Evaluation of effectiveness various seed processing combination technique to produce True Shallot Seed (TSS) with good quality

N Waluyo1,*, A Rahayu1, R Rosliani1, T Wikan2, R Gaswanto1

1 Indonesian Vegetable Research Institute, Jln. Tangkuban Parahu No. 517, Lembang, Bandung Barat, Indonesia 40391
2 Indonesian Center for Agricultural Engineering Research and Development, Jl. Sinarmas Boulevard, Situ Gadung, Kec. Pagedangan, Tangerang, Banten 15338

* E-mail: nuralitawaluyo@gmail.com

Abstract. The seed processing technique is essential to maintain quality and suppress seed deterioration rate as long as processing time. This research aims to evaluate various seed processing combination techniques to produce TSS with good quality. The study was conducted at Indonesian Vegetables Research Institute, Lembang (1,250 m sal) from March until December 2018. The research used a Randomized Complete Block Design (RCBD) with three replications. The treatment consisted of 12 combinations of seed processing, including the technique of drying, capsule breaking, and sorting. The research result showed that the best treatment was a combination technique with umbels drying in the room at RH 50 % and 30-35°C for 72 hours, breaking capsule by hand manually, and seed sorting by winnower followed by hand manually. The produced seed quality in this treatment showed the seed germination was 75%, the moisture content was 7.5%, and the physical purity was 99.9%. This research implies that the availability of TSS processing technology can be carried out by massal, but still can produce good seed quality.

1. Introduction
Shallot (*Allium cepa* L. var. ascalonicum) is an essential vegetable with high economic value [1]. Along with the growing population number, shallots domestic consumption demand also increases. Nowadays, shallots are included as the main crop because they have an economic effect on triggering national micro inflation [2].

Indonesia's horticultural statistics informed that the harvested area, production, and shallots' productivity increased in 2015-2019. In 2019 the harvested area was 159,195 ha, or an increase of 1.54% compared to 2018. Shallot production was around 1,580,247 t with a productivity of 9.59 t ha⁻¹. The shallot production and productivity also increased by about 5.11% and 3.55%, respectively. Three provinces in Indonesia that are the main production centers of shallots are Central Java, East Java, and West Nusa Tenggara [3].

All this time, shallot vegetative propagation uses bulbs, but they have some disadvantages. Bulbs can't be kept in the storage for an extended period, and thus after the offseason, the seed availability is usually limited. Sometimes the bulbs also can be a medium for transmitting pathogens [4]. In addition, it is not easy to manage storage and distribution. In terms of genetics, the used same variety continuously of bulbs will decrease diversity, thereby reducing trait improvement through the breeding program [5].
Nowadays be introduced right shallot seed (TSS) as an alternative seed. Some advantages of TSS are easily able to be kept in storage for a long time, free from seed-borne pathogens, more efficient in using the necessity of seed and fertilizers, easier and cheaper for seed distribution, and higher production due to propagation ratio, in this case, 1: 200 compared 1: 10 if using bulbs. However, it takes a long time to maintain and harvest in the field [6] [7].

Agroclimate in Indonesia, as a tropical country, has high temperatures and humidity. The condition is not ideal for producing TSS. It is known that TSS is a conventional seed type with hygroscopic; hence it is straightforward to deteriorate [8]. Many aspects will determine TSS quality, such as plant growth condition in the field, the technique of flowering and pollination, umbel condition at harvesting time, until seed processing technique [9]. Therefore TSS production should be carried out in the highlands (> 900 m asl) during the dry season to produce many umbels and attacks of pollinator insects [10]. Another advantage of plants will be avoided by primary pathogens such as Colletotrichum spp, Alternaria porri, and Stempyllum vesicarium [11]. The number of umbels can be stimulated and increased by bulbs vernalization technique and application of growth regulators such as benzylaminopurine (BAP) 37.5 ppm [9][6].

Seed quality includes indicators of genetic, physiological, physical purity [12] and its health. A critical part of producing TSS with good quality is seed processing. The processing properly is intended to maintain seed quality at an obtained physiological mature stage and suppress deterioration rate, TSS processing covers drying harvested umbel, breaking capsules, and sorting seeds. The drying process should be done as soon as possible after the umbels are harvested because it is easy to get infected by fungal. The drying process by sunlight is usually for 7-14 days. The capsule drying process correctly will make it easy to separate seeds from shells. The cling shell on seeds can stimulate pathogens to infect it until less the quality.

In Indonesia, TSS processing for only a small scale capacity can be done manually. Seed processing by hand manually usually involves many laborers, high costs, and takes a long time. Indonesia's government had decided on a self-sufficiency policy on shallots; hence it should be supported by sufficient qualified seeds. Therefore TSS processing for large capacity by machine is essential to support the expected production target. The TSS certification minimum standard had already been determined by agriculture ministry No. 131/2015, i.e., physical purity 99.9%, moisture content 8%, and seed germination 70% [13].

Indonesian Center for Agricultural Engineering Research and Development had already assembled some TSS processing machines such as dryer' hallway type', pulper, and winnower machine. It was needed to study the operational effectiveness of these machines and to evaluate the produced seed quality. Finally, the present study's objective was to preliminary research and assessed the efficacy of various seed processing combination techniques to make TSS of good quality.

2. Methods
The research was conducted at the Vegetable Crops Research Institute-Lembang (1,250 m asl) from March to December 2018. The used variety was Trisula. The research activity was carried out in three parts.

2.1. TSS capsule production of Trisula variety
The used bulbs were two months of age after harvesting, then vernalized at a temperature of 6–10°C for four weeks. The growth regulator benzylaminopurine (BAP) was applied with a recommendation dose, then dissolving in 5 ml of 1 M KOH/NaOH. After that, it was diluted in water to obtain a concentration of 37.5 ppm. The vernalized bulbs were soaked in BAP solution for one hour, then drained on a bamboo tray.

The research field was plowed with a depth of 30 cm and cleared of weeds, then loosened. Furthermore, the beds were made with a width of 1 cm, a length of 10 m, or adapted to field conditions. Dolomite lime 1.5 t ha⁻¹ was applied on the bed with horse manure at a dose of 20 t ha⁻¹, SP-36 (75-90 kg P₂O₅ ha⁻¹) as basal fertilizer the insecticide for soil insect, then mix it evenly with soil using a hoe. After that, the beds were covered with silver plastic mulch.

After soaking in BAP solution, the drained bulbs have applied a fungicide with active content mancozeb at a dose of 20 g for 1 kg bulbs by spreading evenly. Bulbs were planted in beds with a
spacing of 20 x 20 cm. The bamboo shading with transparent U.V. plastic was made after umbels appear (± 3 WAP). NPK 16:16:16 was applied once a week for ten times since 10 DAP at a dose of 60 kg ha⁻¹ per each application. The used boron dose was 3 kg ha⁻¹ applied three times since 3, 5, and 7 WAP with 1/3 quantity per each application by dissolving in the water then sprayed to the plants especially head of umbel part.

Pollination can be carried out by some techniques such as planting marry gold plants surrounding of research field for attracting pollinator insects, placing swarms of honey bees in several points of the research field, or swab umbels by hand manually. Watering was done every day if be needed. The dew at the leaves tips was removed by spraying water in the morning. Weeding was done intensively. Selective chemical pesticides control pests and diseases. Harvesting was carried out if the capsule was already cracked and half of the shell was yellow with black seed color. Harvesting TSS was done by cutting the umbel with or without the stalk [7].

### Table 1. Treatment of TSS processing combination techniques

| Treatment | Seed processing technique | Drying | Capsule breaking /Pulper | Sorting |
|-----------|---------------------------|--------|-------------------------|---------|
| 1         | Drying process by sunlight at the screen house (7-14 days) | Hand manually | Hand manually |
| 2         | Drying process by sunlight at the screen house (7-14 days) | Hand manually | Winnower |
| 3         | Drying process by sunlight at the screen house (7-14 days) | Pulper | Hand manually |
| 4         | Drying process by sunlight at the screen house (7-14 days) | Pulper | Winnower |
| 5         | Drying at dehumidifier (R.H. 50%) & heater room (30-35°C for 72 hours) | Hand manually | Hand manually |
| 6         | Drying at dehumidifier (R.H. 50%) & heater room (30-35°C for 72 hours) | Hand manually | Winnower |
| 7         | Drying at dehumidifier (R.H. 50%) & heater room (30-35°C for 72 hours) | Pulper | Hand manually |
| 8         | Drying at dehumidifier (R.H. 50%) & heater room (30-35°C for 72 hours) | Pulper | Winnower |
| 9         | Drying by dryer’ hallway type’ (30-35°C for 5-6 hours) | Hand manually | Hand manually |
| 10        | Drying by dryer’ hallway type’ (30-35°C for 5-6 hours) | Hand manually | Winnower |
| 11        | Drying by dryer’ hallway type’ (30-35°C for 5-6 hours) | Pulper | Hand manually |
| 12        | Drying by dryer’ hallway type’ (30-35°C for 5-6 hours) | Pulper | Winnower |

### 2.2. TSS capsules processing
TSS capsule processing used Randomized Complete Block Design (RCBD) with three times replications. There was 12 TSS processing treatment as a technique combination of drying umbels, breaking capsule, and sorting clean seed of TSS. (Table 1). After sorted, all seeds were dried again by
dehumidifier room temperature of 30-35°C for two days or by the dryer machine. Then the produced seed was observed on seed weight per treatment.

2.3. Testing of the produced TSS
The produced TSS was conducted quality testing consisted of moisture content, physical purity, viability and vigor, electric conductivity. Also, be observed the time duration of seed processing per treatment. Data were analyzed using the F test and DMRT test at a 5% level

3. Results and discussion
3.1. The produced seed and rendement percentage
Plant conditions in the vegetative and early generative phases were right. Still, in the seeding phase, the stalks began to be infected by the pathogen Stenphyllum vesicarium, while the insect Spodoptera exigua infected florets. The situation was due to the research conducted in the rainy season with high humidity, so pest and disease infection was also relatively high. Suppose stalks are infected by Stenphyllum vesicarium, so photosynthate and water distribution to umbels were inhibited [11]. In the end, umbels became died. Plant protection was applied by pesticides two times a week.

According to observation could be known that umbels emerging percentage of Trisula variety are around 70%. Naturally, the umbels percentage in the highland (>900 m sal) is high because of low temperature (<18°C). In addition, bulbs vernalization treatment was applied, BAP growth regulators' application stimulated umbels number more than 100%. Umbels emerging began at the age of 2-3 WAP. If without vernalization and BAP application umbels appearing more than 30 DAP with small size and a few numbers [9].

Tabel 2. The produced seed and rendement percentage of harvested umbel per processing treatment

| Treatman t | Weight of harvested umbel (kg) | Capsules containing seed per harvested umbels (%) | Produced clean seed (g) | Seed rendement percentage (%) |
|------------|-------------------------------|-----------------------------------------------|------------------------|-------------------------------|
| 1          | 3.11                          | 91.05                                         | 309.27                 | 11.22                         |
| 2          | 3.11                          | 92.53                                         | 326.28                 | 12.07                         |
| 3          | 3.11                          | 92.38                                         | 345.02                 | 12.40                         |
| 4          | 3.67                          | 89.21                                         | 441.24                 | 11.61                         |
| 5          | 3.13                          | 89.88                                         | 368.03                 | 11.86                         |
| 6          | 3.47                          | 81.31                                         | 426.78                 | 11.82                         |
| 7          | 3.96                          | 89.79                                         | 456.10                 | 11.34                         |
| 8          | 3.96                          | 89.39                                         | 422.68                 | 10.37                         |
| 9          | 3.57                          | 79.75                                         | 348.20                 | 9.60                          |
| 10         | 3.57                          | 83.28                                         | 364.66                 | 10.08                         |
| 11         | 3.49                          | 84.17                                         | 366.88                 | 10.27                         |
| 12         | 3.49                          | 85.59                                         | 367.87                 | 10.27                         |
| $F_{value}$ | 0.92$^{ns}$                   | 2.04$^{ns}$                                   | 1.47$^{ns}$            | 0.26$^{ns}$                   |
| CV (%)     | 16.08                         | 6.06                                          | 17.76                  | 28.31                         |

At the age of 110, DAP was the first time umbel's Trisula variety was harvested. This information is appropriate with Rosliani et al. (2017) [7] that mentioned the harvesting time usually at the age of 105-110 DAP identified by the capsules already cracked, and half of the shell was yellow with black seed color. Harvesting was done three times by only selecting the good umbels. The total yield of harvested umbels was around 124.92 kg. Furthermore, these materials were used to research the study, with an average of each treatment per replication range from 3.11-3.96 kg (Table 2).

Prior to processing, the observation was conducted on the percentage of capsules containing seed per harvested umbels distributed to each treatment per replication. The result showed a high percentage in
the range 79.75 – 92.53% (Table 2). It indicated that the pollination technique by insect pollinator and swabbed by hand manually were effective enough [10]. These pollination techniques could be applied to produce TSS in the field.

Table 2 could be known that the produced seeds number of each treatment showed no difference significantly. This caused by the processed umbel's weight capacity per each treatment was the same in range 3-4 kg. Treatment No 7 was the best performance in producing TSS (456.10 g). It was possible because the harvested umbel number capacity was also the most a lot (3.96 kg).

Each treatment had the same umbels number capacity. This condition caused the rendement percentage among them also no different significantly. In addition, if the used umbels number that processed only small scale capacity, the possibility of no difference significantly between processed by machine or by hand manually. Treatment No 3 (12.40%) was the highest percentage of seed rendement performance. However, it was suggested that the minimum processed umbel capacity of 10 kg per treatment for the next study could prove a difference significantly between each treatment.

3.2. Preliminary study working effectiveness of TSS processing machine

The results showed that umbels drying by dryer ‘hallway type’ could be used for large capacity per one processing. Umbels as much as 3-4 kg capacity could be dried only within 5-6 hours with a temperature of 30-35°C. Drying by a dehumidifier and heater room needed temperature 30-33°C for three days until the umbels can be processed. Umbel withering treatment should be done at the screen house, either processing by a dryer machine or a dehumidifier & heater room for 1-3 days depending on the harvested umbel humidity to avoid heat shock. At this stage, the stalks and florets must be cut to make easier capsule processing and reduce waste [7]. As for drying processing by sunlight at the screen house is very dependent on time and weather conditions. The processing can’t be done in the early morning because the umbel’s condition is still chewy due to high humidity in the screen house.

![Figure 1. Three kinds of TSS processing machine: (a) Umbels drying 'hallway type'; (b) Pulper; (c) Winnower sorting machine](image)

Umbels drying by dryer machine took the shortest time compared to other treatments because the wither capsules could be processed directly for 4-6 hours depending on the dried capsule capacity per one drying period. But this machine's working was considered inefficient because the processed wither capsule's capacity was only 4-6 kg and needed much more labor than other treatments. In this case, the being dried capsules had to be turned over every 2 hours. Besides that, it took time enough to prepare the machine. Drying by dehumidifier & heater room was more efficient because it could dry umbels in large capacity and not depend on weather conditions. The capsules could be dried for 3.33-4.00 days with controlled temperature and humidity. Hence possibility the maximum viability and vigor achieved at physiological mature could be kept well.

After umbels drying, the capsules were processed by a pulper or by hand manually. The pulper's capsules were considered more effective and efficient than hand manually based on the produced seed amount and speed of time. The processed capsules of 2-3 kg by hand manually needed time for 60
minutes, while the pulper was only for 20 minutes. However, seed processing by the pulper had a risk of damaging seeds. In this case, be indicated by the electrical conductivity value [14].

The winnower is used to sort good seed and dirty waste such as remain capsule, shell, umbels stalks. Based on the produced good seed, the winnower should be evaluated because the physical seed purity was still low. This result was slightly different as reported by [15] mentioned that sorting by winnower more efficient than hand manually with the capacity rate was 11.14 kg/hours and faster than hand manually (only 0.2 kg/hours). The expected seed product causes differences. In this research, the produced seed had to fulfil the minimum standard requirement as a breeder seed class; thus, the physical purity percentage must high.

It is recommended that a winnower still needs to be assisted by hand manually if the expected seeds had to fulfil minimum standard requirements [13]. Unfortunately, sorted by hand manually takes a lot of time, which ± 180 g of seeds took around 9 hours or equivalent with 20 g/hour. Nevertheless, the winnower's seed quality was excellent because it produced a lot of the weighted seed until it predicted that it would affect the germination percentage. Seed sorting by the winnower would be more effective if TSS umbels from good plant conditions would produce a lot of the weighted seed. As high as seed viability at the mature physiological stage so that the winnower working will be useful.

Figure 2. The time duration of TSS processing combination treatment

3.3. Viability, vigor, moisture content, and physical purity percentage of produced TSS

Although the produced TSS is abundant, the processing technique is useless if the quality is not good. Therefore, each treatment's produced TSS must be tested quality as a reference is the minimum standard quality of seed certification [13]. The quality testing results showed that seed germination parameters, seed germination, and electrical conductivity were differences significantly between treatments (Table 3). Still, there was no difference in the parameters of seed moisture content and physical purity (Figure 3). The results showed that the seed processing treatment influenced to quality of the produced seeds, especially viability and vigor. Information on early viability and vigor value will determine the storage ability [12].

The seed germination test represents viability. Germination is one parameter quality with a required minimum percentage of 70% [13]. The result showed that the seed germination percentage of treatment. No. 6 (75.00%) was the highest and differed significantly from other treatments (Table 3). The produced TSS of treatment No 6 was the only one that could fulfill the required minimum standard of seed certification with an average of germination, moisture content, and physical purity were 75.00%, 7.53%, and 99.91%, respectively.

Seed vigor was tested by seed germination (%/etmal) and electrical conductivity (µs/cm/g). It could be known that results in both parameters showed that there were differences significantly among treatments. Treatment No 6 (12.38%/etmal) was the best performance for speed germination and different from other treatments, whereas treatment No 1 (control) was the worst (6.76%/etmal). This
result proved that using the dryer machine positively affected viability and vigor than processed by hand manually. In a recent study, the speed of germination correlated with seed germination directly. As high as germination percentage, so speed germination became higher also. The drying processing technique was predicted to influence seed germination, seed germination, and moisture content. In contrast, the capsule breaking technique affects electrical conductivity as for seed sorting technique influences physical purity.

**Table 3.** Seed quality of the produced TSS

| Treatment | Seed germination (%) | Speed of germination (%/etmal) | Electrical conductivity (µs/cm/g) |
|-----------|----------------------|--------------------------------|----------------------------------|
| 1         | 41.58 c              | 6.76 c                         | 486.99 ab                        |
| 2         | 47.92 bc             | 7.79 bc                        | 411.55 b                         |
| 3         | 50.92 bc             | 8.39 bc                        | 422.70 b                         |
| 4         | 50.67 bc             | 8.35 bc                        | 496.24 ab                        |
| 5         | 51.17 bc             | 8.40 bc                        | 502.81 ab                        |
| 6         | 75.00 a              | 12.38 a                        | 259.88 c                         |
| 7         | 57.33 b              | 9.48 b                         | 561.15 ab                        |
| 8         | 55.17 bc             | 9.11 bc                        | 481.35 b                         |
| 9         | 46.33 bc             | 7.57 bc                        | 528.00 ab                        |
| 10        | 56.67 bc             | 9.31 b                         | 461.52 b                         |
| 11        | 44.67 bc             | 7.42 bc                        | 640.27 a                         |
| 12        | 55.33 bc             | 9.15 bc                        | 401.22 b                         |
| CV (%)    | 14.83                | 14.92                          | 17.35                            |

**Figure 3.** Seed moisture content and physical purity of TSS processing combination techniques

Electrical conductivity is one of the vigor parameters. This parameter is an indicator of seed leakage [14]. It means high electrical conductivity value indicates damage inside a seed and can affect low viability and vigor performance. According to statistical analysis, there was a different significance in electrical conductivity among treatments in the range of 259.88-640.27 µs/cm/g. Treatment No. 6 showed the lowest electrical conductivity performance (259.88 µs/cm/g) and differed significantly from other treatments. It was proved treatment No 6 had the best viability and vigor performance.

Figure 3 shows that seed moisture content value in the range 7.17% (treatment No. 1 and No. 4) until 7.80% (treatment No. 11). The test result showed that the seed moisture content parameter was not significantly different from each treatment because the seed dried after processed manually until minimum reaches moisture content 8.0% as a requirement for all seed classes. Figure 3 could also be known that each treatment's physical purity percentage was not significantly different, in this case in the range of 99.78% (treatment No. 11) until 100.00% (treatment No. 10 and No. 12). This result was caused by a double sortation technique, which the first sorting by winnower, then followed by hand manually;
thus the physical purity level became better. All treatments' physical purity level had fulfilled a minimum requirement as a stock seed (S.S.) class within a limit of 99.5% [13].

4. Conclusion and Suggestion
1. The best treatment was a combination technique with seed capsule drying in the dehumidifier room at 30-35°C for 72 hour - breaking capsule by hand manually – seed sorting by winnower followed by hand manually, then redried in the dehumidifier & heater room at 30-35°C until moisture content was appropriate for breeder seed standard requirement.
2. The produced seed quality in this treatment showed the germination was 75%, the moisture content was 7.5%, and the physical purity was 99.9%.
3. This research implies that the availability of TSS processing technology can be carried out by massal but still can produce good seed quality.

5. Acknowledgments
The authors are thankful to the Indonesia Agency for Agricultural Research and Development (IAARD) for funding research through the IVEGRI DIPA 2018 Project No. 1804.208.053.B.1. Besides that Authors are thankful to the Director of IVEGRI and Dr. Redy Gaswanto, SP., MP, for guidance, motivation encouraging and supporting all this time technically.

References
[1] Fanny T, Eliyani and Kurniadinata O F 2020 Can We grow shallot (Allium ascalonicum L.) root in hydroponic system with simple growing media?. J Trop Hortic. 3 (2) 54-59. DOI: http://dx.doi.org/10.33089/jhort.v3i2.50
[2] Direktorat Jenderal Hortikultura 2017 Petunjuk teknis kegiatan pengembangan sayuran dan tanaman obat tahun 2016. Kementerian Pertanian.
[3] Direktorat Jendral Hortikultura 2020 Statistik hortikultura tahun 2019 (angka tetap). Direktorat Jenderal Hortikultura Kementerian Pertanian.
[4] Sumarni N, Sopha G A and Gaswanto R 2012 Respons tanaman bawang merah asal biji true shallot seeds terhadap kerapatan tanaman pada musim hujan. J. Hort. 22 (1) 23–28.
[5] Pangestuti R and Sulistyantingsih E 2011 Potensi Penggunaan true seed shallot (TSS) sebagai sumber benih bawang merah di Indonesia. Prosiding Semiloka Nasional “Dukungan Agro-Inovasi untuk Pemberdayaan Petani, Kerjasama UNDIP, BPTP Jateng, dan Pemprov Jateng, Semarang.
[6] Nurjanani and Djufry F 2018 Test potential for some variety to produce true shallot seed in highland South Sulawesi. J. Hort. 28 (2) 201-208.
[7] Rosliani R., Hilman Y, Waluyo N and Yufdy M P 2017 Petunjuk teknis teknologi produksi biji botani bawang merah/TSS (True Seed of Shallot). Balai Penelitian Tanaman Sayuran. Pusat Penelitian dan Pengembangan Pertanian. Badan penelitian dan Pengembangan Pertanian.
[8] Selvi D T and Saraswathy S 2017 Seed viability, seed deterioration and seed quality improvements in stored onion seeds: a review. J. of Hort. Scienc and Biotechnology 93 1-7.
[9] Prahardini P E R and Sudaryono T 2018 The true seed of shallot (TSS) technology production on Trisula variety in East Java. J Pembang dan Alam Lestari. 9 (1) 27–32.
[10] Sumarni N, Suwandi, Gunaneni, N and Putrasamedja S 2013 Pengaruh variasi dan cara aplikasi GAs terhadap pembungaan dan hasil biji bawang merah di dataran tinggi Sulawesi Selatan J. Hort. 23 (2): 153–163.
[11] Suheri H and Price T V 2001 Infection of onion leaves by Alternaria porii and Stemphylium vesicarium and disease development in controlled disease. Plant Pathol. 49 (3) 375–82. DOI:10.1046/j.1365-3059.2000.00458x.
[12] Hampton J 2002. What is seed quality?. Seed science and technology 30 (1) 1-10. https://www.researchgate.net/publication/289831470_What_is_seed_quality.
[13] Direktorat Perbenihan Hortikultura 2015 Pedoman Teknis Sertifikasi Benih Bawang Merah Keputusan Menteri Pertanian Nomor : 131/Kpts/Sr.130/D/11/2015. Direktorat Jenderal Hortikultura Kementerian Pertanian.
[14] Lazar S L, Mira S, Pamfil D and Martínez-Laborde J B 2014 Germination and electrical conductivity tests on artificially aged seed lots of 2 Wall-Rocket species. *Turkish J Agric For.* 38 (6) 857–64. DOI: 10.3906/tar-1402-76. https://www.researchgate.net/publication/270684400

[15] Lestari F and Kusumasari A C 2019 Penerapan teknologi mekanisasi pada proses penanganan pascapanen biji bawang merah. Prosiding Seminar Nasional Kesiapan Sumber Daya Pertanian dan Inovasi Spesifik Lokasi Memasuki Era Industri 4.0. http://repository.pertanian.go.id/handle/123456789/9148