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Effect of quality seed and improvement of cultivation technology to increase the yield of shallots (*Allium cepa* L. Var. Aggregatum)

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Abstract

Shallots are important horticultural commodities that have high economic value in Indonesia.One of the efforts to increase the yield of shallots is the use of quality seeds supported by improvement cultivation technology. The purpose of this study was to determine the effect of seed sources and cultivation technology that can produce the best growth and yield of shallots. The field research was carried out in the village of East Penfui. Kupang Regency, in May–October 2021. The design used was a split plot and 3 replications. The main plot is the source of seeds used by farmers (Super Philip F5 Variety, Semau 1 Local Variety and Super Philip F3)and sub-plots are cultivation technology (farmers and Good Agricultural Practices/GAP). Results of research showed, the interaction of Semau 1 Local variety seed source and GAP technology had significantly affect on plant growth rate, bulbs weight/plant, yield/plot and productivity. GAP technology provides higher growth and yields compared to farmer technology. Semau 1 Local variety has the highest tissue N content, bulbs weight/plant, yield/plot and productivity compared to Super Philip F5 and Super Philip F3 varieties. The Semau 1 Local variety and GAP technology applied together can increase the yield and productivity of shallots by 45-59%.

Keywords: Good agricultural practices; Seeds; Shallots; Yield

1. Introduction

Shallots (*Allium cepa* L. var. aggregatum) are horticultural commodities with a relatively stable level of demand throughout the year. Seed is an important input that absolutely must exist in a plant cultivation activity including shallots. Quality (certified) shallot seeds are able to give a yield of 15-20 tons/ha, or can increase production efficiency by 20%, uncertified seeds only give a yield of 7.5 tons/ha [1]. Certified shallot seeds in Kupang Regency are still limited because farmers' knowledge about certified seeds is still lacking and there are limited seed breeders. The number of registered shallot seed breeders in Kupang Regency is still very limited. The available certified shallot seeds at the national level only range from 20 to 30% annually of the national seed requirement, while other needs are met by farmers' own seed production from consumption shallot bulbs which are stored as next season's seed [1].

Farmers produce and use their own seeds in an effort to ensure availability of seeds in the next growing season and reduce seed costs. Certified shallot seeds used by farmers are very few (only 22.2-23%) compared to seeds produced by farmers (72-77.8%) and the remaining 5% are imported seeds [1,2]. The seeds used by farmers are mostly local varieties which are used for generations. The certified seeds used by farmers are aid seeds from local governments. such as Super Philip and the Philippines. Some of the main reasons shallot farmers store and use their own seeds for generations, i.e. (1) saving costs and guaranteeing seeds, (2) limited sources seed, (3) limited shallot seed producers,

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(4) seeds of new varieties have not been widely produced, seed producers (5) being sold for money and getting seeds of known quality [1,2]. The cost of shallot seeds ranges from 38.64-58.9% of the total production cost [3,4].

Seeds produced by farmers are generally produced using the same cultivation technique as shallot cultivation for consumption (with a longer harvest life) without any selection of plants in the field. The seeds produced by farmers have various qualities so that it affects the quality of the seeds and yields. Seed produced by farmers has relatively better quality than imported varieties purchased, but in terms of seed productivity of imported varieties (15.8 tons/ha) is higher than farmers' seeds (13.2 tons/ha) [2]. The seeds produced by farmers have good potential to be used as a source of seeds, as an effort to overcome the limitations of certified seeds. It has good potential to be used as a source of seeds, as an effort to overcome the limitations of certified seeds.

Appropriate cultivation technology needs to be applied to support the use of seeds produced by farmers to produce high consumption shallots. The productivity of shallots in Kupang Regency is not optimal, which is 6.1 tons/ha [5], so it is necessary to improve cultivation technology to increase productivity. The technology applied by farmers in general only focuses on increasing production (the use of inorganic fertilizers and synthetic chemical pesticides is quite high) so that it often ignores environmental and food safety.

The yield of shallots can be increased through the application of cultivation technology based on Good Agricultural Practices (GAP). According to the FAO definition of GAP is a set of principles to be applied to agricultural production and post-production processes, producing safe and healthy agricultural food and non-food agricultural products, while taking into account economic, social and environmental sustainability. The application of GAP on shallots is not only emphasized on increasing yields but also on the application of technology that supports sustainable agriculture.

Several research results show that the application of shallot GAP technology can increase farmers' production and income compared to conventional technology used by farmers. The application of GAP can increase the production of shallots by 8-10% or productivity reaches 17-20.51 tons/ha [6,7,10], the number of bulbs reaches 141/kg and dry bulb weight reaches 1.55 kg/m^2 or an increase 25.41% compared to farmers' technology [8-10], income increased by 7.29 compared to technology that farmers usually apply [7].

The quality shallot seeds produced by farmers are expected in the future to be one of the solutions to overcome seed limitations and support the independent seed program. GAP technology which is modified according to farmers needs and environmental conditions of cultivation is expected to increase the yield of shallots as well as the ecologically sustainable cultivation of shallots.

2. Material and methods

2.1. Location and materials

The source of onion seeds comes from seeds produced by farmers. The seeds were taken from 3 shallot center locations in Kupang Regency. i.e., South Semau. Semau and East Kupang Districts.The seeds used are those that have been stored for ± 9 months (derived from the previous growing season) and are ready to be planted. The field research was conducted in May–October 2021, located in Matani, East Penfui Village, East Kupang District. N analysis of plant tissue was carried out at the Quality Test Laboratory of the Research Institute for Spices and Medicinal Plants, Bogor.

The materials used were shallot seeds of medium weight (3-4 g), organic fertilizer, Urea, KCl, NPK Phonska, ZA, liquid organic fertilizer (LOF), *Trichoderma* Spp., Silver black plastic mulch (SBPM). The instruments used are: oven, ruler, digital camera, Petiole application, digital scales.

2.2. Experimental design

The design used was a split plot with three experimental groups.The main plot is the source of seeds used by farmers (Super Philip F5, Semau 1 Local Variety and Super Philip F3). Sub-plots are cultivation technology (farmers and GAP).The experiment consisted of 6 treatment combinations with 18 experimental groups. Descriptions of subplots are presented in Table 1.

2.3. Procedure

The seeds are cleaned of dry outer skin. then cut off the end of the bulb (1/3 part), done the day before planting. The treatment plots used beds with a size of 3 x 1 m. The space between beds in groups is 0.3 m and the space between groups is 1 m. Treatment applications from land preparation, plant spacing, fertilization (basic and follow-up), pest control were adjusted to each treatment (Table 1.). The GAP treatment plots were given organic fertilizer at a dose of 10 tons/ha and silver black plastic mulch (SBPM) was installed, while the farmers' technology plots were not given any treatment. Planting was carried out according to the spacing of each treatment: for GAP technology it was 15 x 15 cm (147 plants/plot), while for farmer technology it was 20 x 15 cm (105 plants/plots).

Fertilization treatments for GAP i.e., 1) Phonska NPK basic fertilization (100 kg/ha), given at planting by immersing ± 3 cm from the planting hole; 2) Follow-upfertilizer I at 2 week after planting (wap) (Urea 75 + ZA 50 kg/ha); 3) Follow-up II after 4 wap (Urea 75 + ZA 50 + KCl 200 kg/ha); 4) Follow-up III at 6 wap (KCl 70 kg/ha). Follow-upfertilizer I,II,III given by dissolving in irrigation water; 5) LOF at 3,5,7,9 wap, with a concentration of 250 mL /15 liters of water, with a concentration of 250 mL/15 liters of water, a dose of 250 mL/plant. Fertilization treatments by farmers i.e., 1) at 1 wap (Urea 150 kg/ha); 2) follow-up I at 2 wap (Urea 150 kg/ha + NPK Phonska 100 kg/ha); 3) follow-up II at 4 wap (NPK 150 kg/ha); 4) follow-up III at 6 wap (NPK 100 kg/ha). Urea and NPK fertilizers are given by spreading on the soil surface and before watering. The amount of water given is according to the water requirement, which is 500 mm/season, with the volume of water given according to the growth phase of the shallots.

Table 1 Description of Onion Cultivation Technology by Farmers and GAP

Cultivation Technology Description	**Cultivation Technology Model**	
	Farmers'	**GAP**
Land preparation	Full tillage + bed	Full tillage + bed+ mulch (SBPM) organic fertilizer 10 ton/ha
Planting spacing	15 x 20 cm	15 x 15 cm
Fertilization	Urea 150 kg/ha (1 wap) Urea 150 kg/ha + NPK 100 kg/ ha(2 wap) NPK 150 kg/ha (4 wap) NPK 100 kg/ha (6 wap)	Basic fertilizer NPK 100 kg/ha Urea 75 +ZA 50 kg/ha (2 week after planting/wap) Urea 75 +ZA 50 + KCl 200 kg/ha (4 wap) KCl 70 kg/ha (6 wap) LOF (3,5,7,9 wap)
Pest control	Technical and chemistry	Technical, chemistry and biologics (*Trichoderma*) applied with organic fertilizer

2.4. Variable

Variables observed i.e., leaf area index (LAI) 15 and 35 day after planting (dap), net assimilation rate (NAR), plant growth rate (PGR), tissue N content, harvest time, bulbs weight/plant, yield/plot and productivity. Calculations ofLAI, NAR, and PGR, are presented in Table 2. Samples of tissue N content used plants aged 45 days after planting (dap).Harvest time, calculated from the time the seeds are planted until they are harvested.The harvest criteria used are bulbs that have appeared on the soil surface and 85% of the plants have fallen/the leaves have dried. The yield/plots was obtained by weighing the total bulbs produced in the tile plot (1 m^2). Productivity is the result of the conversion of yield/plots into tons/ha.

2.5. Statistical analysis

Table 2 Calculation of Indices

Parameter	**Equality**	**unit**
Leaf a area index	Leaf area / planting space	-
Net assimilation rate	$\frac{W_2 - W_1}{T_2 - T_1} X \frac{\ln La_2 - \ln La_1}{La_2 - La_1}$	mg/cm2. day
Plant growth rate	$\frac{1}{Ga} X \frac{W_2 - W_1}{T_2 - T_1}$	mg/cm2. day

Note: W1 = dry weight of plants 15 dap; W2= plant dry weight 35 dap; La1 = leaf area 15 dap; La2 = leaf area 35 dap; T1 = 15; T2 = 35; Ga= planting space

The collected data was analyzed using Analysis of Variance (Anova). If there was a significantly difference between treatments then tested further with Duncan Multiple Range Test (DMRT). Analysis using portable SAS 9.1.3 software.

3. Results and discussion

3.1. Plant Growth

The results of the analysis of variance showed that the interaction between seed sources and cultivation technology had a significant affect on leaf area index (LAI) 35 dap, net assimilation rate (NAR) and plant growth rate (PGR), but had no significant affect on LAI 15 dap and tissue N content. Each single treatment of seed source and cultivation technology significantly affected LAI 15 dap and tissue N content (Table 3.).

Growth is the process of increasing the quantitative size of plants and is irreversible. The increase in the size of the plant as a whole is the result of the increase in the size of the plant organs which is the result of the increase in tissue produced by the increase in cell size. Leaves are generally the main photosynthetic producing organs, based on their function as light receptors and photosynthetic tools because the rate of photosynthesis per unit plant in most plants is determined largely by leaf area [11]. The results of the analysis of variance showed that the interaction between seeds of Super Philip F5 variety and GAP technology had the highest LAI 35 dap, with value 1.33 or 37-65.17% higher than the other treatments. This shows that the high LAI is the result of the interaction of the ability of Super Philip F5 seeds to expand wider leaves and the availability of N from various sources (Urea and ZA) and sufficient water (use of SBPM mulch) from GAP. At the vegetative growth stage, leaves tend to require higher nitrogen and energy, so the ability to partition assimilate by plants has an important role [12]. The rate of change in LAI values is highly dependent on the quality of metabolism in plant growth through the ability of plants to intercept radiation to produce assimilate [13]. Super Philip F5 variety seeds have high assimilate partitioning ability and supported by adequate supply of nutrients and water from GAP technology capable of producing higher LAI.

Net assimilation rate (NAR) describes the ability of plants to produce assimilated dry mass per unit leaf area per unit time. The NAR value is the net result of Carbon obtained (from photosynthesis) after deducting Carbon losses (respiration, exudation) expressed per unit leaf area [14]. The results showed that the interaction between the seeds of Super Philip F5 variety and farmer technology had the highest NAR of 0.99 mg/cm^2.days or 20-59.60 % higher than the other treatments. Super Philip F5 varieties produced the highest NAR with a value of 0.84 mg/cm^2. days or 9.5-30.95% higher than the seeds of Local Semau 1 and Super Philip F3 varieties. This shows that high NAR is more influenced by genetic factors/variety of Super Philip F5 than by cultivation technology. The ability of Super Philip F5 variety seeds to produce better plant growth through higher LAI compared to other treatments. Wider leaf expansion (high LAI) resulted in higher radiation interception so that plant NAR also increased. The NAR value is influenced by ILD where the leaf is the main organ in light interception that plays a role in the photosynthesis process [15]. The seeds of the Super Philip F5 variety have a high LAI, thus supporting higher assimilate production during growth. Species with wider leaves have higher N utilization efficiency, because the N partition is more allocated to photosynthetic functions (*Rubisco* formation) which tends to show higher catalytic activity than structural functions, resulting in higher net similation rates [14]. Super Philip F5 variety produces higher LAI thus supporting higher NAR.

Plant growth rate (PGR) describes the accumulation of plant dry mass per unit area of land per unit time. The results showed that the interaction between Super Philip F5 varieties and GAP technology had the highest PGR with a value of 0.393 mg/cm^2. days, although it was not significantly affect from its interaction with farmer technology and the interaction of the Semau 1 Local variety with GAP. This shows that each seed source has a different growth pattern. The Super Philip F5 variety and GAP cultivation technology each produced the highest PGR. GAP technology produces the highest PGR with a value of 0.363 mg/cm^2.days or 41.32% higher than farmer technology. High PGR is associated with high LAI which is indicated by a strong correlation with a value of 0.77. These results are in line with Isoda et al. [16] which states that a high average LAI in the early stages of growth will have a positive effect on PGR, where a high LAI accelerates plant growth over a certain period. The results of the research by Irianto et al. [17] showed that the PGR of shallots of the Bima Brebes variety was determined by a high LAI, where there was a positive relationship between PGR and the increase in leaf area for each plant. Higher N utilization efficiency in species with wider leaves resulted in assimilate which supported higher plant growth rates [14]. The interaction of Super Philip F5 variety and GAP technology was able to produce a higher LAI so as to support a high plant growth rate.

The seeds of the Semau 1 Local variety had an LAI of 15 dap and the highest tissue N content, with values of 0.19 and 1.33%, respectively.This indicates that the Semau 1 Local variety had wider leaves at the beginning of growth and then was directed at increasing leaf mass (higher specific leaf weight). Plants with high leaf area at the beginning of growth have a greater ability to accumulate more photosynthate at an early stage for further growth and development [18].

Higher leaf mass is one of the plant strategies related to leaf function in obtaining and using higher resources (growth factors) [19]. Higher leaf mass is associated with high yield capacity of plant cultivars which contributes to long leaf viability, nutrient uptake and protection from drought [20]. Leaf N content was linearly related to typical leaf weight (thick leaf), where thicker leaves had higher Nitrogen content [21]. Species with thick leaves have higher chlorophyll content, resulting in higher organic N content per unit leaf area [14, 20]. The seeds of the Semau 1 Local variety had dry mass partitioning which was more directed at increasing leaf mass than leaf expansion so that they were able to absorb higher N.

Table 3 The Effect of Seed Sources and Cultivation Technology on the Growth of Shallots

Treatment	LAI 15 (dap)	LAI 35 (dap)	NAR (mg/cm2. day)	PGR (mg/cm2. day)	Tissue N content (%)
Seed source	**	**	*	**	**
Super Philip F5	0.15 b	1.03 a	0.84 a	0.362 a	0.815 b
Local Semau 1	0.19 a	0.64 b	0.58 b	0.230 b	1.333 a
Super Philip F3	0.16 b	0.66 b	0.76 ab	0.273 ab	0.883 ab
Cultivation technology	**	**	ns	*	*
Farmers	0.14 b	0.56 b	0.70	0.213 b	1.153 a
GAP	0.20 a	1.00 a	0.75	0.363 a	0.868 b
Interaction	ns	*	*	*	ns
Super Philip F5 x Farmers	0.12	0.73 b	0.99 a	0.330 a	0.780
Super Philip F5 x GAP	0.17	1.33 a	0.70 b	0.393 a	0.850
Local Semau 1 x Farmers	0.15	0.45 c	0.40 c	0.107 b	1.570
Local Semau 1 x GAP	0.23	0.83 b	0.75 ab	0.353 a	1.097
Super Philip F3 x Farmers	0.14	0.50 c	0.72 ab	0.203 b	1.110
Super Philip F3 x GAP	0.19	0.83 b	0.79 ab	0.343a	0.657

Note: The same letter in each column were not significantly different based on DMRT (p>0.05). **, *: significant different at the 0.01, and 0.05 probability level, respectively; ns: non-significant

Nitrogen is an essential basic element of various organic compounds (amino acids, proteins, nucleic acids) and is needed in the formation of new cells and promotes cell elongation [22]. The results showed that the highest tissue N content was indicated by the Semau 2 Local variety, which was 1.333% or 33-38.86% higher than the other two seed varieties. This shows that at the end of vegetative growth, the Semau 2 Local variety had a higher N partition pattern to the structural component than the metabolic component. Species that have lower photosynthetic N utilization efficiencyhave a higher proportion of leaf N in structural or non-photosynthetic components [23]. High N content can result in longer vegetative growth [24], so plants have a longer life. This is similirity with the results obtainedthat the seeds of the Semau 2 Local variety produced a longer harvest life of 83 days compared to the Super Philip variety of 79.33 days. Farmer's technology has a higher plant N content of 1.153% or 24.72% higher than GAP. In Farmer's technology, NPK fertilization is still given up to 6 weeks after planting, while the GAP technology only until the age of 4 weeks. The concentration of N in leaves is highly dependent on the level of N application and the growth stage of the onion [25].

3.2. Crop Yield

The results of Anova showed that the interaction between seed source and cultivation technology had a significant effect on bulbs weight/plant, yield/plot and productivity (Table 4). The interaction between Semau 1 local seed and GAP technology had the highest yields, i.e. bulbs weight/plant (74.58 g), yield/plot (3.665.9 g/m^2) and productivity (21.58 tons/ha). Semau 1 Local seeds had the highest yields, i.e. bulbs weight/plant (59.96 g), yield/plot (2.698.1 g/m2) and productivity 15.75 tons/ha, while Super Philip F5 seeds have the shortest harvest time, which is 79.33 days. GAP technology has high yields, i.e. shortest harvest time (79.22 days), bulbs weight/plant (62.64 g), yield/plot (3.079.5 g/m^2) and productivity (18.18 tons/ha).

Super Philip F5 seeds had the shortest harvest time with a value of 79.3 days (4.42%) shorter than the Semau 1 Local and Super Philip F3 varieties. In the early generative phase of shallots, reproductive organs have a stronger absorption of photosynthate than other organs including leaves [17]. High assimilate in the late vegetative phase will be allocated in higher amounts to the formation and bulbing more quickly, resulting in a shorter harvest life. This is different from the Semau 1 Local variety seed which has a slower growth pattern which results in a longer harvest time, but has a higher tissue N nutrient absorption capacity than the Super Philip F5 variety seed. GAP technology produces the shortest harvest time with a value of 79.22 days (5.32%), earlier than farmer technology. It has a higher growth rate (LAI) due to the availability of sufficient growth factors. Sufficient nutrients through more complete fertilization, availability of water through the use of silver black plastic mulch (SBPM) which supports the absorption of available nutrients for plants. Plants with high LAI will produce high PGR because they are able to produce higher photosynthate through better light interception. Onions with high radiation efficiency will be able to produce larger amounts of dry matter.The high amount of photosynthate will support a faster bulbing process so that the harvest time is shorter [12]. GAP technology provides growth factors in the form of nutrients and sufficient water to support the plant's ability to maximize photosynthate translocation for faster bulbs formation and filling.

Table 4 Effect of Seed Source and Cultivation Technology on Shallot Yield

Treatment	Harvest time (day)	Bulbs weight/ plant (g)	Yield/plot (g/m²)	Productivity ton/ha
Seed source	*	**	**	**
Super Philip F5	79.33 b	55.83 ab	2.441.0 ab	14.45 ab
Local Semau 1	83.00 a	59.96 a	2.698.1 a	15.75 a
Super Philip F3	83.00 a	46.00 c	2.055.9 b	11.87 b
Cultivation technology	*	**	**	**
Farmers	83.67 a	45.25 b	1.703.8 b	9.87 b
GAP	79.22 b	62.64 a	3.079.5 a	18.18 a
Interaction	ns	*	*	*
Super Philip F5 x Farmers	79.00	49.55 c	1.823.2 d	10.73 c
Super Philip F5 x GAP	76.67	62.23 b	3.058.7 b	18.16 b
Local Semau 1 x Farmers	85.00	45.34 c	1.730.3 d	9.92 c
Local Semau 1 x GAP	81.00	74.58 a	3.665.9 a	21.58 a
Super Philip F3 x Farmers	87.00	40.86 c	1.557.8 d	8.94 c
Super Philip F3 x GAP	79.00	51.14 c	2.513.9 c	14.79 b

Note: Note: The same letter in each column were not significantly different based on DMRT. **, *: significant different at the 0.01, and 0.05 probability level, respectively; ns: non-significant

The interaction between the seeds of the Semau 1 Local variety and GAP technology resulted in the highest bulbs weight/plant of 74.58 g compared to other treatments. Semau 1 Local variety seeds have slower vegetative growth, but have higher N nutrient absorption capacity. High leaf N content at the end of the active growth phase will cause leaves to have a longer green leaf duration (longer harvest life), so that the efficiency of leaf photosynthesis is higher. Leaf N concentrations were associated with an increase in leaf area duration for the synthesis of photosynthetic components which are thought to contribute to higher bulbs yields [26]. GAP technology provides sufficient available growth factors through balanced fertilization (NPK, Urea, ZA, KCl and POC fertilizers), the use of SBPM (sufficient water available) and organic matter to maintain appropriate soil quality during plant growth.The use of mulch was able to increase the bulbs weight by 45.17% compared to without mulch at the level of water supply with an irrigation volume of Eo 0.50 [27]. GAP technology provides sufficient growth factors for the growth of shallots, so that the leaves have efficient light interception (high LAI) and high plant dry matter accumulation (PGR). *Allium cepa L.* has a different pattern of photosynthate partitioning, some have a higher partition pattern in the leaves, but there is also a photosynthate partition that is divided into leaves and bulbs, but during the generative phase the largest photosynthate partition is allocated to the bulbs [28]. Plants with good genetic ability in maximizing available growth factors to produce leaf growth with high photosynthetic efficiency and the largest allocation of photosynthate to bulbs will produce high bulbs weights/plant. Semau 1 Local variety seed cultivated with GAP technology was able to produce bulbs weight/plant of 16.56-45.83%. The yield of bulbs weight/plantwill support yield/plot as indicated by a very strong correlation between the two with a value of 0.96. The interaction between Semau 1 Local variety seeds and GAP technology had the highest yield/plot with a value of 3,665.9 g/m^2. Yield/plot was determined by bulbs weight/plants and the number of plants/plots. Semau 1 Local seed has the ability to produce high bulbs weight/plant. GAP technology in addition to producing high bulbs weight/plant also has a higher number of plants with 49 plants/m^2 (15 x 15 cm), compared to farmers technology with 35 plants/m^2 (15 x 20 cm). Plant density has an impact on bulbs size, the higher the plant density, the smaller the bulbs size, so proper spacing is needed [29]. *Allium cepa* L. with high density causes an increase in bulbs production, but decreases bulbs size, this can be seen from bulbs production increasing from 6.96 to 7.30%, but decreasing bulbs size from 11.59 to 13.36% [30]. The study showed differentresults where a density of 49 plants/m^2 resulted in a higher average bulbs weight than a low density of 35 plants/m^2. Optimization of plant density is very important in maximizing yields, because increasing plant density / unit area can cause competition between plants for the use of growth factors such as solar radiation, water, and nutrients, while less than optimal density causes inefficient use of resources [31]. Shallots have an vertikal crown shape and leaf arrangement that does not shade each other, so that an increase in LAI does not result in significant competition for sunlight interception [17]. This shows that the growth factors available in GAP technology, through fertilization, available water and sunlight, are still sufficient to meet plant needs or have not become limiting factors for plant growth and yield for a density of 40 plants/m^2. These results are in line with the research of Farooq et al. [32], that the density of *Allium cepa* L. 40 plants/m^2 had a maximum production of 3.56 kg/m^2 or 22.75-39.23% higher than the density of 20 and 30 plants/m^2. Semau 1 Local variety seeds with GAP technology can give yields/plots of 16.56-57.51%.

The interaction between Semau 1 Local variety seeds and GAP technology gave the highest productivity of 21.58 tons/ha or 15.85-58.57%, higher than the other treatments. The productivity of shallot bulbs is influenced by the interaction between varieties and plant density [33]. Semau 1 Local variety seeds with high yield potential and supported by GAP technology which provides nutrients, sufficient water sources and optimal plant density, can increase the productivity of shallots. The use of Semau 1 Local variety seeds and GAP cultivation technology together produces shallot productivity of 45-59%.

4. Conclusion

Semau 1 Local seeds cultivated with GAP technology gave the highest yields, i.e. bulbs weight/plant 74.58 g, yields/ plot (3,665.9 g/m^2) and productivity (21.58 tons/ha) or had yields and productivity of 45-59%.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declared that there is no conflict of interest.

References

[1] Baswarsiati, T Sudaryono, K.B Andri, S Purnomo. Development of Potential Shallot Varieties from East Java. In: Horticultural Innovation Leveraging People's Income Increase. Jakarta: IAARD Press; 2015. p.5–20. [Indonesian]. Available at: http://hortikultura.litbang.pertanian.go.id/web/Buku_Inovasi/5-20.Baswarsiati%20Pengembangan%20bawang%20merah.pdf

[2] Basuki, RS. Procurement and Distribution System of Shallots Seed at Farmer Level at Brebes District.JurnalHortikultura. 2010, 20(2):186–195. [Indonesian].

[3] Maftukin M, Hastuti D, Subekti E. Feasibility Analysis of Shallot Bulbs Seedling (Case Study in Sentani Seed Breeders in the Village Group, Wanasari District, Brebes Regency).Mediagro. 2015, 11(1):60–74. [Indonesian].

[4] Hamdani KK, A Nurawan, A Rachman, M Dianawati. Shallot Farming Study in Pabuaran District, Cirebon Regency, in Proceedings of the National Seminar on Agricultural Resource Readiness and Location-Specific Innovation

Entering the Industry 4.0. 2020, 339–346. Available from: http://repository.pertanian.go.id/handle/123456789/9213. [Indonesian].

[5] Central Agency on Statistics. Kupang Regency in Figures 2021. [internet].[citied 2022 May 20]. Available from: https://kupangkab.bps.go.id/publication/download.html?nrbvfeve=NmYyZmY1NDgzOTAwMjc3YzA1ZDg2YmQw&xzmn=aHR0cHM6Ly9rdXBhbmdrYWIuYnBzLmdvLmlkL3B1YmxpY2F0aW9uLzIwMjEvMDIvMjYvNmYyZmY1NDgzOTAwMjc3YzA1ZDg2YmQwL2thYnVwYXRlbi1rdXBhbmctZGFsYW0tYW5na2EtMjAyMS5odG1s&twoadfnoarfeauf=MjAyMi0xMC0yNiAxMzoyMjowOQ%3D%3D

[6] Baswarsiati and Tafakresnanto C. A Study on the Application of Good Agricultural Practices (GAP) of Shallots in Nganjuk and Probolinggo. Agrika. 2019, 13(2):147-161. doi: 10.31328/ja.v13i2.1206. [Indonesian].

[7] Simatupang S, Sipahutar T, Sutanto AN. Shallot Farming Study with Good Agriculture Practices Technology Package. JurnalPengkajiandanPengembanganTeknologiPertanian. 2017, 20(1):13-24. doi: 10.21082/jpptp.v20n1.2017.p13-24. [Indonesian].

[8] Indrayana K. Improvement of Lowland Shallot Farming with Comparison of Farmer Technology Packages with Intrusion Technology Packages in Majene Regency. J. Agrotan. 2017 Mart, 3(1): 56-66,ISSN : 2442-9015. [Indonesian].

[9] Firmansyah I and Sumarni N. Effect of N Fertilizer Dosage and Varieties on Soil pH, Total Soil N, N Uptake, and Yield of Shallots (Allium ascalonicum L.) in Entisols-Brebes Soil, Central Java. J. Hortikultura. 2013, 23(4): 358–364. [Indonesian].

[10] Winarto L, Yufdy MP, Haloho L. Shallot Technology Package Study in Haranggaol, North Sumatra. JurnalPengkajiandanPengembanganTeknologiPertanian. 2009, 12(1):1–10. [Indonesian].

[11] Sitompul SM and Guritno B. Plant Growth Analysis. Yogyakarta: Gadjah Mada Unversity Press; 1995. [Indonesian].

[12] Tei F, Scaife A, Aikman DP. Growth of Lettuce, Onion, and Red Beet. 1. Growth Analysis, Light Interception, and Radiation use Efficiency. Annals of Botany. 1996, 78(5):633–643. doi: 10.1006/anbo.1996.0171.

[13] Risdiyanto I and Setiawan R. Energy Balance Method for Leaf Area Index Growth Using Multi Spectral Satellite Imagery Data. JurnalAgromet Indonesia. 2007, 21(2):27–38. Available from: http://digilib.unila.ac.id/4949/15/BAB II.pdf. [Indonesian].

[14] Poorter H and Remkes C. Leaf Area ratio and Net Assimilation Rate of 24 Wild Species Differing in Relative Growth Rate. Oecologia. 1990, 83:553–559.

[15] AlmodaresA, Taheri R, Adeli S. Inter-Relationship Between Growth Analysis and Carbohydrate Contents of Sweet Sorghum Cultivars and Lines. Journal of Environmental Biology. 2007, 28(3):527–531.

[16] Isoda A, H Maong, Z Li, P Wang. Growth of High-Yielding Soybeans and its relation to air Temperature in Xinjiang, China. Plant Production Science. 2010, 13(2): 209–217. doi: 10.1626/pps.13.209.

[17] Irianto, Yakup, Harun MU, Susilawati. Growth and Yield Characteristics of Three Shallot Varieties Affected by Phosphate Fertilizer Dosages on Ultisol.Russian Journal of Agricultural and Sosio-Economic Sciences. 2017,5(65):246–254.

[18] Ebone LA, A Caverzan, A Tagliari, JLT Chiomento, DC Silveira,G Chavarria. Soybean Seed Vigor: Uniformity and Growth as Key Factors to Improve Yield. Agronomy. 2020, 10(4):1-15. doi: 10.3390/agronomy10040545.

[19] Vile D, Garnier E, Shipley B, Laurent G, Navas ML, Roumet C, Lavorel S, Díaz S, Hodgson JG, Lloret F, Midgley GF. Specific leaf area and dry matter content estimate thickness in laminar leaves. Annals of botany. 2005 Nov 1, 96(6):1129-36.

[20] Amanullah. Specific leaf area and specific leaf weight in small grain crops wheat, rye, barley, and oats differ at various growth stages and NPK source. Journal of Plant Nutrition. 2015 Sep 19, 38(11):1694-708.

[21] Nageswara Rao RC, Talwar HS, Wright GC. Rapid assessment of specific leaf area and leaf nitrogen in peanut (Arachishypogaea L.) using a chlorophyll meter. Journal of Agronomy and Crop Science. 2001 May 15, 186(3):175-82.

[22] Marschner H. editor. Marschner's mineral nutrition of higher plants. Academic press; 2011 Aug 8.

[23] Hikosaka K. Interspecific difference in the photosynthesis–nitrogen relationship: patterns, physiological causes, and ecological importance. Journal of plant research. 2004 Dec, 117(6):481-94.

[24] Messele B. Effects of nitrogen and phosphorus rates on growth, yield, and quality of onion (Allium cepa L.) at Menschen Für Menschen Demonstration Site, Harar, Ethiopia. Agri Res & Tech: Open Access J. 2016, 1(3):001-8.

[25] Geisseler D, Ortiz RS, Diaz J. Nitrogen nutrition and fertilization of onions (Allium cepa L.) –A literature review. ScientiaHorticulturae. 2022 Jan 3, 291:110591.

[26] Siliquini OA, Orioli GA, Lobartini JC. Onion yield as affected by plant density, nitrogen level and loss of leaf area. Phyton. 2015, 84(2):338-344.

[27] Zuliati S, EkoSulistyono, HeniPurnamawati. Effect of Mulching and Irrigation on Growth and Yield of Shallots (Allium cepa L. var. aggregateum).JurnalAgronomi Indonesia (Indonesian Journal of Agronomy). 2020,48(1):52–58. doi: 10.24831/jai.v48i1.29191. [Indonesian].

[28] Salo T. Effects of band placement and nitrogen rate on dry matter accumulation, yield and nitrogen uptake of cabbage, carrot and onion. Agricultural and Food Science. 1999 Jan 2, 8(2):157-232.

[29] Khokhar KM. A short review on onion bulb dormancy metabolism. Adv. Biotechnol. Microbiol. 2020, 15(3):67-70. doi: 10.19080/AIBM.2020.15. 555915.

[30] Leskovar DI, Agehara S, Yoo K, Pascual-Seva N. Crop coefficient-based deficit irrigation and planting density for onion: growth, yield, and bulb quality. HortScience. 2012 Jan 1, 47(1):31-7.

[31] Caliskan M E, Kusman N, Caliskan S. Effects o f Plant Density on the Yield and Yield Components of True Potato Seed (TPS) Hybrids in Early and Main Crop Potato Production Systems', Field Crops Research.2009, 114(2):223–232. doi: 10.1016/j.fcr.2009.08.002.

[32] Farooq C, Mahmood K, Khan MA, Qadir A. Effect of plant density on plant growth, size and yield of onion. Pakistan Journal of Agricultural Research. 1990, 11(4):239-42.

[33] Wiguna G, Hidayat I, Azmi C. Improvement of Shallot Seed Production Technology through Fertilization, Density, and Variety Regulations.J. Hort. 2013, 23(2): 137–142. [Indonesian].