ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS

Journal of Agronomy

ISSN 1812-5379
DOI: 10.3923/ja.2020.138.144

Research Article

Yield Potential of Shallots (*Allium cepa* L. Aggregatum Group) from Several Sources of Planting Material in Tropical Region

Eddy Triharyanto and Djoko Purnomo

Department of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret, Indonesia

Abstract

Background and Objective: The productivity of shallots in Indonesia is low. Productivity on average is only 9 t ha^{-1}. That is far from the potential to produce up to 15 t ha^{-1}. The research aims to evaluate the yield potential of planting material in the form of seed tubers, aerial tubers and *in vitro* culture tubers. **Materials and Methods:** The study was carried out at experimental field, ecology laboratory and *in vitro* Culture Laboratory from October, 2018-June, 2019. The study was conducted in two seasons. The first season to produce planting material such as; True Shallot Seed (TSS) tuber seeds, *in vitro* culture tuber seeds, aerial tubers and consumption tubers. The second season tested with one treatment factor. The experimental design used was complete randomized block design with 3 replications. **Results:** The results showed that type of planting material that had the highest yield potential was aerial tubers of 17.1 t ha^{-1}, then followed by *in vitro* culture of 15.3 t ha^{-1} and TSS of 9.9 t ha^{-1}. Consumption tubers has the lowest yield potential of 7.2 t ha^{-1}. **Conclusion:** To increase the productivity of shallots, planting material from aerial tubers can be used.

Key words: Aerial tubers, consumption tubers, *in vitro* culture, true shallot seed, planting material

Citation: Eddy Triharyanto and Djoko Purnomo, 2020. Yield potential of shallots (*Allium cepa* L. Aggregatum group) from several sources of planting material in tropical region. J. Agron., 19: 138-144.

Corresponding Author: Eddy Triharyanto, Department of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret, Indonesia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Indonesian shallots production in 2018 amounted to 1.470.155 t with an area[1] of 158.172 ha. Shallots productivity of Indonesia in 2013-2017 has decreased significantly[2]. Planting material is a problem in shallots cultivation. Shallots planting material used in the tropics, including; in Indonesia, is planting material from consumption tubers. This planting material is used for generations in a long time. It has been a decrease of planting material quality which has an impact on reducing the productivity of shallots yields. It is caused the tubers are susceptible to infectious diseases of *Fusarium* sp. and viruses like Shallot Latent Virus and Onion Yellow Drawf Virus (OYDV). The disease causes a decrease in productivity up to 60%[3,4].

Efforts to get quality seeds without viruses infection can be developed in various ways, such as; planting material of seed tubers[5], tubers planting material from *in vitro* culture[6] and aerial tubers planting material[7]. However, shallot cultivation through TSS in the tropical region is faced with problems such as; a low percentage of flowering, seeds produced have low viability, longer planting time than tuber seedlings, higher mortality rates in the nursery period and transfer of seedlings in the field and technical culture technology that has not been managed by farmers[8,9].

Aerial tubers are formed tubers from other parts of the plant above the surface of the ground which are usually from axillary nodes on stems and in certain circumstances can usually be formed from flowers[10]. Aerial tubers can also form from injured plant parts, as a result of disturbed assimilate translocation[11]. Aerial tubers are widely known in tuber crops such as; begonias, potatoes and *Dioscorea* sp. Aerial tubers are vegetative parts that can be used for seedlings benefit. Aerial tubers from begonias have long been carried out especially in studies of dormancy breakage[12-15]. Aerial tubers on *Dioscorea* sp. not used widely either for the benefit of food and seeds, while the shallots aerial tubers can be formed in summer with a 12 h irradiation length. In addition, shallots aerial tubers can be formed by gibberellins treatment (GA_3). The role of GA_3 is able to increase the lengthening of flower stalks quickly. In shallots, elongation of flower stalks is not only followed by flower emerge, but also often followed by the formation of aerial tubers. The results of studies on potatoes, aerial tubers are more resistant to pathogens[16], so that the aerial tubers are a source of planting material that has a better quality than consumption tubers. In sub-tropical countries naturally aerial tubers can form. This tuber has been used as planting material and is able to produce good yield.

In vitro culture nursery is an effort to obtain disease resistant seedlings[17,18]. The most important stage that causes fail *in vitro* culture is acclimatization[19]. The success of acclimatization of *in vitro* culture has been found among others in orchids, bananas and sugar cane. In addition for obtain healthy plants from pathogen infection, the purpose of *in vitro* culture is multiplication. However, *in vitro* culture multiplication of garlic have not been successfully carried out[9]. This also occurs in shallots[20]. *In vitro* culture yield potential in many studies have been shown higher crop yields and better quality as in banana[21], potatoes[22], sugar cane[23], orchids[24], chrysanthemums[25] and other types of plants. This study aims to produce and determine potential yield of planting material in the form of seed tubers, aerial tubers and *in vitro* culture tubers.

MATERIALS AND METHODS

This research was conducted in two growing seasons. The first growing season conducted several studies to obtain tuber planting material that will be tested for yield potential. The second growing season was a study to test potential yield of planting material obtained from the first growing season. The study was carried out at experimental field in Ngringo village, Palur district, Karanganyar regency, Central Java, *in vitro* Culture Laboratory and Ecology Laboratory from October, 2018-June, 2019.

First growing season: The first study was the planting of TSS that began with nurseries in trough. Transplanting was done at age 3 weeks. Planting was conducted in Ngringo experimental field, Karanganyar Central Java with planting distance of 10x10 cm. Harvesting was done at 80 days after planting.

The second study was *in vitro* culture by taking explant material from the growing point on the shallots discs. Media used was Murashige-Skoog (MS). Furthermore, acclimatization was conducted from *in vitro* culture plantlets to obtain tuber yield. Acclimatization was conducted at 2 altitudes at 100 m above sea level and 1200 m above sea level.

The third study was a study to obtain aerial tubers by soaking consumption tubers seed in a solution of gibberellins (GA_3). Concentration of GA_3 used was 0,100 and 200 ppm.

This research was surveys and observations to obtain planting material that will be tested for potential yield in the 2nd growing season. Data analysis used tabulation and explanation.

Second growing season: The second growing season was a potential test of tuber seed yields from first growing season, which includes TSS yield tuber seedlings, *in vitro* culture tuber seedlings and aerial tubers compared to consumption tubers. The research was one-factor treatment experiment, which was type of planting material source consist of four treatments namely TSS yield tuber seedlings, *in vitro* culture tuber seedlings, aerial tubers and consumption tubers. The design used Complete Randomized Block Design (RCBD) with three replications. Observation variables included tuber weight per clump, tuber weight per plot, tuber weight per ha, number of tubers per clump and tuber diameter.

Statistical analysis: Data analysis used analysis of variance with Duncan's multiple range test at the 5% level.

RESULTS

First growing season research results: The TSS yield obtained by the number of tubers with an average of 2.3 tubers per clump (Table 1). This yield was relatively low compared to the consumption tubers yield. The diameter of the tuber from TSS yield was smaller than the planting material from tuber (Table 1). The average diameter of the tuber was 1.8 cm smaller than diameter of consumption tuber with diameter of 2.8 cm. The size of tubers produced from botanical seeds is classified as small tubers which when compared to tubers consumption that have diameter ranges from 2-5 cm per tuber.

The results of *in vitro* culture studies showed that plantlet growth in MS media was very good (Fig. 1). Shallots were able to grow well in MS media. However, the results of acclimatization show that in the highlands (1200 masl) plantlets can grow as planting material, but not in lowlands (100 masl) (Table 2). The highlands has supported temperature for acclimatization, with average temperature in the range of 20°C with relatively high humidity (>60%). *In vitro* acclimatization of garlic can be successfully grown at temperature range of 20°C. The results showed acclimatization that carried out in March had a high success rate, plantlets which grew by 64.58%. This was because the daily temperature was relatively stable in the temperature range of 20°C. In January, although the average temperature was around 20°C, but the rainfall was very high which caused many plantlets affected by fungi. While, in May there was a change in temperature where the average temperature could reach 26°C which resulted in unsuccessful acclimatization.

The results of the first growing season that *in vitro* culture planting material were able to produce an average large tubers diameter of 2.9 cm (Table 3). The results of *in vitro*

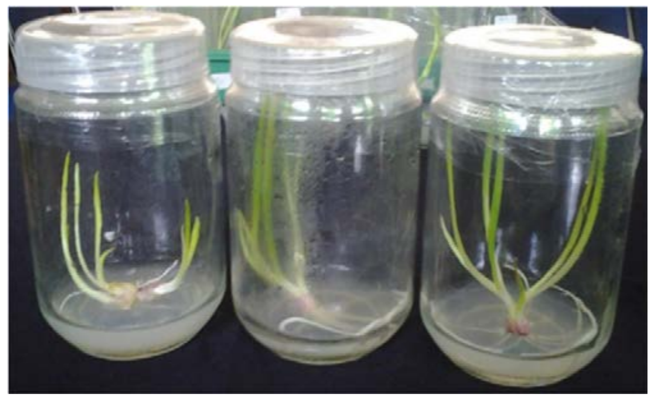

Fig. 1: Shallots plantlet growing in MS media

Table 1: Tuber yield from TSS

	TSS tuber yield		
Repetition	Weight per clump (g)	Number of tubes per clump	Diameter (cm)
1	25.50	2.00	2.30
2	14.30	2.00	1.50
3	18.40	2.00	1.70
4	34.00	3.00	1.90
Average	23.10	2.30	1.80

Table 2: Shallots plantlets acclimatization yield

Location	Acclimatization time	Average daily temperature (°C)	Humidity (%)	Number of plantlet	Number of growing plantlet
Highland (1200 masl)	January	20.80	82.40	10.00	4.00
	March	21.10	81.60	48.00	31.00
	May	26.20	80.50	12.00	0.00
Lowland (100 masl)	January	27.80	79.10	80.00	0.00
	March	27.60	79.00	74.00	0.00
	May	27.90	79.50	76.00	0.00

Table 3: Tuber yields from *in vitro* culture

	Tuber yields from *in vitro* culture		
Replication	Weight per clumps (g)	Tubers number per clump	Diameter (cm)
1	34.80	5.00	3.10
2	48.30	4.00	2.50
3	42.30	4.00	3.10
4	40.20	3.00	3.00
Average	41.40	4.00	2.90

Fig. 2: Shallot aerial tubers

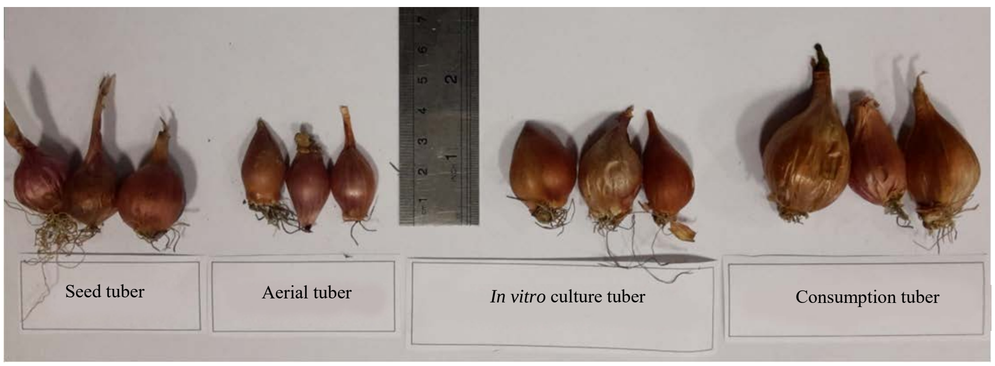

Fig. 3: Planting material from TSS yield tubers, aerial tubers, *in vitro* culture tubers and consumption tubers

Table 4: Effect of GA_3 in consumption tubers seedling to aerial tubers forming

GA_3	Average number of flowering clump (%)	Average number aerial tubers per clump (%)	Average of tubers weight (g)	Average of tubers diameter (cm)
0 ppm	20.00	0.00	0.00	0.00
100 ppm	25.00	5.00	0.80	1.30
200 ppm	35.00	9.00	1.30	1.40

studies showed that average weight per clump and tubers number per clump were quite large, namely 40.4 g and 4 clumps (Table 3).

GA_3 application is an effort to add hormones to shallots. The results showed that the immersion of GA_3 in shallot tubers planting material was able to increase the number of aerial tubers and the number of flowering (Table 4). In addition to increase flowering, GA_3 was able to increase the number of aerial tubers, tubers weight and tubers diameter (Table 4). Increasing number of aerial tubers at concentration of 100 and 200 ppm by 5 and 9%. In shallots, bolting was not only followed by the emerge of flowers but often also followed by formation of aerial tubers (Fig. 2).

The planting material of first growing season from TSS tubers, aerial tubers, *in vitro* culture tubers were tested for potential yield in the second growing season (Fig. 3). Each planting material has been stored for 3 months to be planted. The shallot tubers dormancy period ranges from 2-3 months. Consumption tubers size was larger than the other tubers. While aerial tubers have smaller sizes. However, aerial tubers show high yield potential (Table 5).

Second growing season research results: The results showed that aerial tubers planting material has average tuber weight per clump, tuber weight per m^2 and the highest tuber weight per ha. The highest yield potential was showed by planting

Table 5: Tubers weight per clump, tubers weight per plot and tubers weight per ha

Treatments	Tubers weight per clump (g)	Tubers weight per plot (kg)	Tubers weight per ha (t)
TSS yield tubers	45.1±2.40^{b}	1.1±0.040^{b}	9.90^{b}
Aerial tubers	77.3±7.50^{c}	1.9±0.185^{c}	17.10^{c}
In vitro culture tubers	68.6±10.74^{c}	1.7±0.270^{c}	15.30^{c}
Consumption tubers	32.1±2.46^{a}	0.8±0.065^{a}	7.20^{a}

Numbers followed by the same letters in the same columns indicate not significantly different on Duncan multiple range rest at a level 5%

Table 6: Number of tubers per plant and tubers diameter

Treatments	Number of tubers per plant	Tubers diameter (cm)
TSS yield tubers	8.00±1.15^{a}	2.20±0.35^{b}
Aerial tubers	12.70±3.33^{b}	2.40±0.04^{b}
In vitro culture tubers	6.30±0.33^{a}	2.90±0.07^{c}
Consumption tubers	6.20±0.50^{a}	1.90±0.07^{a}

Numbers followed by the same letters in the same columns indicate not significantly different on Duncan multiple range rest at a level 5%

material from aerial tubers (17.1 t ha^{-1}). The use of aerial tubers planting material was not significantly different with *in vitro* culture tubers (Table 5). Potential yield of planting material from aerial tuber seedlings showed the highest yield followed by *in vitro* culture tubers and TSS. The results of planting tuber seedlings from shallots *in vitro* culture showed high yield (15.3 t ha^{-1}). The yield quality indicated by the number tubers per clump and size of planting material from TSS, *in vitro* culture seedlings and aerial-tuber seedlings were also much better than consumption tubers (Table 6). The number of tubers per clump was more and the tuber size was bigger. The results showed that the largest size was *in vitro* culture yield (2.9 cm). The TSS not significantly different with aerial tubers yield (Table 6).

DISCUSSION

Planting material from vegetative organs used continuously for decades will reduce the quality of seedlings. Such in shallot cultivation in tropical regions such as in Indonesia. The planting material used is tubers that have been used for decades so that easily infected with a virus. Some alternatives to produce high-quality planting materials include using tuber seedlings produced by TSS, tuber seedlings from *in vitro* culture and aerial tuber seedlings.

The TSS has great potential in the cultivation of shallots in Indonesia, because it is not infected with a virus, cheap and efficient[16,26]. The yield of tubers per plant in TSS cultivation is 2 tubers[9]. The low yield of tubers cultivation is one of the problems faced in the cultivation of shallots by using botanical seeds[9]. However, the use of botanical seeds is one alternative that can be developed to improve the quality of shallot seeds[27]. The use of TSS seeds can increase yields up to two times, highest tuber yield, weight and diameter compared to the use of consumption tubers[28,29].

Temperature is a main factor in acclimatization of shallots. The percentage of plantlet mortality increases as acclimatization temperature[30]. The results showed that the highland has a temperature that supports the acclimatization, the average temperature recorded in the range of 20°C with relatively high humidity (>60%). *In vitro* culture acclimatization of garlic can be grown at temperature range of 20°C[31] temperatures can increase the percentage and rate of shallot growth[32]. The influence of agroclimate on the growth of garlic cultivars was strongly influenced by the location of planting changes in temperature from *in vitro* culture (25±1°C) to *in vivo* which can reach 18°C at night and 32°C during the day result in depressed plantlets growth so that acclimatization often fails[33].

Tuber seedlings from *in vitro* culture are also seeds that are not infected by viruses. The use of *in vitro* culture media with high levels of sucrose has a positive effect on shoot proliferation, culture maintenance and tuber initiation in *Allium* sp.[34]. *In vitro* culture is a proper alternative method for increasing the multiplication efficiency of *Allium* species from various explant sources[24,35-38].

GA_3 soaking in shallot tubers can increase the number of aerial tubers and number of flowering plants. Increasing amount of aerial tubers at concentration of 100 and 200 ppm by 5 and 9%. In lettuce, GA_3 are able to induce bolting and increase seed yield[39]. The results of the second growing season of aerial tuber planting material showed that highest tuber weight per ha. Aerial tubers are vegetative parts that are formed on flower stems with very small tuber sizes[10]. Aerial tubers can formed in suitable climatic conditions in summer with full irradiation length. The formed aerial tubers have resistance to pathogen[40]. Potential yield of planting material derived from aerial tuber seedlings showed the highest yield followed by tuber seedlings resulting from *in vitro* culture and seed tuber seeds. The quality of yields from aerial tubers and TSS is quite high. The size of the tubers produced from aerial tubers planting material, *in vitro* culture tubers and seed provide better quality compared to consumption tubers.

CONCLUSION

Aerial tubers and TSS formation can be increased by using GA_3. Acclimatization in *in vitro* culture is largely determined by temperature. Acclimatization can grow plantlets in low temperatures. Potential yield of planting material derived from aerial tuber seedlings showed the highest yield followed by tuber seedlings resulting from *in vitro* culture and seed tuber seeds.

SIGNIFICANCE STATEMENT

This study discovers that GA_3 can increase air tuber production, but is still very low and can increase TSS production. Plant material from air tubers has high productivity followed by planting material *in vitro*. This finding can be applied to onion farmers in the tropics. This study will help researchers to uncover the critical areas of the role of GA_3 in increasing aerial tuber yield, the role of aerial, TSS and *in vitro* tuber for increasing shallot productivity in the tropics.

REFERENCES

1. BPS., 2018. Statistics of Indonesia (Statistical Yearbook of Indonesia) 2018. 1st Edn., Badan Pusat Statistik Indonesia, Pages: 719.
2. DGH., 2020. Shallot production statistics. http://hortikultura2.pertanian.go.id/produksi/sayuran.php
3. Brewster, J.L., 2008. Onions and other Vegetable Alliums. 2nd Edn., CABI., Wallingford, UK.
4. Fletcher, P.J., J.D. Fletcher and S.L. Lewthwaite, 2010. *In vitro* elimination of onion yellow dwarf and shallot latent viruses in shallots (*Allium cepavar.ascalonicum* L.) New Zealand J. Crop Hortic. Sci., 26: 23-26.
5. Triharyanto, E., S. Nyoto and I. Yusrifani, 2018. Aplication of giberelins on flowering and yield of two varieties of shallot in lowland. IOP Confer. Ser.: Earth Environ. Sci., Vol. 142. 10.1088/1755-1315/142/1/012066.
6. Dharmayanti, K., E. Sulistyaningsih and R.A. Wulandari, 2017. Callus induction on True Shallot seed explant using a combination of BA and 2,4-D. Ilmu Pertanian (Agric. Sci.), 2: 137-143.
7. Askari-Khorasgani, O and M. Pessarakli, 2019. Evaluation of cultivation methods and sustainable agricultural practices for improving shallot bulb production – a review. J. Plant Nutr., 43: 148-163.
8. Triharyanto, E., Sudadi and S Rawandari 2018. Adaptation of six shallots varieties to phosphate solubilizing bacteria on the flower formation, seeds fromation, and yields on the lowland. IOP Confer. Ser.: Earth Environ. Sci., Vol. 142. 10.1088/1755-1315/142/1/012067.
9. Kemal, Y.O, 2013. Effects of irrigation and nitrogen levels on bulb yield, nitrogen uptake and water use efficiency of shallot (Allium cepa var. ascalonicum Baker). Afr. J. Agric. Res., 8: 4637-4643.
10. Ewing, E.E. and P.C. Struik, 1992. Tuber formation in potato: Induction, initiation, and growth. Hortic. Rev., 14: 89-198.
11. Jackson, S.D., 1999. Multiple signaling pathways control tuber induction in potato. Plant Physiol., 119: 1-8.
12. Esashi, Y. and A.C. Leopold, 1969. Regulation of the Onset of Dormancy in Tubers of *Begonia evansiana* Plant Physiol., 44: 1200-1202.
13. Esashi,Y. and M. Nagao., 1973. Effects of Oxygen and Respiratory Inhibitors on Induction and Release of Dormancy in Aerial Tubers of *Begonia evansiana* Plant Physiol., 51: 504-507.
14. Okagami, N. and Y. Esashi., 1972. Dormancy regulation by morphactin in aerial tubers of *Begonia evansiana* Planta, 104: 195-200.
15. Okagami, N., Y. Esashi and M. Nagao, 1977. Gibberellin-induced inhibition and promotion of sprouting in aerial tubers of *Begonia evansiana* Andr. in relation to photoperiodic treatment and tuber stage. J. Planta, 136: 1-6.
16. Degewione, A., S. Alamerew and G. Tabor, 2011. Genetic variability and association of bulb yield and related traits in shallot (*Allium cepa* var. *Aggregatum DON.*) in Ethiopia. Int. J. Agric. Res., 6: 517-536.
17. Krishnamurthi, M., 1976. Isolation, fusion and multiplication of sugarcane protoplasts and comparison of sexual and parasexual hybridization. Euphytica, 25: 145-150.
18. Sharma, U., V. Kataria and N.S. Shekhawat, 2017. *In vitro* propagation, *ex vitro* rooting and leaf micromorphology of *Bauhinia racemosa* Lam.: a leguminous tree with medicinal values. Physiol. Mol. Biol. Plants, 23: 969-977.
19. Pospisilova, J., I. Ticha, P. Kadleaeek, D. Haisel and S. Plzakova, 1999. Acclimatization of micropropagated plants to *ex vitro* conditions. Biol. Plant, 42: 481-497.
20. Istiqomah, N., N. Barunawati, N. Aini and E. Widaryanto, 2019. True shallot seed production of lowland shallot (biru lancor varieties) under the application of seaweed extract and n fertilizer. Russ. J. Agri. Socio-Economic, 90: 325-338.
21. Prabhuling, G. and B.N. Sathyanarayana. 2017. Optimization of explants density for tissue culture propagation of banana cv. 'GRANDE NAINE' Int. J. Agric. Sci., 13: 71-76.
22. De Morais, T.P., S.A. Asmar, H.F. De Jesus Silva, J.M.Q. Luz and B. De Melo, 2018. Application of Tissue Culture Techniques in Potato Biosci. J., 34: 952-969.
23. Kumari, R., D. Gena, R.A. Bhat, R.S. Rawat and B.L. Jat, 2016. *In vitro* tissue culture of *Saccharum officinarum* L. (sugarcane). World J. Pharm. Res., 5: 592-625.
24. Zheng, S.J., B. Henken, F.A. Krens and C. Kik, 2003. The development of an efficient cultivar-independent plant regeneration system from callus derived from both apical and non-apical root segments of garlic (*Allium sativum* L.). *In vitro* Cell. Dev. Biol. Plant, 39: 288-292.

25. Nasri, F., H. Zakizadeh., Y. Vafaee and A.A. Mozafari, 2018. *In vitro* propagation of Chrysanthemum: an overview on its utility in mutagenesis and genetic transformation techniques. Agric. Res. Technol., 10.19080/ARTOAJ.2018.15.555962.
26. Aklilu S., 2014. The performance of true seed shallot lines under different environments of Ethiopia. J. Agric. Sci., 59: 129-139.
27. Triharyanto, E., Sudadi and S Rawandari 2018. Adaptation of six shallots varieties to phosphate solubilizing bacteria on the flower formation, seeds fromation, and yields on the lowland. IOP Confer. Ser.: Earth Environ. Sci., Vol. 142. 10.1088/1755-1315/142/1/012067.
28. Biru, F. N., 2015. Effect of spacing and Nitrogen fertilizer on the yield and yield component of shallot (*Allium ascalonium* L.). J. of Agron., 14: 220-226.
29. Saidah, S., M. Muchtar, S. Syafruddin and R. Pangestuti, 2019. The effect of plant spacing at the growth and yield of shallot from true shallot seed in Sigi district, Central Sulawesi. Pros. Sem. Nas. Masy. BIODVIN. Indon. 5: 209-212.
30. Andini, D.C., E.T. Haryanto and D. Purnomo, 2015. Radiation for garlic planlets on aclimatization phase. Caraka Tani: J. Sustain. Agric., 30: 25-29.
31. Matsubra, S. and D. Chen, 1989. *In vitro* production of garlic plants and field acclimatization. Hort. Sci., 24: 677-679.
32. Desta, B., K. Woldetsadi, W. Mohammed and B. Abebie. 2017. Duration of low temperature swtorage, clove topping and smoke water on garlic sprouting and seedling vigor J. Agron., 16: 124-130.
33. Elizani, P. and E. Sulistyaningsih, 2019. The correlation and regression analysis of the growth and physiological parameters: how paclobutrazol increases bulb yield on three cultivars of true shallot seed. Caraka Tani J. Sustain. Agric., 34: 128-139.
34. Hidayat, I.M., 2015. *In vitro* plant regeneration and bulblet formation of shallots (*Allium ascalonicum* L.) 'sumenep'. Acta Hortic., 10.17660/ActaHortic.2005.688.34.
35. Luciani, G.F. A.K. Mary, C. Pellegrini and N.R. Curvetto, 2006. Effects of explants and growth regulators in garlic callus formation and plant regeneration Plant Cell. Tiss. Organ. Cult., 87: 139-143.
36. Xu, Z., Y.C. Um, C.H. Kim, G. Lu and D.P. Guo *et al.*, 2008. Effect of plant growth regulators, temperature and sucrose on shoot proliferation from the stem disc of Chinese jiaotou (*Allium chinense*) and *in vitro* bulblet formation. Acta Physiol. Plant, 40: 521-528.
37. Bah, A.A., Z.D. Wang, X.Q. Wang, M.M. Yan, Y.C. Um, Z. Xu and D.P. Guo, 2012. *In vitro* plant regeneration from unpollinated ovaries of *Allium chinense*. Sci. Hortic., 147: 105-110.
38. Hailekidan, B., M. Andargie, M. and K. Assefa, 2013. *In vitro* plantlet regeneration from the bulbs of shallot (*Allium cepa* var. group aggregatum) Res. Plant Sci., 1: 45-52.
39. Passam, H.C., A.C. Koutri and I.C. Karapanos, 2008. The effect of chlormequat chloride (CCC) application at the bolting stage on the flowering and seed production of lettuce plants previously treated with water or gibberellic acid (GA3). Sci. Horti., 116: 117-121.
40. Percival, Karim and Dixon, 2003. Pathogen resistance in aerial tubers of potato cultivars. Plant Pathol. 48: 768-776.