for mung bean development is Pariaman City. Areas that are suitable in terms of physical characteristics and GDD for mung bean growth with an area of > 100 ha are Kab.Lima Puluh Kota, Kab.Pasaman, Kab.Solok, and Kab.Solok Selatan. These areas have extensive potential for mung bean development. In addition to the appropriate land suitability factor, the role of optimum temperature also supports the growth and development of mung bean plants. Mildaerizanti & Retno (2016) stated that temperature has an important role in plant growth, temperature affects the physiological processes of plants such as nutrition, transpiration rate, photosynthesis water absorption rate.

CONCLUSIONS

Based on the results of the research on land suitability analysis of mung bean crops using the Growing Degree Days method in West Sumatra Province, it can be concluded:

1. The area of land in West Sumatra whose GDD value is optimal for mung bean growth with the level of land suitability in physical characteristics in class S1 is 15,819.29 ha and in class S2 is 877,501.06 ha.
2. Areas that are suitable in terms of physical characteristics and values with an area of > 100 ha are Kab.Lima Puluh Kota, Kab.Pasaman, Kab.Solok, and Kab.South Solok. These areas have extensive potential for mung bean development.
3. The best time to plant mung beans based on the planting scenario is from December to March.

REFERENCES

BPS. 2021. Luas Panen, Produksi, dan Produktivitas Kacang Hijau Menurut Provinsi, https://sumbar.bps.go.id/indicator/53/61/1/luas-panen-produksi-dan-produktivitas-kacang-hijau.html, diakses pada 29 Juni 2022

BPS Provinsi Sumatera Barat. 2021. Provinsi Sumatera Barat Dalam Angka 2021.

BMKG. (2022). Prakiraan Musim Hujan 2022/2023 Di Indonesia. 1–69.

Ekaputra, Eri G., Feri A., Fadli I., & Eri S. (2022). Aplikasi GIS di Bidang Pertanian : Bogor. IPB Press

Irawati, E., Fianti, & Nurbaiti, U. 2021. Perbandingan Tanaman Jagung dan Kacang Hijau pada Musim Kekeringan di Grobogan. *17*(1), 18–23.

Killa, Y. M. 2020. Penilaian Kesesuaian Lahan Padi dan Jagung di Kecamatan Lewa Tidahu Kabupaten Sumba Timurn Padi dan Jagung di Kecamatan Lewa Tidahu Kabupaten Sumba Timur. *Savana Cendana*, *5*(04), 72–74.

Malik, S., Sewhag, M., Kumar, P., & Singh, K. 2018. *Yield and Thermal Requirement of Mungbean as Influenced by Planting Methods and Weed Management Practices*. *August*.

Mildaerizanti, & Retno, P. 2016. Pengaruh Cekaman Suhu Rendah terhadap Tanaman. *Jurnal Pengkajian Dan Pengembangan Teknologi Pertanian*, *1*(1), 185–187.

Parthasarathy, U., Nirmal Babu, K., Senthil Kumar, R., Ashis, G. R., Mohan, S., & Parthasarathy, V. A. 2013. Diversity of Indian Garcinia - A medicinally important spice crop in India. *Acta Horticulturae*, *979*, 467–476.

Pertiwi, N. N. I. 2018. Kajian Pertumbuhan, Hasil dan *Growing Degree Days* (GDD) Beberapa Varietas Sorgum (*Sorghum bicolor* L.) di Lahan Tadah Hujan. *Skrispi Program Sarjana Universitas Muhammadiyah Gresik*, *December*, 1–3.

Salimah, C. 2013. Pengaruh Jarak Tanam dan Dosis Pupuk NPK terhadap Pertumbuhan dan Hasil Tanaman Kacang Hijau (*Phaseolus radiatus* L.)

Simbolon, J., Lubis, A., & Jamilah. 2019. Pertumbuhan dan Produksi Kacang Hijau di Ultisol dengan Aplikasi Kompos Cair Ganggang Coklat pada Berbagai Kombinasi N dan K. *Jurnal Agroekoteknologi FP USU*, *7*(2), 246–253.

Utami, D. N. 2019. Kajian Dampak Perubahan Iklim terhadap Degradasi Tanah. *Jurnal Teknologi Reduksi Risiko Bencana*, *3*(2), 122.