Input Saving Technology Package of True Seed of Shallot (TSS) Production in Indonesia

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Abstract. True seed of shallot (TSS) can be an alternative source of shallot seeds. But the use of TSS in Indonesia is still limited because not many people produce TSS because of high input production. This research aimed to evaluate the technical and economic feasibility of input saving TSS production technology packages. The research was carried out in Ciwidey district, Bandung Regency, West Java, Indonesia from June to October 2016. The research consisted of two factors arranged in a split plot with a randomized block design and eight replications. The main plot was technology packages, namely farmer, recommendation and input saving. The subplot was harvest time, which were 80, 90, and 100 weeks after planting. The observed variables were yield component and yield, soil status, climate data, and farming data. The technical data were analyzed by ANOVA test and continued using the Duncan test at a 95% confidence level. Farming data was analyzed by RC ratio. The results showed that input saving package did not meet seed standards with an RC ratio of 1.07. Savings input on TSS production in Indonesia were only possible by choosing the right location and planting time and must be followed by climate prediction.

1 Introduction

True seeds of shallot (TSS) can be an alternative source of shallot seeds because TSS can be stored for a long time, so TSS can be used at any time especially when tuber seeds are scarce. TSS has several other advantages compared to tuber seeds such as the use of a little (5-7 kg / ha), relatively healthy, easy to transport, and no period of dormancy [1, 2]. The many advantages of this TSS cause many farmers to be interested in developing it. TSS could increase yields doubled compared to tuber seed, making it economically feasible [1]. However, the availability of TSS in Indonesia is still limited because not many people produce TSS.

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The technology package of recommended TSS production has been produced by the Indonesia Vegetable Research Institute (IVEGRI) [1]. But to deal with environmental constraints in the tropics such as Indonesia in the form of high temperatures and high rainfall, this technology package requires quite high production inputs with a cost range of 200-300 million per ha [3]. Shallots required temperatures of 7-12 °C for flowering induction, temperatures of 17-19 ºC for the development of umbles and blooming flowers and higher temperatures of 35 °C for fertilization and seeding [4]. Tuber seed vernalization and selection of appropriate location and planting time are an effort to increase flowering in relation to high temperature and rainfall constraints [1,2,4]. However, increased flowering was sometimes not always followed by seed production, because the viability of shallot pollen was relatively low, so it was necessary to add additional production inputs [1]. Application of benzylaminopurine (BAP) and boron in TSS production can increase flowering and seeding [1,2,4]. Plastic shade is needed to protect flowering and seedlings from rain and *Alternaria* sp., but can also increase the seed survival [1].

The technology package of input saving TSS production is a technology package that uses lower production inputs, but the TSS production output is expected to be not significantly different from the package technology of IVEGRI recommendation, so that it is easily adopted by farmers. GA_3 application can improve TSS seed yield [2]. The use of ultraviolet (UV) as a shade affected the growth and yield of tomato plants and white clover [5]. The relatively cheaper GA_3 and PE plastic production inputs are each expected to replace BAP and UV plastic, which are more expensive. This research aimed to evaluate the technical and economic feasibility of input saving TSS production of technology package.

2 Methodology

The research was conducted in Ciwidey district, Bandung Regency, West Java, Indonesia with an altitude of 1000 meters above sea level from June to October 2016.

The research consisted of two factors arranged in a split plot with a randomized block design and eight replications. The main plot was the three technology packages, namely farmer, recommendation and input saving (Table 1). The technological components in the technology package tested were boron fertilization, use of growth regulators (Benzilaminopurine=BAP and GA_3), and types of shade plastic (Polyetilene=PE and Ultraviolet=UV). The sub plot was harvest time, which were 80, 90, and 100 WAP. One unit of the experiment was a bed measuring 1 m x 5 m.

Table 1. Three technology packages tested

No	Technology components	Technology packages		
		Farmer	Recommendation	Input saving
1	Boron fertilization	No	Boron	Boron
2	Growth regulators	No	BAP	GA_3
3	Types of shade plastic	PE	UV	PE

The variety used was Bima with large tuber size (± 5 g / tuber). Tuber was vernalized at 10ºC for 4 weeks. The tubers were then soaked with BAP 37.5 ppm or soaked with GA_3 100 ppm, according to the treatment for 30 minutes. The width of the beds was 1.2 m. After the land was cultivated and given 15 t / ha of manure, the beds were installed in black silver plastic mulch. Plant spacing used was 20x20 cm, so there were 5 rows of plants. The fertilizer used was NPK (16-16-16) of 600 kg/ha. The application of boron fertilizer according to treatment was 3 kg/ha at 3, 5, and 7 WAP. Plastic shade was installed when the plant started flowering with a sloping roof with bamboo support as high as 1.3 m at the back and 1.5 m at the front, 1.5 m wide roof and 10 m long roof. The plastic used according to the treatment was UV or PE. Anti-UV plastic 14% size of 200 microns, while PE plastic with a size of 80 microns. To attract insect pollinators, caisin was planted around the plantations at the same time as the shallot planting and installation of two boxes of honey bees after the flowering plants for an area of 750 m^2.

Maintenance included watering, controlling weeds, and controlling pests and diseases. Watering was done every 1-2 days adjusting the conditions in the field. Weed control was done manually in 1, 2, and 3 months. The frequency of spraying pesticides was adjusted to the level of pest attack. Harvesting was done after the capsules were yellowish brown with several capsules already broken and black. Drying was done with the help of indirect sunlight from 7.30 to 10:00 for 10 days to obtain a 10% moisture content. After drying, the capsule was broken down and released from the skin, so the seeds came out. After that, the selected seeds were sorted and then wrapped in aluminum foil and stored in a refrigerator.

Data collected included percentage of flowering plants (%), seed dry weight (g), germination (g), percentage of pest attack (%), climate data, soil physical and chemical properties, and farming data. The percentage of flowering plants was the number of plants that produce flowers in each unit of the experiment. Seed dry weight per plant was seed dry weight with a moisture content of 10% of the total per plant. Germination percentage was the percentage of the number of normal sprouts in the first count (6 DAP) and the second count (12 DAP) of the total seeds planted [6]. Percentage of pest attack was calculated based on the percentage of the number of plants attacked divided by plant population. The observed climate data were the amount of rainfall and rainy day from Ciwidey Agricultural Extension Service. Soil analysis was carried out at the IVEGRI Soil Laboratory on soil texture and macro and micro nutrient content. The farming variables calculated were costs, income, and profits. Technical data were tested using ANOVA test and continued using the Duncan Multiple Range Test (DMRT) at a 95% confidence level. Farming data was analyzed by RC ratio.

3 Results and discussion

3.1 Soil characteristics

Soil analysis results showed that research soil was clay loam (Table 2). Clay loam were classified as medium-textured and moderately smooth so that the water-binding ability was high. More clayey soils, the moisture content in the soil will be higher, increasing the available water content for plants [7]. The CN ratio of research soil was low (Table 1), so that mineralization was going well. The CN ratio showed the rate of organic matter decomposition and this results in the release (mineralization) or immobilization of soil nitrogen [8]. This was indicated by the very high P and K nutrient content and the moderate CEC (Table 2). The research field was classified as intensive to be used every season as a dry paddy field, so it was common to use organic fertilizers and chemical fertilizer residues were quite high. However, the soil was quite acid approaching neutral.

Table 2. Analysis results of soil physical and chemical properties before research

Soil Character	Results	Criteria
Texture		
Sand %	31	Clay loam
Dust %	35	
Clay %	34	
C (%)	2,6	Moderate
N (%)	0,34	Moderate
C/N	8	Low
P_2O_5 HCl 25% (mg%)	296,4	Very high
K_2O HCl 25% (me%)	92,47	Very high
pH H_2O	6,4	Moderate acid
Exchanged bases:		
Ca (me %)	23,71	Very high
Mg (me %)	2,96	High
K (me %)	2,19	Very high
Na (me %)	0,22	Low
CEC %	24,99	Moderate

Source: Results of IVEGRI soil laboratory analysis

3.2 Climate condition

Rainfall in 2016 since the research until the harvest was always high above 100 mm, even more than 200 mm of rainfall at the end of growth (Table 3). Shallots required enough available water for entire life because of its short root system. Thus, for early growth, high rainfall increased plant growth without the need for regular watering. At the beginning of flowering, rainfall began to decrease and plastic shade began to be installed to avoid rain. But then the rainfall increased again to exceed 200 mm per month when the flowers bloom and will form a capsule. Even during seed maturation and harvest, rainfall reached over 300 mm. High rainfall from morning to evening was accompanied by strong winds. Rainfall in this research was too high for the shallot growth and flowering and seeding phase. This condition will be very moist and resulting the attack of pests and diseases which cause decay [9].

Table 3. Climate data during research

No	Month	Amount of rain (mm)	Number of rainy days
1	June	155,5	15
2	July	132	16
3	August	129	10
4	September	230,5	22
5	October	331	22

Source: Ciwidey Agricultural Extension Service

3.3 Development of pest and disease

Pests that attacked plants were *Spodoptera exigua* and *Alternaria solani*, anthracnose, and soft rot. Plants at the beginning of growth were attacked by *Spodoptera exigua*, but could be suppressed by the use of yellow traps and routine insecticides. Rosliani et al (2018) stated that high rainfall was very beneficial for the development of anthracnose and

Alternaria solani. However, the attacks of *Alternaria solani* and antracnose in this research were still below 10%, because the leaves affected by the disease were compressed and fungicide was applied routinely.

When it started raining heavily, the plant was attacked by soft rot. But soft rot attack was not significantly different between treatments (Table 4). This showed that differences in the treatment of boron fertilizers, growth regulator, and the type of plastic shade did not affect soft rot attack. Soft rot disease attack in this research was caused by high humidity due to high rainfall. Although shading and drainage improvement had been carried out, because the land was on the lowest terrace and the soil texture was clay loam as paddy land with high water holding capacity (Table 2), thus increasing soft rot attack. Clay soils drained water poorly and become easily waterlogged [10]. This condition influenced the development of root rot. High soil moisture due to an abundant rainfall on heavy soil dan poor drainage, increased disease development [11]

Table 4. Percentage of soft rot attack and percentage of flowering plants on many technology packages of TSS production

Technology packages	% soft rot	% flowering
Farmer	21.88a	72.5b
Recommendation	23.13a	83.13a
Input saving	21.25a	80.63a

Note: Numbers followed by the same letter in one column showed no significant difference at 95% confidence level

3.4 Yield components and yields

The percentage of flowering of recommendation and input saving package was higher than that of farmer package (Table 4). This was thought to be due to the influence of the use of boron fertilizer and growth regulators both GA_3 and BAP, while the difference in the use of UV and PE plastic types did not affect the percentage of flowering.

Using boron in this research could increase the percentage of flowering plants significantly by 11.2-14.6%. Rosliani et al (2018) reported the use of boron could increase the amount of capsule per umbel by 8.8-11.2%. This was because boron was one of the micro elements associated with auxin metabolism [12]. Auxin hormone could encourage flowering and growth of parts of flowers and induce fruit formation [1, 13]

GA_3 in the input saving package and BAP in the recommendation package were not significantly different from the percentage of flowering plants (Table 4). This was similar to what happened in the study of Rosliani et al (2018) which showed a higher percentage of flowering plants with BAP application than that with GA_3 application but not significantly. This showed that application both GA_3 and BAP contribute to increasing flowering. This was because BAP was a cytokinin that functions to increase cell division. The positive influence of BAP on flower production was due to cytokinin activity in meristematic tissue to increase meristem size or expand meristematic zones. An increase in apical meristems of shallot that had been changed from meristems of leaf buds to flower buds produce more flowers per plant [1]. Meanwhile GA_3 was known to affect the hormonal balance of gibberiline and auxin which could stimulate flowering [13]. Gibberellin for any varieties like Bima which was used could specifically replace the cold temperature function to induce flowering [14].

There was no interaction of the technology packages with the harvest times to the seed dry weight (Table 5). The technology packages did not affect the seed dry weight, but the harvest times affected the seed dry weight (Table 5). It meant the treatment of growth regulator, boron fertilizer, and type of plastic shade did not affect the seed dry weight. This was thought to be due to soft rot attacks, so that the effects of growth regulator, boron, and type of plastic shade were not seen. Seed dry weight in the first harvest time was lower than the third harvest. Triharyanto and Purnomo (2014) stated that seed quality was affected by harvest time conditions. The first harvest in this research was the initial crop yields of plants when they were exposed to soft rot and the seeds were formed imperfectly, so seed dry weight was low.

Table 5. Interaction of technology packages and harvest times to seed dry weight (g) of TSS production

Technology packages	Harvest times (WAP)			Average
	80	90	100	
Farmer	8.75	17.00	23.75	16.50
Recommendation	18.69	21.75	35.50	25.31
Input saving	10.25	20.88	28.50	19.87
Average	12.56 b	19.88 ab	29.25 a	

Note: Numbers followed by the same letters in one column and one row show no significant difference at 95% confidence level

An interaction occurred between the technology packages and the harvest times for TSS seed germination (Table 6). The longer the harvest times, the germination of the recommendation packages obtained was higher, while the germination of the input saving package was not affected by the harvest times and the best germination of the farmers package in the second harvest. The third harvest times in the recommendation package had the highest germination because it was the last harvest that produced perfect seeds and was not attacked by soft rot. Kurniasari et al (2017) stated that differences in germination were influenced by harvest time. During the initial harvest, many soft rot disease occured, so that the seeds were not fully formed and low germination. Abnormal seed structure defined as seed consisting of less healthy embryo, not solid and not fully endosperm, and weak black colored testa [15]. Soft rot attacks caused abnormal embryos or a less healthy endosperm so that the seeds could not grow perfectly.

Table 6. Interaction of technology packages and harvest times on germination of TSS production

Technology packages	Harvest times (WAP)		
	80	90	100
Farmer	38.67 d	57.33 bc	50.67 c
Recommended	49.33 c	52.00 bc	77.33 a
Input saving	56.00 bc	56.00 bc	64.00 b

Note: Numbers followed by the same letters in one column and one row show no significant difference at 95% confidence level

Differences in harvest times for input saving package did not affect germination (Table 6). At the harvest beginning, soft rot attacked on relatively low input saving package, so the seeds were healthier and could form seeds perfectly to the end. However, because the germination capacity was less than 75% as required as quality seeds [16], the input saving package of both GA_3 and PE plastic could not replace the recommendation package using BAP and UV plastic.

The best seed quality in farmer package was second harvest times. This showed the harvest times of the farmer package was short, so that seed quality of third harvest times had decreased. The germination value was far from the 75% value, indicating that seeds from farmers package could not replace the recommendation package.

The best germination of this research was the recommendation package in third harvest times, 100 WAP with a value of germination of more than 75%. It meant that recommendation package using boron fertilizer, tubers soaking with BAP, and the use of UV plastic could produce the best seed quality. Efforts to save production inputs by eliminating boron fertilization, replacing BAP with GA_3, UV plastic with PE in this research were found to reduce seed quality. This was then in accordance with the research of Rosliani et al (2018) that seed quality of technology package using BAP was better than GA_3. BAP and boron in this research affected the percentage of flowering plants, did not affect seed dry weight, but affected germination. This also happened in the research of Kurniasari et al (2017).

The three packages in this research carried out vernalization to induce flowering (Table 3), because Indonesia has a high temperature. Rosliani et al (2018) stated that in tropical regions such as Indonesia, vernalization needed to be carried out at 10 °C for 4 weeks. Shallots can be induced for flowering by cold treatment in storage [18]. However, after the flowers were formed, plants needed additional input to induce seed formation, both micro fertilizer and growth regulator [1,13]. After flowering initiation, further flower growth until the formation of fruit and seeds was largely determined by internal and external factors. Among the influential factors were hormonal balance. Zheng et al (2014) reported that application of boron and BAP decreased the abortion rate of fertile florets on winter wheat.

The boron requirement of many plants during reproductive growth was much higher than vegetative growth [20], specifically for warm season plants, such as shallot. This was caused that boron deficiency depressed pollen viability [21] by retarding pollen germination and pollen tube [22]. Al-Amery et al. (2011) stated that boron deficiency at flowering could affect pollen viability and abortion of pistils and stamens which contribute to low seed sets. Bhoyar and Ramdevputra (2016) stated that fruits can be increased by size because either by improving pollen germination or by helping the growth of pollen tubes and thus facilitating in timely fertilization before tte stigma loses its receptivity or style becomes non-functional. After fertilization, low boron in plants affected embryogenesis, showing in the formation of incomplete or damaged embryos, or seed deterioration [25]. Boron also involved in translocation of starch to fruit resulting into better photosynthesis, greater starch accumulation in fruit balance of auxin which prevented the abscission and facilitated the ovary to remain attached with the shoot, resulting in lower fruit drop [43] and higher fruit in length [26].

Increased flowering was sometimes not followed by an increase in seed formation, so that a growth regulation application was needed. This was because viable pollen was needed for the formation of seeds and fruit [27]. BAP increased the division of tapetum cells in microsporangum before meiosis, resulting in pollen with high viability [28].

UV plastic increased the interception of sunlight and increased temperature when it was cloudy and decreased temperature when it was sunny compared to PE plastic. Such conditions were currently good for the growth of shallots because shallots required more than 12 hours of sun exposure and did not like protected areas. Conditions of a lot of rain and the unsunny weather in this research, especially at the end of the harvest caused differences in the type of plastic UV and PE did not affect the seed quality. Installation of shade was intended to avoid the loss of flowers due to rain.

3.5 Farm performance

Average production with an area of 750 m^2 produced 9,491 gr seeds or 126 kg per ha, so TSS production in this research was classified below the standard 150-225 kg/ha according to Rosliani et al., (2018) statement. The success of TSS production depends on a high percentage of flowering plants, the ability of insects as pollinators, and the supportive environment. The low seed production in this research was due to the high soft rot attack due to high rainfall especially during flowering and seeding. High rainfall and high use of pesticides in early growth to control *Spodoptera* caused the population of pollinating insects in this research to be low. The bees did not visit flowers that were often applied by pesticides [29], because the pesticides were sprayed together with the time of insect visit during sunny weather at 09.00-13.00. Bee visit decreased when it rained because the sugar content in nectar secreted by flowers was lower or there was a lot of nectar, but little sugar or nectar was difficult to extract in large amounts because of wet pollen. Adgaba et al (2012) reported that during high temperature, nectar secretion was higher than low temperature.

The labor cost of farmer package was the lowest because there was no cost of soaking tuber in the growth regulator and spraying boron fertilizer (Table 7). The most expensive production input cost was the recommendation package due to BAP treatment and UV shade, while the cheapest one was the farmer package. The highest seed production was the recommendation package, followed by input saving, and farmer package. The output of farmer package was minus, or losers, because of low production, so that its income was low. Meanwhile the highest profit was found in the recommendation package. Similarly, the highest RC ratio was recommendation package followed by input saving package.

Table 7. Farming analysis of TSS production per 750 m^2 from many technology packages

No.	Description	Technology packages		
		Farmer	**Recommendation**	**Input saving**
A	Cost	13,590,000	14,605,000	13,975,000
	Labour	4,620,000	4,780,000	4,780,000
	Production input	8,970,000	9,825,000	9,195,000
B	Production (g)	6,188	9,491	7,451
C	Income (IDR)	12,375,000	18,982,500	14,902,500
D	Profit (IDR)	(1,215,000)	4,377,500	927,500
E	RC rasio		1.30	1.07

RC value of recommendation was more than value of 1, or was economically feasible. The recommendation package had an RC value (1.3) higher than the results of the Sembiring et al (2018) conducted in Central Java (0.41), but lower than in North Sumatra (3.44) or East Java (2.63). The lower value of RC in this research was due to high farming costs, while its seed production was low and only received income from seeds, not including tubers due to soft rot attack.

Efforts to save production inputs by eliminating boron fertilization, replacing BAP with GA_3, and UV plastic with PE plastic could reduce seed quality (Table 6). With the high temperature and rainfall constraints faced in Indonesia, the use of additional inputs in the form of boron, BAP, and UV plastic shade could not be eliminated. Rosliani et al. (2018) reported that reduction or replacement of recommended TSS technology package could reduce TSS production and seed quality.

Savings on TSS production inputs in Indonesia were only possible by choosing the right location and planting time. Sembiring et al (2018) reported TSS production in North Sumatra of 320 kg was quite successful because it was supported by conditions in a dry and no foggy location, so that it did not require plastic shade and at the site also found many pollinating insects. The chosen location in this research was in the appropriate environmental locations, namely on dry land agroecosystems with elevations above 1000 m above sea level and sufficient water availability [1, 2, 4, 13]. According to Puspitasari

(2016), Bandung was one of regencies in Indonesia which was suitable for TSS production. This research was carried out during the dry season according to the technology package produced by IVEGRI [1] and was carried out in the paddy fields to anticipate water shortages during the dry season, but apparently when entering flowering and seeding, heavy rain had already occurred. It meant it was also necessary to pay attention to local rainfall predictions to determine the exact location of TSS production.

4 Conclusion

Efforts to save production inputs by eliminating boron fertilization, replacing BAP with GA_3, and UV plastic with PE plastic on saving input technology package could reduce seed quality and did not meet quality seed standards with an RC ratio of 1.07, almost close to the breakeven point level. Savings input on TSS production in Indonesia were only possible by choosing the right location and planting time and must be followed by climate prediction. The recommendation package with the application of boron fertilization, BAP, and the use of UV shade plastic could improve the quality of TSS seeds with a germination of 77.13% and an RC value of 1.3.

References

1. R. Rosliani, Y. Hilman, I. Sulastrini, M.P. Yufdy, R. Sinaga, I.M. Hidayat, J. Hort. **28**.1. 67-76 (2018)
2. O. A. Khorasgani, M Pessarakli. Advances in Plants & Agric Res. **9**. 318-322 (2019)
3. A. Sembiring, R. Rosliani, S. Simatupang, P.E.R. Prahardini, S. Rustini, J. Hort. **28**. 2. 289-298 (2018)
4. P.E.R. Prahardini, T. Sudaryono . J-PAL. **9.** 27-32. (2018)
5. N. Katsoulas, A. Bari, C. Papaioannou. Agron. **10**. 1-17 (2020)
6. ISTA, *International rules for seed testing* (The International Seed Testing Association, Basserdorf CH, Switzerland, 2010)
7. A. D. Costa, J.A. Albuquerque, A.D. Costa, P. Pértile, F.R.D. Silva. Rev. Bras. Ciênc. Solo. **37**. 1535-1548 (2013)
8. K. Swangjang. International Conference on Advances in Environment Research. **87.** 36-40 (2015)
9. Rahayu, Mujiyo, R.U. Arini. J. Degraded and Mining Lands Management. **6.** 1505-1511 (2018)
10. M.K. Amooh, M. Bonsa, JOGAE. **3**. 152-161 (2015)
11. M. Fiers, V. Edel-Hermann, C. Chatot, Y.L. Hingrat, C. Alabouvette, C. Steinberg. Agron. Sustain. Dev. **32**. 93-132 (2012)
12. M.M. Amanullah, S. Sekar, S. Vincent S, Asian J. Pl. Sci. **9**, 215-222 (2010)
13. I. Nurul, B. Nunun, A. Nurul, W. Eko. RJOAS. **6.** 325-338 (2019)
14. E. Triharyanto, S. Nyoto, I Yusrifani. *IOP Conf. Series: Earth and Environmental Science*. **142**. 1-10 (2018)
15. E. Triharyanto, D. Purnomo, J. Agric. Sci. Tech. **4**, 121-125 (2014)
16. L. Kurniasari, E.R. Palupi., Y. Hilman, R. Rosliani, J. Hort. **27**, 2. 201-208 (2017)
17. Directorate General of Germination, *Guidelines for certification and supervision of seed quality circulation* (Directorate General of Food Crops and Horticulture, Jakarta, 2007)

18. Y. Krontal, R. Kamenetsky, H.D. Rabinowitch. J. Hort. Scie. Biotech. **75**. 35-41 (2015)
19. C. Zheng, Y. Zhu, H. Zhu, G. Kang, T. Guo, C. Wang, Field Crops Res. **169.** 70-76 (2014)
20. M.B. Jokanovi´. Int. J. Mol. Scie. **21**.1-20 (2020)
21. S. Lordkaew, S. Konsaeng, J. Jongjaidee, B. Dell., B. Rerkasen, S. Jamjud, Plant Soil **363.** 287-295 (2013)
22. U. Gupta, H. Solankl, Int. J. Bioassays **2**, 7. 1048-1050 (2013)
23. M.M. Al-Amery, J.H. Hamza, M.P. Fuller, Int. J. Agron, 1-5 (2011)
24. M.G. Bhoyar, M.V. Ramdevputra, J. Appl. Nat. Sci. **8**, 2. 701-704 (2016)
25. B. Rerkasem, S. Lordkaew, N. Yimyam, S. Jamjod. Int. J. Agric. Biol. **21.** 385-390 (2019)
26. D.C. Meena, S. Maji, J.K. Meena, Govind, R. Kumawat, K.R. Meena, S. Kumar, K. Sodh, Int. J. Biores. Stress Manage. **6**, 5. 598-601 (2015)
27. H.A. Abdelgadir, S.D. Johnson, J.Van Staden. South African J. Botani. **79.** 132-139 (2012)
28. F. Xiaoqi, H.G. Dickinson, Development. **137**, 2409-2416 (2010)
29. G. Suwannapong, M.E. Benbow, J.C. Nieh. *In: Bees: Biology, Threats and Colonies Editor: Richard M. Florio*. 1-98 (2011)
30. A. Nuru, A. M. Awad, A. A. Al-Ghamdi, A. S. Alqarni, S. E. Radloff. J. Apicultural Scie. **56.** 49-58 (2012)
31. Puspitasari, A.M. Kiloes, A. Sulistyaningrum, *Proceedings of the Technopreneurship Seminar and Technology Transfer*. 73-81 (2016)