

## WATER SAVING TECHNOLOGY PACKAGE TO IMPROVE SHALLOT PRODUCTIVITY FOR SMALLHOLDER FARMERS IN EASTERN INDONESIA

### PAKET TEKNOLOGI HEMAT AIR UNTUK MENINGKATKAN HASIL BAWANG MERAH BAGI PETANI KECIL DI INDONESIA TIMUR

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#### ABSTRACT

Dryland usage for shallot cultivation is very potential in West Nusa Tenggara (NTB) Province Indonesia. However, its utilization is faced with various obstacles such as soil low fertility, limited water availability, and high pest and disease attacks. Currently, farmers apply flood and furrow irrigation methods for shallot cultivation in NTB Province, which may not suitable on dryland, especially on coarse texture soils. The purpose of this study was to obtain a package of water-saving technology to increase the productivity of shallots in the dryland of NTB. There were three treatments of technology packages tested laid as Randomized Block Design: A (*Trichoderma* sp., bio-urine liquid fertilizer, sprinkler irrigation; B (bio-urine liquid fertilizer, furrow irrigation); and C (farmer practice), involving farmer group members from planning to evaluating for the technology package that being tested. The amount of water used was measured using a water meter. The results showed that package A had achieved the highest shallot yield at 31.6 tons ha<sup>-1</sup>, which was 14% and 45% higher compared to package B and C, respectively. Package A was also able to save water irrigation for 62.1% and 95.8% compared to package B and C, respectively. Thus, sprinkler irrigation not only can increase shallot yield but also better in saving water irrigation.

Keywords: dryland, productivity, shallot, technology package, water saving

#### ABSTRAK

Penggunaan lahan kering untuk budidaya bawang merah di Nusa Tenggara Barat sangat potensial. Namun hal tersebut terkendala oleh beberapa masalah seperti rendahnya kesuburan tanah, terbatasnya air irigasi, dan tingginya gangguan hama dan penyakit. Saat ini, petani di NTB mengairi tanaman bawang merah dengan cara direndam atau lele yang belum tentu sesuai dengan kondisi lahan kering terutama pada tanah dengan tekstur berpasir. Tujuan dari penelitian ini adalah untuk mendapatkan paket teknologi hemat air yang dapat meningkatkan hasil dan pendapatan budidaya bawang merah di lahan kering. Ada tiga perlakuan paket teknologi yang ditata dengan rancangan acak kelompok yaitu A (*Trichoderma* sp., pupuk organik cair bio-urine, dan irigasi curah); B (pupuk organik cair bio-urine, dan pengairan lele), dan paket C (cara petani: pengairan lele). Penelitian ini melibatkan petani mulai dari perencanaan sampai

evaluasi paket teknologi yang diujikan. Hasil penelitian menunjukkan bahwa paket A menghasilkan produksi tertinggi sebesar 31,6 t ha<sup>-1</sup>, atau 14% dan 45% lebih tinggi dari paket B dan C. Paket A juga mampu menghemat air irigasi sebanyak 62,1% dan 95,8% dibandingkan dengan paket B dan C. Dengan demikian, penggunaan irigasi curah mampu meningkatkan hasil dan menghemat air irigasi.

Kata kunci: bawang merah, hemat air, lahan kering, paket teknologi, produktivitas

## INTRODUCTION

West Nusa Tenggara (NTB) province is the third-largest national producer of shallots (*Allium ascalonicum* L.) with harvest area of 11,518 ha. The largest shallot cultivation area is located in Bima District for 8,027 ha followed by East Lombok District for 1,156 ha (Badan Pusat Statistik, 2015). Although the potential land for the development of shallots cultivation is huge up to 118,241 ha, but currently only 6.32% has been used (Nazam *et al.*, 2012).

Extensification of shallots is increasing from year to year due to the surge of demand and the profitable selling price for farmers. The expansion of shallot cultivation area mostly occupies dryland which covers more than 80% of the total land of NTB (Badan Pusat Statistik, 2015). The development of shallot cultivation in dryland is one of the strategic policy to reduce poverty in NTB because most of the poverty live in dryland areas moreover their livelihood relies on agricultural activities.

Quantitatively, dryland utilization is very potential and strategic policy in supporting agricultural development (Mulyani & Hidayat, 2009). However, qualitatively, the utilization has faced various obstacles both technically, socially, and economically (Benzinger *et al.*, 2006; Jensen *et al.*, 2003; Ma'shum, 1997). Constraints in the usage of the dryland include limited water availability, relatively low soil fertility, also short and erratic wet season periods (Debaeke &

Aboudrare, 2004). These conditions affect plant growth and plant production (Abdurachman *et al.*, 2008; Mulyani & Hidayat, 2009; Utomo, 2002). Most of the dryland conditions in NTB are characterized by a dry climate, namely the D3 climate type (3-4 wet months and 4-6 dry months), D4 climate type (3-4 wet months and > 6 dry months), E3 type (<3 wet months, 4-6 dry months), and E4 climate types (<3 wet months and > 6 dry months) (Oldeman *et al.*, 1980).

The main constraints on the development of shallot cultivation on dryland are water scarcity also pests and diseases attack. Furthermore, farmers always irrigate shallots by furrow and flood irrigation methods. This causes waste of water and labour. One method of irrigation that quite efficient to be used is sprinkler irrigation, because this method can save water, besides the water irrigation can be applied in accordance to the needs of plants accurately (Li & Rao, 2003; Undang, 2004). However, the sprinkler irrigation system has not been studied in detail and demonstrated at the farmer level. This can be seen where rarely farmers used a sprinkler to irrigate the shallots. In addition, the farmers irrigate shallot plants not based on crop needs and the right time but they irrigated every day to keep the soil moist. Thus, it is very necessary to study and demonstrate an effective and efficient irrigation system that is economically profitable, socially acceptable, and technically easy to do.

Components of water-saving technology of shallot cultivation sufficiently available from the results of research elsewhere (Roy, 2014; Sumbayak & Susila, 2018; Vickers *et al.*, 2015; Yenus, 2013). However, most of these components have not been assembled and combined in the form of technological packages that are ready to be adopted by farmers at the field level. So far there is no local-specific technology package that considers the amount of irrigated to be applied on shallot cultivation in dryland. With the technology package, the shallots productivity can be increased by at least 20%. The purpose of this study was to determine the productivity of shallot with a water-saving technology package in the dryland of NTB.

**MATERIAL AND METHODS**

The experiment was conducted from June to August 2018 at Labuhan Lombok Village, Pringabaya sub-district, East Lombok

District (-8.51157, 116.65475). The site has been regarded as a dryland and semi-arid climate agroecosystem and centre of shallot production in NTB.

The technology package studied consisted of three packages as treatment (Table 1). Package A was a technology package from the results of experimental technology components carried out in 2017, especially the use of *Trichoderma sp.*, biopesticides, bio-urine, sprinkler irrigation, and timing of irrigation with soil moisture testing equipment. Package B was almost similar to package A but with furrow irrigation and without *Trichoderma sp.*, and package C was conventional farmers' practice. The experiment was conducted through participatory research approach, which was carried out on farmers' land basis by fully involving farmers and extension agents starting from the planning stage until evaluating the performance of each technology packages.

Table 1 Package of water-saving technologies for shallot cultivation

Components of Package	Packages of Technology		
	Package A	Package B	Package C
Land preparation	Complete tillage	Complete tillage	Complete tillage
Seed quality	Certificated seed	Certificated seed	Certificated seed
Seed treatment	Yes	Yes	No
Fertilizer applied ha <sup>-1</sup>	Compos=10 t ha <sup>-1</sup> +SP 36= 150 kg ha <sup>-1</sup> + ZA= 250 Kg +NPK =250 kg + Urea=100 kg ha <sup>-1</sup>	Compos=10 t ha <sup>-1</sup> +SP 36= 150 kg ha <sup>-1</sup> + ZA= 250 Kg +NPK =250 kg + Urea=100 kg ha <sup>-1</sup>	Farmers practices (SP36=250 kg ha <sup>-1</sup> + ZA=350kg ha <sup>-1</sup> +NPK =300kg ha <sup>-1</sup> and urea= 100kg ha <sup>-1</sup>
Biopesticide	<i>Trichoderma sp.</i>	No biopesticide	No biopesticide
Weeding	As condition	As condition	As condition
Irrigation	Sprinkler	Furrow	Furrow
Time of irrigation	Using soil moisture kit	Using soil moisture kit	When the soil dry
Pest and disease	Integrated pest and diseases control	Integrated pest and diseases control	Every 2 days upto harvest
Bio-urine	12% for 4x applied	12% for 4x applied	No bio-urine

Each farmer applied three technological packages for at least 0.2 ha of each. Thus, the amount of land used in this experiment was

about 2 ha. Data about the amount of water given during the plant growth period were recorded to determine water efficiency and

water savings in each irrigation treatment using a water meter. For packages A and B, irrigation water was applied when soil moisture content had reached 14.8%, which was measured using a soil moisture test. The soil moisture content limit was based on 20% of available water that was still present in the soil before reaching a permanent wilting point. For package C, irrigation water was applied based on farmer practice, still the amount and times for irrigation were recorded.

Every activity on shallot cultivation in the field was recorded in the form of a farm record-keeping for each farmer co-operators. This was done to ensure that all of the packages of technology were applied by farmer co-operators.

Agronomical parameters observed in this study included plant height and numbers of leaves observed using 15 plant samples at 20

days after sowing (DAS), 40 DAS and at harvesting time; fresh and dry weight of yield. Data were analysed using T-test by comparing treatment AB, AC, and BC.

## RESULTS AND DISCUSSION

### Climate and water irrigation

The Sandubaya site of Labuhan Lombok Village, Pringgabaya District is regarded as a dryland and semi-arid agroclimatic zone. This is indicated by the total annual rainfall which is less than 1500 mm per year and included in climate types of D and E (Oldeman *et al.*, 1980). The average annual rainfall for the last 17 years in the region is 640 mm. The average monthly rainfall for 17 years (2000 - 2016) in the region is presented in Figure 1. The wet months of the study area are only three months from December to February meanwhile the rest are dry months.

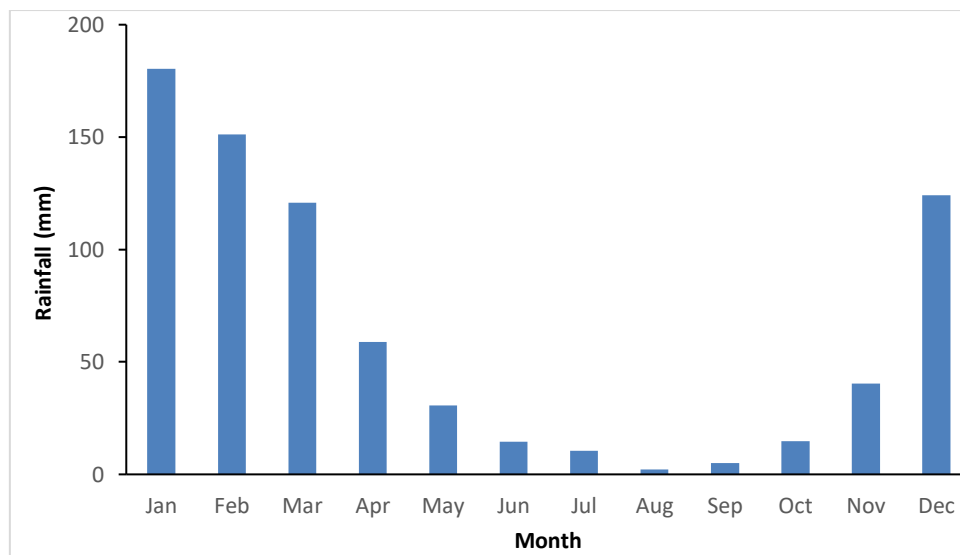


Figure 1 Average monthly rainfall for 17 years (2000-2016) at Pringgabaya East Lombok

The topography of the Sandubaya region is relatively flat, dominated by Entisols soil type with sandy to sandy loam texture. Besides relying on rainwater, Sandubaya also uses ground water (pumping wells) for irrigation called P2AT.

In the Pringgabaya Subdistrict area, there are 72 P2ATs with varying debits of around 10-20 l s<sup>-1</sup>. P2AT wells are managed by a groundwater user farmer association (P3AT). Irrigation costs using P2AT wells vary from Rp. 30,000-35,000 per hour. One ha of land

requires around 20 hours to irrigate the plants.

**Land characteristic**

Land characteristics of the site are shown in Table 2. In general, the nutrient contents of phosphor and potassium were high, while nitrogen (N) status was low. Soil pH was in the range of neutral to slightly alkaline. The ability of soil to hold water was quite low due

to the very low content of clay and organic matter. The percentage of clay at the site was about 10% in the top layer of 0-10cm and decreased to 6% at soil depth of 20-40cm. Thus, the furrow irrigation method may be less suitable for this location. However, the reality in the field farmers always apply furrow and flooded irrigation for shallot cultivation.

Table 2 Soil properties at Sandubaya site

Soil layers	pH-H <sub>2</sub> O	pH-KCl	EC	N Total	Organic-C	P <sub>2</sub> O <sub>5</sub> Olsen	CEC	K	Na	Ca	Mg
	pH-meter		μS cm <sup>-1</sup>	%	%	ppm	cmol kg <sup>-1</sup>		cmol kg <sup>-1</sup>		
0-10	7.95	6.52	0.140	0.250	0.807	58.87	18.83	2.73	3.70	13.63	3.60
10-20	7.91	6.51	0.103	0.167	0.602	52.30	16.37	0.77	1.77	8.73	3.13
20-40	7.97	6.71	0.170	0.120	0.273	41.80	19.40	1.33	2.03	12.43	3.57
Soil layers	Texture (%)			Bulk Density	WP	UL	AW	Infiltration rate			
	sand	silt	clay	gr per cm <sup>3</sup>		% volume		cm h <sup>-1</sup>			
0-10	57	33	10	1.08	11.29	29.19	17.90	5.38			
10-20	56	36	9	1.1	13.23	28.83	15.60	6.02			
20-40	54	40	6	1.08	10.98	24.93	11.95	4.98			

Note: EC= electrolyte conductivity; CEC=cation exchange capacity; WP= wilting point; UL= upper limit and AW=available water content

**Agronomic parameters and yield of shallot**

Plant height during the growth of shallots at various technological packages applied is shown in Figure 3. In general, the performance of shallot height at 20 days after sowing (DAS) was not significantly different for package A and package B, except package C, where it was higher than other packages. At 40 DAS, the height of shallot at package A was higher than the others, although this was not significantly

different with package B but significantly different from package C. Furthermore, at 60 DAS or harvest stage, plant height of shallot was not significantly different at all packages. It was observed that shallot height at 40 DAS was shorter than at 20 DAS. This was due to manually cutting leaves that were attacked by caterpillar pests. Yoo *et al.* (2019) reported that the the bulb weight of short-day onions plants was either reduced or increased by cutting leaves.

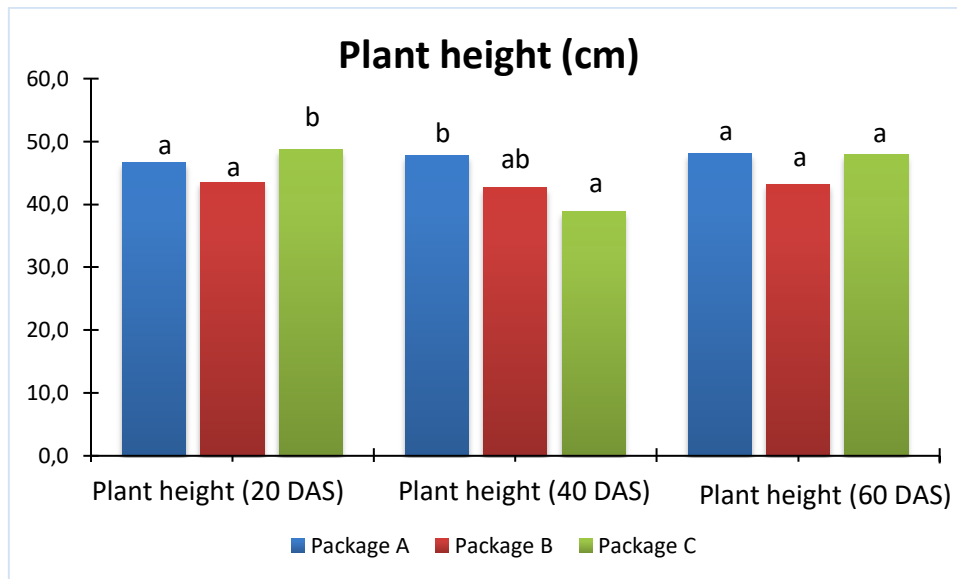


Figure 2. plant height of shallot at various package of technology

The effect of the technology packages on leaves number during growth period of shallot is shown in Figure 3. In general, the number of leaves of shallot increased along with the growth period. The number of leaves on package A at 20 and 60 DAS was higher than other packages, although this was not significantly different with package B, indicating that technology package A had

given good influence in increasing growth of shallot compared with farmer practices. The number of leaves at package C treatment was less than the other packages. The leaves of shallot at package C was very dry at the time of harvest compared to the other packages. While leaves of shallot at package A and package B were still look green.



Figure 3 Influence of saving water package technology on leaves number of shallot.

One of yield parameters that determines the productivity of shallots is number of bulbs. The more bulbs, the higher yield of shallots obtained. Variation of bulb number of shallots for whole technology packages is shown in Figure 4. Generally, the number of bulbs per square meter for each technology

package applied was not significantly different. This indicates a uniformity of growth and population at all packages technology applied. However, there was a tendency of shallot bulb increase at package A compared to packages B and C.

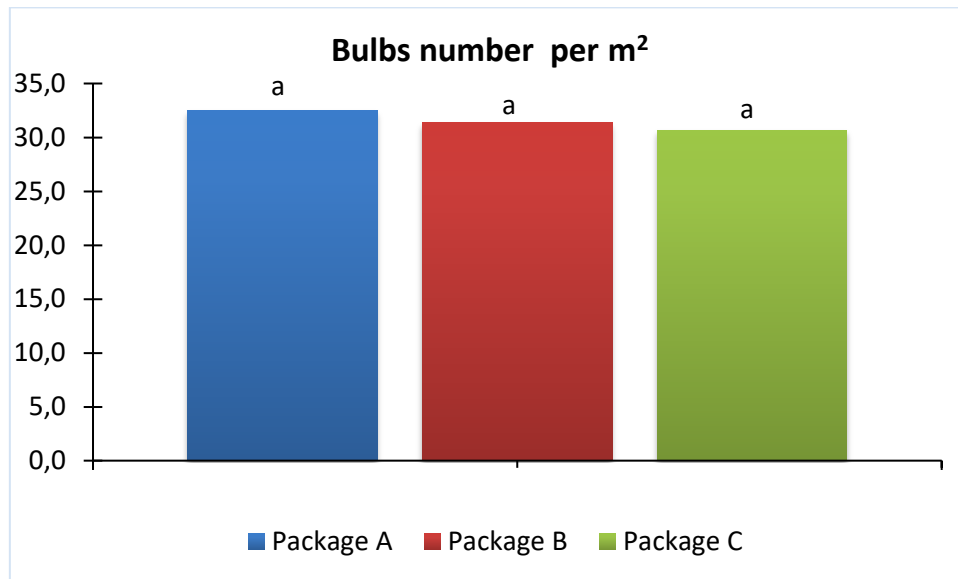


Figure 4 Influence of water-saving package technology on number of shallot bulbs.

Variation of shallot yield on wet and dry weights is shown in Figure 5. In general, the yield of shallots was quite varied due to the implementation of the technology package. The highest shallot yield was found at package A technology followed by package B and the lowest was package C (farmers practice). The technology of package A increased yield of shallots by 31.6 tons ha<sup>-1</sup> (fresh weight), it was 14% and 45% higher

compared to package B and package C, respectively. Thus, package A which was water-saving technology for shallot was quite feasible to be applied by farmers around the study site. The yield of shallot in dry conditions also showed a similar trend to wet weight. In dry conditions, the technology of package A increased yield of shallot by 10% compared to package B and 45% compared to package C.

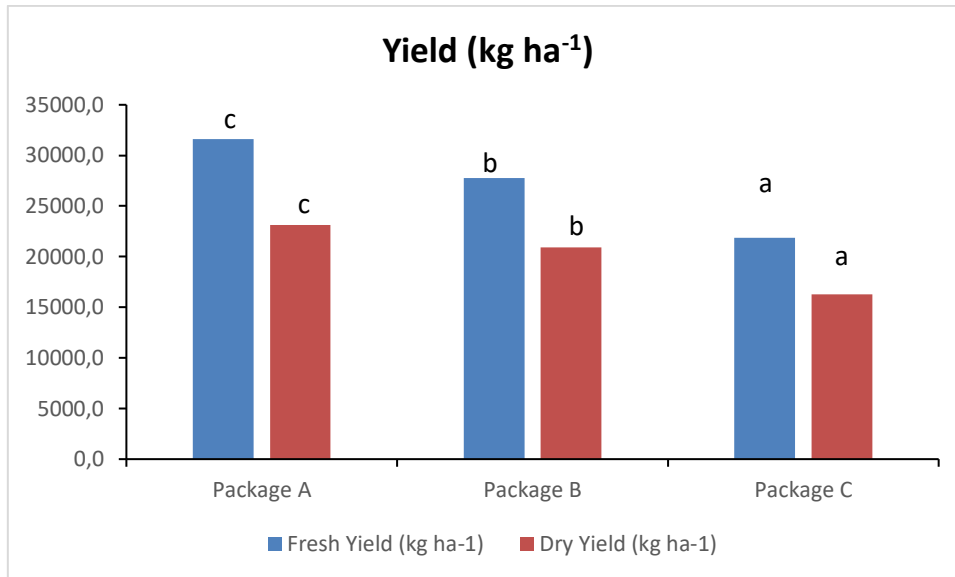


Figure 5 Yield of shallot influenced by water-saving technology packages in dryland of NTB

**The amount of water irrigation**

The amount of water irrigation used during shallot plant growth period (63 days)

for each technology package is shown in Table 3.

Table 3 Water irrigation used at various shallot growth stages due to water-saving technology packages

Growth stages	Stage duration (days)	Irrigation used (mm)		
		Package A	Package B	Package C
Sowing time		64.0	64.0	64.0
Early stage	15	89.4	119.0	147.0
Optimum growth	25	95.5	199.0	246.0
Maximum growth	15	79.7	119.0	147.0
Ripening	8	20.2	64.0	79.0
<b>Total</b>	<b>63</b>	<b>348.8</b>	<b>565.3</b>	<b>683.0</b>
Irrigation efficiency (%)			62.1	95.8
Irrigation cost (Rp.)		3,725,000	6,037,000	7,294,000

Package A amounted to 348.8 mm as the lowest value than other packages. Debit of pumping well used to irrigate shallot was 7.9 l s<sup>-1</sup> and duration required for irrigation was 22.5 hours per hectare. Package A (sprinkler) was able to save water up to 62.1% and 95.8% compared to package B (furrow irrigation) and packages C, respectively. Undang (2004) stated that in coarse-textured soil, the efficiency of water use with

the sprinkler method was twice as high as surface water irrigation.

**CONCLUSION**

1. Water-saving technology package for shallot in dryland using sprinkler irrigation increased productivity of shallots by 31.6 t ha<sup>-1</sup>, which was 14% and 45% higher compared to package B



- (furrow irrigation) and package C (farmer practice), respectively.
- The amount of water used during the growth of shallots for package A was 348.8 mm which was 62.1% and 95.8% lower than package B and C, respectively. The irrigation cost of package A was less than the others, which was more efficient by 15.8% to package B and 30.4% to package C.
  - The development of a water-saving technology package is very promising. Therefore, socialization and demonstration plots in several regions are very necessary to disseminate and adopt the technology package by the farmers. However, this technology may need financial analysis in order to meet economic feasibility.

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