A Review: TSS (True Shallot Seed) Development in Indonesia and Its Health Benefit

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Abstract. With annually 145,000 ha cultivated area, shallot is widely used in Indonesian daily cuisine and therefore an important crop for farmers and consumers in Indonesia. Bulb propagation for many years resulted in yield reduction. Alternatively, True Shallot Seed (TSS) has many advantages to offer as lower costs of planting material, higher yield, and better quality. Highlighting 3 decades activities at PT East West Seed Indonesia (Ewindo), a review of TSS Development of breeding process, seed availability effort, and introduction new cultivation technique are explained. For its health benefit, preliminary experiment of nutritious compound that holds by shallot called quercetin was carried out in April-September 2019. To find out the quercetin content, we used 5 varieties (Ewindo varieties: Sanren F1, Lokananta, BM-9008, BM-9474 and Local Variety: Bima Brebes) planted in 3 elevations (Low, Med, High Land). Bulb harvested was raised using TSS Cultivation Technique and followed by Quercetin Lab Check in UGM LPPT Laboratory. The result showed the highest quercetin content was in variety Sanren F1 planted in Low Land of 691 mg/kg. While lowest quercetin content was in variety Bima Brebes planted in Low Land of 312 mg/kg. Therefore, highlighting quercetin content will be beneficial for further varieties development.

Keywords: TSS · Breeding · Seed availability · Cultivation technique · Quercetin

1 Introduction

Shallot (*Allium cepa* var. *Ascalonicum* Backer) is widely used in Indonesian cuisine and therefore an important crop for farmers and consumers in Indonesia**.** The main production areas are located on Java which account for 75% of the national production. Projected harvest area in 2019 is 145,000 ha, the widespread development of harvested shallot in the last five years (2014–2018) and the last nineteen years (2000–2018) both experienced positive growths. The average growth in the last five years was 10.11%, while in the nineteen years it was 3.91% [1].

Traditionally, farmers use bulbs of their own crop as planting material, or they buy local, or imported bulbs from the market. For 1 ha, it would absorb 1 – 1.5 tons planting bulb. The field dry yield is about 10 tons/ha. For many years, Indonesian shallot farmers

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are always using bulbs as their planting materials. Significant yield increase is scarce, recorded data in 2013 that the productivity of national shallot at 10.22 tons/ha [2].

Associated with the fact that the cost of producing shallots per hectare is increasing from year to year, productivity stagnation can affect the interests of farmers-producers and consumers (short/medium term). Farmers will take the decision to stop growing shallots if the farm is financially declared unfit. In these conditions, farmers may only survive, if the increase in the price of the product can compensate for the increase in production costs. However, increasing product prices in turn will also pose an additional burden for consumers. Therefore, interventions that can provide a win-win solution for producers and consumers is through efforts to increase the productivity of shallots [3].

One of the efforts taken to increase the productivity of shallots is the use of seeds of botanical seed origin (True Shallot Seed – TSS) which has a high potential as an alternative to tuber seeds. Some of the advantages offered by TSS include: (1) not taking place much – not bulky, in average 5 kg/ha, (2) planting materials that are relatively cheap – less expensive, (3) easy in terms of transportation, (4) long-term capacity and shelf life, (5) producing healthy tubers relatively pathogen-free and large-sized, (6) higher productivity [4–8].

In view of benefit to offer to Indonesian shallot farmers, PT East West Seed Indonesia (Ewindo), as Vegetable seed company which focus on breeding activities to provide better vegetable seeds for Indonesian farmers and consumers was initiating in developing shallot varieties. Ewindo is the first integrated vegetable seed company in Indonesia which produces vegetable seeds through plant breeding. Ewindo primarily aims for the development of local, cutting-edge seed industry to produce high-quality vegetable seeds. In developing seeds, Ewindo uses professionals who are experienced in plant breeding and seed science. Vegetable seeds resulting from research and development are produced, processed, packed, and marketed for Indonesian farmers with the brand Cap Panah Merah. For more than three decades Ewindo always provides healthy seeds with high genetic purity and good germination to achieve good results aligning with the consumers' wants and to become the key to success for Indonesian farmers.

Highlighting development in breeding work, seed availability effort, introduction new cultivation technique in delivering the first TSS Variety in Indonesia, together with exploration in nutritious compound, the topics will be explained.

2 A Review of 3 Decades of TSS Development: Breeding, Seed Availability, Cultivation Technique, and Nutritious Compound

2.1 Breeding

Through breeding work in plant science, improvement aim is achieved. The simplest definition of plant breeding is crossing two plants to produce offspring that, ideally, share the best characteristics of the two parent plants. Throughout the history of civilization, plant breeding has helped farmers solve complex challenges while also nourishing the wishes of consumers.

The shallot breeding work in Ewindo has started in 1990 with actively collecting local shallot bulbs. It was numerous works since screening mother bulbs able to produce

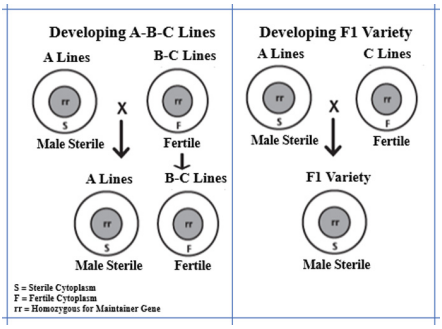

Fig. 1. Developing A-B-C lines and F1 variety in Ewindo.

flower was challenging. Understanding mother bulb characters and its ability to produce flower was revealed once we combined planting mother bulb in lowland, Purwakarta (50 m asl) and re-planting the selection for flowering in highland, Lembang (1.150 m asl).

Poor flowering ability was also main constraint to produce seed among mother bulbs selection. Focusing the lines which were able to produce next generation seed was the key to have better lines.

Once we had improved lines, we considered regarding developing Cytoplasmic Male Sterility (CMS) as parental. It was a strategy need to be started in the beginning of the program, since we would like to offer better variety. Recombined so many germplasms, we could introduce sterility in the program.

Developing CMS Parentals, it concerns A-Line as Female plants with Sterile Cytoplasmic - Homozygous Gene, while B-Line as Maintainer plants with Fertile Cytoplasmic - Homozygous Gene, together with the C-Line as Male plants with Fertile Cytoplasmic - Homozygous Gene. Readiness of A-Line crossed with C-Line produces F1 Variety with Sterile Cytoplasmic - Homozygous Gene (Fig. 1) [9].

Not only developing CMS in F1 Variety development, but we also developed Synthetic Variety. The concern arouses since producing F1 seed was delayed. A Synthetic Variety which is produced by crossing in all combination several inbred lines that combine well with each other. To have better comparison in Variety Development, we describe the scheme of F1, Synthetic and Open Pollination (OP) Variety in Fig. 2.

Milestone of Ewindo's variety release was first OP-Tuktuk in 2006, follow by F1-Sanren in 2013 and Syn-Lokananta in 2017 (Table 1):

Our breeding objective comparison in 3 Varieties is describe in Table 2 and Fig. 3. Exploring more germplasm, testing under specific treatment, and selecting improved traits are our main goal to be able delivering the best fit variety to Indonesian shallot farmers.

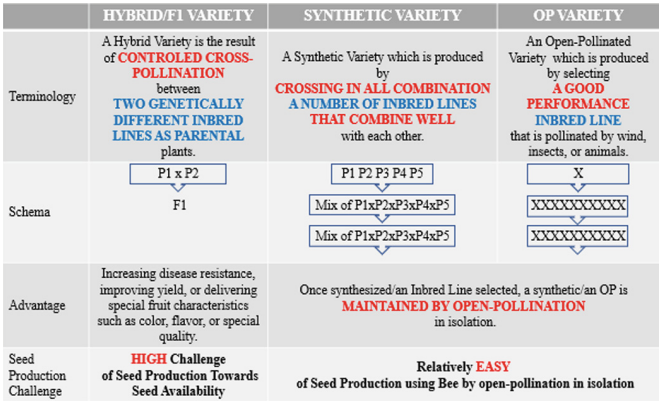

Fig. 2. Comparison of development F1, Syn, and OP variety.

Table 1. Ewindo's shallot variety release

Variety Name	Ministry Registration Number
Tuktuk	361/Kpts/SR.120/5/2006
Sanren F1	072/Kpts/SR.120/D.2.7/7/2013
Lokananta	059/Kpts/SR.120/D.2.7/6/2017

Table 2. Comparison 3 Ewindo's shallot variety

Variety	Bulb Caracter	Planting Season Recommendation
Tuktuk – OP 2006	Red 85–95% Single Bulb	Dry Season
Sanren – F1 2013	Red Pink 100% Split Bulb	Dry Season & Early and End Rainy Season
Lokananta – Syn 2017	Red 75% Split Bulb	

2.2 Seed Availability

Once we could develop candidate variety, we likewise explored the possibility to produce seed. It was not an easy task since Indonesian climatic is not the best fit for producing TSS.

According to Rabinowitch, onion plants require a temperature of 7–12 °C for the initiation of flowering and a temperature of 17–19 °C for the development of umbel

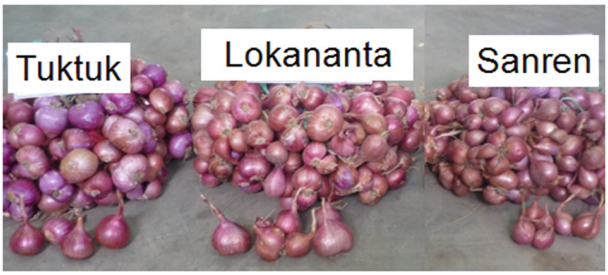

Fig. 3. Ewindo's shallot variety.

Fig. 4. Mother bulb preparation and Bulb-BAP soaking.

and blooming flowers. This is a challenge for the production process because the daily temperature range in Indonesia is outside the optimum temperature range and shows a trend of increasing temperatures every year. This increase in temperature causes almost all of Indonesia is not ideal for use as a cultivation location for TSS production [10–12].

Optimalization in producing seed was manage in our research station located in highland (Lembang, 1.150 m asl). It was not considered as the best fit location thought we could manage to explore the plant-flower characteristic and accommodation-cultivation needed resulting in know-how TSS production in our farm.

Flowering in shallot could be induced by vernalization or chemical treatment. Though not all treatment could be accomplishment, it was an effort to be applied. In 2016–2017, collaboration with Balitsa (Indonesian Vegetable Research Institute-Ivegri), we produced TSS of Bima Brebes Variety in Lembang. Using Balitsa guidance, we tried to optimize the TSS production. Adding Benzil Amino Purin (BAP) for flowering was used (Fig. 4) [13].

Organizing time planting was crucial for best result. Our TSS production was started in October 2016 with rainy season condition. Even so flowering treatment was applied by BAP, it was not resulting in high seed yield (Fig. 5).

In line with the result reported by Ramadan that even though vernalization is required to induce flowering of true shallot, however, the planting date plays important role to the production and quality seeds. Reducing the detrimental effect of raining season to true shallot plant induced with vernalization, such as by maintaining the production inside

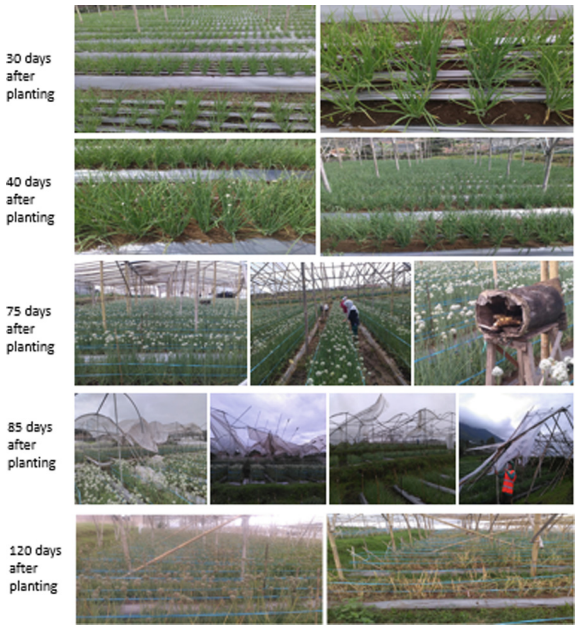

Fig. 5. Plant and flower performance in Ewindo field trial.

closed system with controlled environment, may become the key factor to sustainable TSS production in Indonesia and other area with similar climate [14].

Producing TSS by optimalization environment condition seems reasonable. However, it was not suggested as evaluating of economic. Our effort using environmental employment in producing TSS started in October 2016-April 2017 was not worth as the seed price was too high of average Rp. 8.850.000 (Table 3.).

Hampering effort of seed availability, we could manage to have better comparison in yielding TSS seed. By having a trial in suitable location, we could optimize better picture of suitable climatic that support of plant - flowering performance and seed yield (Fig. 6).

Exploration effort of more than 10 years, abroad and in Indonesia, resulting in having better knowledge and suitable location in producing TSS. By combining Indonesian breeding result with suitable seed production site resulted in TSS availability for Indonesian shallot farmers. Further improvement and information exploration in seed availability effort for Indonesian shallot farmers welfare is highlighted.

2.3 Introduction TSS Cultivation Technique

Breeding Varieties, Seed Availability, and Proper Cultivation Technique provided to Indonesian shallot farmers is a package to gain success. Our effort in educating shallot farmers by introducing TSS cultivation technique was challenging. For many years, Indonesian shallot farmers using vegetative planting bulbs. Consideration to have proper TSS cultivation technique introduction was highlighted.

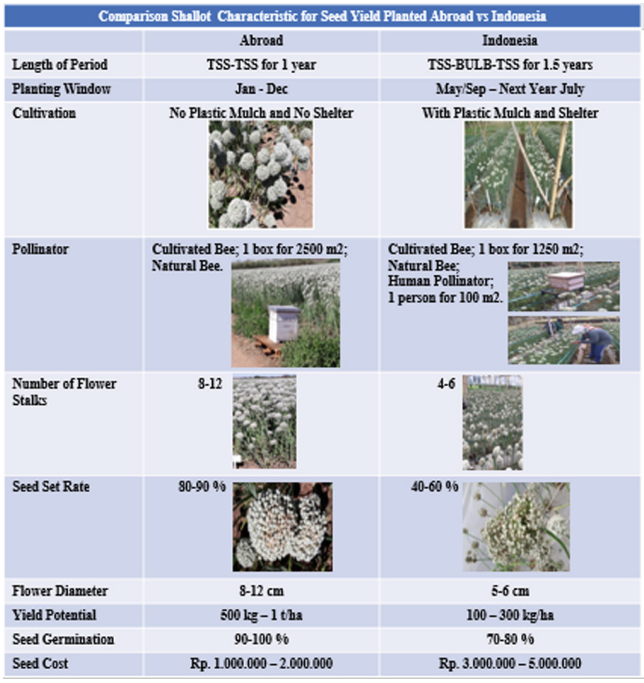

Fig. 6. Comparison of shallot characteristic for plant, flowering and seed yield - Abroad vs Indonesia- Ewindo.

Table 3. TSS Bima Brebes production cost

TSS Production Cost in 1 ha		
1	Mother Bulb Total Cost; Rp. 50.000 × 500 kg	Rp. 30.000.000
2	Mother Bulb Curing; 2 people @ Rp. 88.000 × 10 days	Rp. 1.760.000
3	Plastic Shading; @/m2 = Rp. 15.000	Rp. 150.000.000
4	Mulch; 17 rolls × @ Rp. 650.000	Rp. 11.050.000
5	Worker	Rp. 57.500.000
6	Bee Box; 8 boxes × @ Rp. 600.000	Rp. 4.800.000
7	Fertilizer and Pesticide	Rp. 28.000.000
	Total Cost	Rp. 283.110.000
	Total TSS Yield	32 kg
	TSS/kg	Rp. 8.850.000

Introduction effort not only run by Ewindo team, but it was also a continues program from Indonesian Government and Indonesian Research Institute. Starting from the 1990s (Indonesia-Netherlands Research Cooperation, Hortin I), TSS research began to

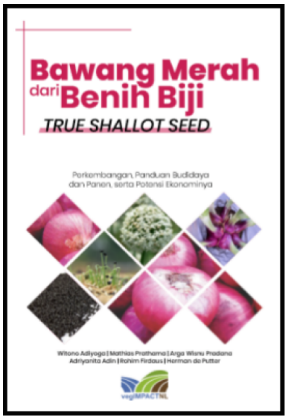

Fig. 7. Book of TSS.

be pioneered and intensified and extensively carried out since the Ministry of Agriculture began to encourage the development of TSS in 2015/2016. Various research activities ranging from improvement of seeding techniques, improvement of seedling after transplanting, improvement of mini bulb production techniques generally give an idea that the use of TSS is technically feasible. The use of TSS as an alternative to seed bulbs also received a positive response from shallot farmers, although the preliminary study conducted by Balitsa showed that the adoption rate (farmers who had planted TSS 3 times or more in a row) was still not as fast as expected [15–31].

By continues collaborating, in 2020, out of joining project of VegIMPACT-NL 2017–2020 (Vegetable Production with Impact-Next Level), we could deliver book of "Bawang Merah dari Benih Biji – True Shallot Seed; Perkembangan, Panduan Budidaya dan Panen, serta Potensi Ekonominya" (Fig. 7).

Main educating part to be delivered to Indonesian shallot farmers was the sowing phase. Sowing activities was not present in bulb planting. Focusing in main 5 aspects, the key success factors to produce healthy seedling is gain. The main 5 factors are:

1. Fine texture of sowing media – Use burn rice hustle (Fig. 8),
2. Watering, scheduled fit by seedling need, be aware of the watering tool fitness (Fig. 9)
3. Drainage of seedling beds,
4. Weed control,
5. Seedling Shading especially needed in rainy season (Fig. 10).

Applying the main 5 key success factors, at 35–40 days after sowing, healthy seedling could be used for transplanting (Fig. 11). At current, not yet many farmers could produce healthy seedling. Producing healthy seedling is still considered difficult. Now a days, by advising farmer who can provide healthy seedling to surrounding area, we also initiate Nursery Seedling Business.

Fig. 8. Sowing bed preparation to have fine texture.

Fig. 9. Watering tool fit for seedling nursery.

Fig. 10. Various shading net to optimize seedling growth.

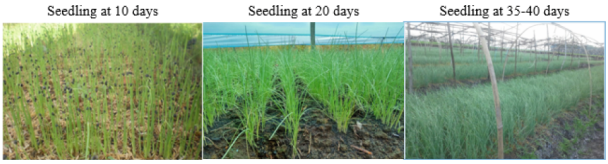

Fig. 11. Seedling growth until 35–40 days after sowing.

Fig. 12. TSS utilities.

Fig. 13. JSS Berkah - Nursery seedling under plastic equipped by RH and temperature monitoring in Majalengka.

The utilization of TSS opens opportunities for the development of several business models: (1) the business of producing consumables, (2) the business of seedling production, (3) the business of production of mini-bulb seeds, (4) the business utilizing consumption bulb as variant food product (Fig. 12) [32].

In 2020, a startup seedling business was settled in Majalengka under JSS Berkah brand (Fig. 13). We expect that such a progress to provide Indonesian shallot farmers welfare could expand.

A simple analysis of farming assuming farmers buy seedling shows that TSS farmers have a higher profit margin per kg of shallot (2 times) than bulb. Through aggressive and

massive promotional strategies, as well as continuously gradual supply to the market, TSS can supply a market of 95 tons/day [33].

2.4 Nutritious Compound

Vegetables are one of food source and they are rich in antioxidants. These antioxidant compounds have a very important role for the health of the human body, both for the treatment of diseases and to maintain the body's condition to be excellent. Two important compounds contained in vegetables are anthocyanin and quercetin. Quercetin can be found abundantly in vegetables such as red lettuce, asparagus, and red onion. In onions, the largest concentration of quercetin is in the outermost ring and in the closest to the root [34, 35].

Quercetin is a flavonoid that is widespread in nature. The name quercetin has been in use since 1857 and is derived from the word quercetum (oak forest). Quercetin is an important bioactive compound for human health. This compound has functions as antihypertensive substances and helps maintain heart health [36].

Knowing the presence of quercetin in onion triggered to find out the presence in shallot. Therefore, we initiated trial to have a better understanding.

3 Materials and Methods

We used 5 germplasm materials (Table 6.) planted in 3 planting locations; Purwakarta (Lowland – 50 m asl), Wanayasa (Medium Land – 672 m asl), and Lembang (Highland – 1.150 m asl) (Table 4).

TSS planting follows the guidance of TSS Cultivation Technique. Seedling was raised in nursery beds and planted after 42 days. Trial was carried out from April-September 2019. By applying five success factors in seedling beds, healthy seedling is consumed 35–42 days or 6 weeks ready for the transplanting. The transplanting is using a planting distance of 10 cm × 10 cm with 1 seedling per hole. Bulbs are harvested at the age of 60–70 days after transplanting.

Quercetin lab check was run in Laboratory LPPT (Layanan Terpadu Penelitian & Pengujian) of UGM (Universitas Gadjah Mada). The quercetin content was observed out of 7 days harvested bulbs.

Table 4. List of five germplasm tested for quercetin content

No	Germplasm	Name
1	BM-3967	Sanren
2	BM-9705	Lokananta
3	BM-9008	BM-9008
4	BM-9474	BM-9474
5	BM-9100	Bima Brebes

4 Results

Based on our preliminary research, we could learn that out of 5 germplasm planted in 3 elevations, that the quercetin content ranges out of 312 – 691 mg/kg. The highest quercetin content was present in varity Sanren planted in Purwakarta of 691 mg/kg. While lowest quercetin content was shown in varity Bima Brebes planted in Purwakarta of 312 mg/kg (Table 5).

We further compared the quercetin content out of 3 elevations, it shown that germplasm planted in Purwakarta compared to germplasm planted in Wanayasa and Lembang did not show any significant different. Varity Bima Brebes and Lokananta shown different pattern that quercetin content was higher out of bulb planted in Lembang than in Purwakarta; data in Wanayasa was absent due to *Fusarium sp.* Attack.

By assuming that elevation as replication, perform all the pairwise comparisons using LSD Test and an overall risk level of 5%, that varity Lokananta was significant higher in quercetin content among the others. Varity Bima Brebes was the lowest quercetin content (Table 6).

Knowing average shallot quercetin content from this trial there is no recommended amount of quercetin intake each day, so dosage recommendations may vary depending on your health condition. Estimates suggest that most people typically get between 5 and 40 mg per day from eating common plant foods; however, if you follow an overall nutrient-dense diet, you're likely to consume more—as much as 500 mg daily. As informed by

Table 5. Quercetin content from 5 germplasm planted in 3 elevations

Name	Purwakarta (mg/kg)	Wanayasa (mg/kg)	Lembang (mg/kg)
Sanren	691	526	459
BM-9474	624	486	316
BM-9008	617	571	534
Lokananta	572	na*	686
Bima Brebes	312	na*	442
na*; data not available			

Table 6. Average quercetin content from 5 germplasm

Name	Average Quercetin Content (mg/kg)
Lokananta	629^{a}
BM-9008	574^{ab}
Sanren	559^{ab}
BM-9474	475^{ab}
Bima Brebes	377^{b}

Raman, taking consideration in average per person consumes 10 – 100 mg quercetin a day is like consume 3–5 bulbs of Sanren or Lokananta (25 g) each day [37, 38].

In Indonesian daily cuisine, shallot is a must, therefore by regular eating shallot will gain benefit for health. It is shown that using mice, it was proved that onion's juice decreased mice MDA (Malondialdehyde) plasma level. MDA, a product of lipid peroxidation, is often used as an indicator to detect the oxidative stress damaged in the body. Lipid peroxidation is associated with progression of atherosclerosis (hardening of blood vessels). It is known that shallot (*Allium ascalonicum* L.) can be used as an antioxidant and hypolipidemic agent [39].

5 Conclusion

- Breeding process since 1990 resulted in availabilities 3 varieties for Indonesian farmers: Tuktuk, Sanren F1 and Lokananta. More candidates are waiting.
- Seed availability effort resulted in finding best place to produced seed with economically seed price.
- TSS Cultivation Technique is available to be used by Indonesian farmers utilizing TSS Varieties.
- Preliminary research regarding nutritious content that holds by shallot called quercetin will make varieties development more beneficial.
- Collaborating was highlighted as one of success key in socializing TSS in Indonesia. Actively since 1990, it is still an effort to be strengthen between Government, Research Institute, and Private Sector. All stake holder's collaboration will result in Indonesian shallot farmers welfare.

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