https://doi.org/10.1051/e3sconf/202337303003

The impact of weather anomalies on shallot seed production in West Lombok, Indonesia

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Abstract. Shallot (*Allium cepa* L.) is one of the strategic commodities in Indonesia, where the Province of West Nusa Tenggara (NTB) is the third largest shallot-producing area. The main constraint in shallot cultivation is the limited availability of certified seeds and the weather strongly influences the cultivation. This paper discusses the impact of the 2021 weather anomaly on shallot seed production in West Lombok Regency, NTB Province, Indonesia. To produce and supply shallot seeds, the Super Phillip variety was planted in the period of May-June 2021 on farmers' land with an area of 4,000 m^2 of alluvial soil. There was a weather anomaly in June 2021, in the form of high rainy days up to 12 days and an increase in rainfall of 176 mm (414%) above normal, resulting in damage to the bulb enlargement phase and *Fusarium* disease attacks on plants older than 40 days which resulted in harvest failures. This weather anomaly resulted in crop failure and losses in almost 100% of shallot seed production. To anticipate failures and minimize risks to the shallot farming system in the future, it is necessary to learn and transfer technology to interpret rainfall prediction information and design a shallot planting calendar.

1 Introduction

Horticulture plays an important role as one of the sub-sectors in agricultural development where shallot (*Allium cepa* L.) is one of the most important commodities [1]. Shallot belongs to the spice vegetable group and is commonly used as food seasonings [2]. In Indonesia, the shallot is a prominent crop and is grown year-round by nearly a million small-scale farmers [3], therefore shallot is categorized as one of the seven national strategic commodities as it affects farmers' lives, macroeconomy, and inflation rate [1].

The Province of West Nusa Tenggara (NTB) is one of the central areas of shallot production after the provinces of Central Java and East Java. The average productivity of

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shallot in NTB in the last 5 years (2015-2019) reached 11.04 tonnes/ha, still higher than the average productivity of shallot in East Java, Central Java, and West Java which were 8.80, 10.17, and 10.56 tonnes/ha respectively [4]. NTB's contribution to national shallot production is around 12.34% with the harvested area in NTB in 2019 reaching 19,341 ha and production of 184,551.8 tonnes [4]. This productivity is still low because the potential yield of new improved varieties such as Trisula and Bima Brebes ranges from 15 to 23.21 tonnes/ha [5].

Shallot farming is very much influenced by weather conditions. Rainfall patterns, evaporation, water run-off, soil moisture as well as climate variation were volatile as the impact of climate change which can threaten the success of shallot production [6]. The objective of this paper is to investigate the influence of weather anomalies in 2021 on shallot seed production in West Lombok, West Nusa Tenggara (NTB) Province of Indonesia.

2 Materials and methods

This research was conducted from April to August 2021 at the Asahan farmer's group in Gelogor village, Kediri Sub-district, West Lombok Regency, West Nusa Tenggara (NTB) Province of Indonesia. The process of implementing the shallot seed demonstration plot was:

2.1 Land preparation

Tillage was done using a tractor. Tillage aims to create a loose tillage layer, remove weeds or plant debris, remove toxins, and eliminate pests in the soil. Therefore, tillage was carried out in stages and requires sufficient time between stages, which was about 5-7 days. The land reversal was carried out by plowing/hoeing as deep as a minimum of 20-30 cm. The land is left open for one week.

2.2 Application of organic materials and making beds

Decomposed organic matter was applied at a dose of 2 tonnes/ha. This dose was based on the low organic matter on land that is continuously used for cultivation. Organic fertilizer was spread evenly on the soil that has been turned over / on the bed. The beds were made with a width of 100 cm, a distance between beds of 30 cm, and a bed height of 30-40 cm, with the length of the beds adjusted to the conditions of the land.

2.3 Seed preparation and treatment

Planting bulbs can be done directly. Seed treatment for fusarium wilt endemic areas was carried out by sprinkling 100 g of mancozeb fungicide every 100 kg of seed bulbs. Furthermore, the seeds were put in a plastic bag and tightly tied to be stored for 2 days before planting. The shelf life of bulbs was 2 months. Before sowing, seeds were divided into three categories: big bulbs size (B), medium bulbs size (M), and small bulbs size (S).

2.4 Seed sowing

The sowing of shallot seeds was done in the morning. One bulb seed was completely immersed in the soil on the bed. Seeds that were ready for sowing were brought to the field. The seeds were placed in the planting hole with a plant spacing of 15x15, 15x20, and 15x25 cm. The planting hole where the seeds have been placed was then covered with organic fertilizer.

2.5 Fertilization

In the cultivation of vegetable crops, the use of organic fertilizers such as manure or compost is a basic need, in addition to the use of inorganic fertilizers. The time and method of fertilization must be right so that nutrients are available to plants. The fertilization technology package applied is shown in Table 1.

2.6 Irrigation

For early growth (after the shoots grow evenly), watering was done every day until the plants were 30 days old. Furthermore, watering was carried out every 2 days until 5 days before harvest, except in the rainy season it is not necessary to water.

2.7 Weeding

Weeding was done before the supplementary fertilization was applied. Weeds around the plant were weeded from the time of growth until the formation of the bulb. To avoid transmission of infected plant parts are put in sacks and disposed of outside the plant.

2.8 Pest and disease control

Preventive pest control was carried out before pest attacks occur, for example, crop rotation, spacing arrangements, use of resistant varieties, etc. Curative control was carried out after a pest attack occurs, that is, if the population or intensity of the pest attack has reached the control threshold. Prevention of plant pest attacks was done by planting 3-5 rows of corn plants on the edge of the land as a border. In addition, yellow traps were also installed to reduce the population of pests. Systemic fungicide spraying was carried out once a week for the first 3 weeks as a plant defence against pathogens in the early vegetative phase. In the fourth week onwards, a contact fungicide was sprayed (depending on the attacking pathogen). Control of plant pests was carried out by alternating insecticides according to the pests that attack and wisely changing the types of insecticides. Spraying was done in the afternoon (between 16.00 to 18.00).

2.9 Harvest and post-harvest

Shallots were harvested after showing signs of 60% soft stem neck, fallen plants, and yellowing of the leaves. Shallots that have been harvested were then tied to the stem for easy handling. Leaf withering was done by drying the leaves to get a red and shiny bulbs skin (2-3 days) in direct sunlight. Drying was done by drying the onion bulbs in direct sunlight (7-14 days) by turning them every 2-3 days.

2.10 Storage

Storage in a warehouse with adequate ventilation so that air circulation is smooth and humidity is around 65 – 70% and the optimum temperature is 30^{o}C, to obtain net weight (after deducting 60% loss) for seeds.

Table 1. The fertilization package applied at the experimental site in 2021.

Input Components	Dose
Basic fertilizers (applied at one week before sowing):	
Organic fertilizer (kg/ha)	2.000
SP-36 (kg/ha)	250
NPK (kg/ha)	250
Supplementary fertilizers I (applied at 15-20 days after sowing)	
ZA (kg/ha)	200
NPK (kg/ha)	200
Liquid fertilizer/PGPR (liter/ha)	2,5
Supplementary fertilizers II (applied at 30-35 days after sowing)	
NPK (kg/ha)	250
Liquid fertilizer/PGPR (liter/ha)	2,5
Pest and disease control	Pest and disease control with pesticide rotation strategies, lowering the water pH with 20% nitric acid, and spraying at the right time.

3 Results and discussion

3.1 General condition of the experimental site

The morphological condition of Kediri District, West Lombok Regency is a plain morphological unit composed of alluvial deposits consisting of sand, clay, silt, pumice, igneous rock fragments with the size of pebbles and plantation morphology units consisting of lava, breccia, and pumice that make this area potential for sand, backfill, and andesite [7]. The study was conducted in irrigated rice fields at an altitude of 5-50 above sea levels (ASL) with rainfall of 1,602 mm/year (Figure 1) and the soil analysis before sowing is shown in Table 2.

The soil texture of the experimental site is sandy clay loam. This shows that the land has a dominant sand content compared to silt and clay content. If the soil contains too much sand, the soil is not good for plant growth because sandy-textured soil has a small surface area, making it difficult to absorb or retain water and nutrients, and in the dry season, it is easy to lack water [8]. In addition, land with the main characteristic of sand texture has a low nutrient content which is the main obstacle when developed for the cultivation of food and horticultural crops [9]. Shallots require a medium-to-clay texture to facilitate bulbs development, in fact, the experimental site has a medium-to-clay texture. Medium-textured soil has a crumb soil structure with a balanced ratio of solid material and pores [10].

The low clay content at the experimental site affected the low C organic content. This is proven based on the results of the analysis of the C organic content obtained which has a low value. The high content of C organic is influenced by the content of clay, dust, and soil pH and altitude, where the higher the clay content, the higher the C organic content of the soil, then the decrease in C organic is followed by a decrease in the clay content. Low levels of C organic are not suitable for the growth of seasonal crops such as red chilies and shallots, because low C organic indicates low nutrient content, organic matter, and microorganism activities, as well as showing poor soil structure [11]. Soil analysis showed that the soil pH was acidic with a value of 5.27. Onions grown at pH 6.5 resulted in a much greater production of total biomass than onions grown at pH 5.8 [12]. Shallot plants require medium to clay textured soil, good drainage, containing organic matter, and no acidic soil reaction (soil pH: 5.6 - 6.5) [10], whilst onion cultivation requires soil that has a crumb structure, with a medium to clay texture, contains high organic matter, has good drainage and aeration and has a pH 5.6-6.5 [13].

Analysis of N available, namely N-NH_4 and N-NO_3 were classified as low-very low. The low N available became a limiting factor for plant growth, especially in the generative phase. N plays a role in stimulating vegetative growth such as leaves and bulbs in onion plants [14]. Based on CEC data, the experimental site is classified as high. The high value of CEC is influenced by the high value of cations. The soil cation values of K-dd, Na-dd, Ca-dd, and Mg-dd are classified as high – very high. Ca and K cations are in the soil adsorption complex and this value will affect the CEC value [15]. The factor of high rainfall also affects this basic cation. Soil with high CEC can absorb and provide nutrients better than soil with low CEC [15]. The P and K available parameters at the experimental site are classified as very high, and based on the results of the analysis of the micronutrient content that can be changed, Na-dd and Mg-dd contained are also classified as high - very high. The high residues of P and K fertilizers that are quite large are left in the soil as a result of the inefficient application of fertilizer to plants which has negative implications for the environment and health. The availability of sufficient and balanced nutrients can optimize plant growth and development, so that onion crop production is optimal [16].

Table 2. Results of preliminary soil analysis at the experimental site in 2021 [17].

Parameters of Analysis	Unit	Value	Criteria*)	Method
pH H2O	-	5.27	Masam	Electrode pH-meter
N-NH4	ppm	2.26	Low	Destilation
N-NH3	ppm	1.33	Very Low	Destilation
C-Organic	%	1.64	Low	Walkey and Black
Texture	%	54	Sandy clay loam	Hydrometer
Dust texture	%	16		
Clay texture	%	30		
K dd	cmol/kg	1.70	Very high	AAS
Na dd	cmol/kg	1.29	Very high	AAS
Ca dd	cmol/kg	19.62	High	AAS
Mg dd	cmol/kg	2.13	High	AAS
CEC	cmol/kg	32.46	High	Percolation
P available	ppm	39.95	Very high	Morgan Wolf
K available	ppm	61.35	Very high	Morgan Wold

3.2 Shallot growth and yield performances

Some agronomic parameters observed were plant height, number of leaves, and number of bulb/plant. While yield parameters were the number of bulb/plant, the weight of the bulb, and the yield of the sampling plot. The performance of agronomic parameters was shown in Table 3 while yield parameters were shown in Table 4. Plant height during the first and second observations indicated that bigger bulb seed size implicated taller plant height but plant spacing was not significant effect. Bulb seed size also affected the number of leaves where bigger bulb seed sizes tend to produce more leaves (Table 3).

Table 3. Analysis of Variance (ANOVA) of plant height and number of leaves of shallot based on bulb seed size and plant spacing at the experimental site in 2021.

Treatment	Plant Height I (cm)		Plant Height II (cm)		Number of Leaves I		Number of Leaves II	
B 15x15	29.7	a	51.8	a	12.2	ab	45.8	a
B 15x20	24.3	a	47	b	15.2	a	47.4	a
B 15x25	27.7	a	44.6	bc	11.6	ab	35.8	b
M 15x15	17.2	cd	42.2	c	5	c	29.8	c
M 15x20	19.5	bc	41.6	c	7.6	bc	29	b
M 15x25	17.7	cd	42.6	c	4.8	bc	32.2	b
S 15x15	19.6	bc	38	d	3.8	c	13	c
S 15x20	15.7	cd	38	d	4.8	c	14.2	c
S 15x25	17.1	cd	42.3	c	3.4	c	14	c

Table 4. Analysis of Variance (ANOVA) of bulb weight/clump, number of bulbs/clump, and fresh yield of sampling plot at the experimental site in 2021.

Treatment	Bulbs weight/clump (g)		Number of bulbs/clump		Yield of 1 m^2 sampling plot (g)	
B 15x15	41.59	bc	9	a	1,871	bcd
B 15x20	53.17	b	8.4	a	1,861	bcd
B 15x25	52.42	b	8	a	1,467.6	de
M 15x15	42.02	bc	5.2	b	2,059.2	ab
M 15x20	45.49	bc	4.6	bc	1,592	cd
M 15x25	37.01	c	4	bc	1,036	e
S 15x15	41.13	bc	3.4	bc	2,015	abc
S 15x20	66.74	a	2.8	c	2,336	a
S 15x25	36.34	c	2.8	c	1,019	e

Table 4 indicated that bulb seed size and plant spacing did not affect bulb weight/clump whereas small bulb seed size even gave the highest weight of bulbs/clump. However, the number of bulbs/clump was highest from the big bulb seed size even though not different between the plant spacing.

3.3 Weather anomaly during the shallot growing season in 2021

During the shallot growing season in 2021, there was a weather anomaly which is shown in Figure 2. The figure presents fluctuations in rainfall in Kediri Subdistrict, West Lombok Regency in 2021 compared to the 1991-2020 Normal Average value. The bar diagram shows the 2021 rainfall conditions, while the dotted line shows the Normal rainfall fluctuations. It can be seen that based on the Oldeman classification 1975 [18], in 2021, Kediri Subdistrict, West Lombok Regency experienced rainfall fluctuations with 6 wet months with an intensity >= 200 mm/month, 4 dry months with an intensity <100 mm/month, and 2 humid months with rainfall intensity between 100-200 mm/month.

 https://doi.org/10.1051/e3sconf/202337303003

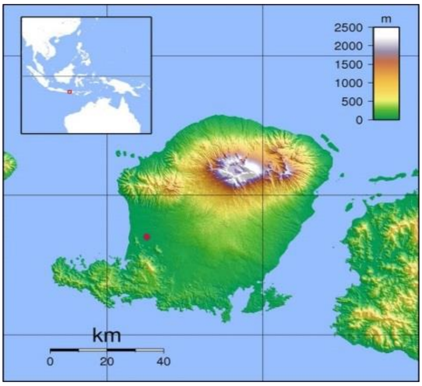

Fig. 1. Map of Lombok Island where the experimental site was in Gelogor Village, West Lombok Regency, West Nusa Tenggara Province with a red dot sign in the South Western part of the map.

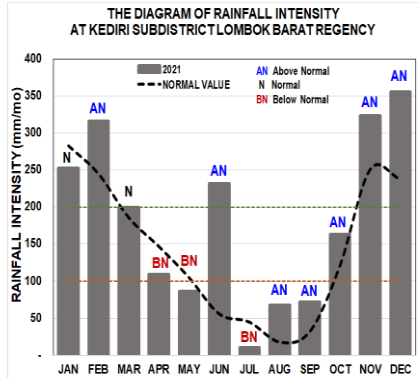

Fig. 2. Rainfall conditions in 2021 in Kediri Subdistrict, West Lombok Regency.

The Oceanic Nino index presented by CPC-NOAA [19] shows that in January-May 2021 the global climate anomaly is La-Nina, then changes to Normal in June-July, and returns to La-Nina which is getting stronger in August-December 2022. Along with the stronger La-Nina, it has been followed by above-normal rainfall conditions in August-December 2021 (Figure 3).

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2020	0.5	0.5	0.4	0.2	-0.1	-0.3	-0.4	-0.6	-0.9	-1.2	-1.3	-1.2
2021	-1.0	-0.9	-0.8	-0.7	-0.5	-0.4	-0.4	-0.5	-0.7	-0.8	-1.0	-1.0
2022	-1.0	-0.9	-1.0	-1.1	-1.0	-0.9	-0.8					

Description: The blue number indicate the La-Nina condition and the black number indicate the Normal condition, based on a threshold of +/- 0.5°C for the Oceanic Niño Index (ONI) on the 3 month running mean of ERSST.v5 SST anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W).

Fig. 3. The Oceanic Nino Index for indicating the ENSO condition in 2020-2022 [13].

4 Conclusion

Shallot farming is very much influenced by weather fluctuation in the field. The weather anomaly resulted in crop failure and losses in almost 100% of shallot seed production in West Lombok, West Nusa Tenggara (NTB) Province of Indonesia during the growing season of 2021. To anticipate failures and minimize risks to the shallot farming system in the future, it is necessary to learn and transfer technology to interpret rainfall prediction information and design a shallot planting calendar.

We would like to thank the Indonesian Agency for Agricultural Research and Development (IAARD) for funding this research. We also would like to thank Dr. Ir. Awaludin Hipi, M.Si., director of the Institute for Assessment of Agricultural Technology (IAAT) West Nusa Tenggara (NTB) Province for his permission to the authors to pursue this research. We also wish to acknowledge assistance from the farmer's co-operator (Asahan Farmers' Group) during the field experiment.

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