Yield potential of soybean under palm oil trees

Gatut Wahyu Anggoro Susanto, Herdina Pratiwi, Novita Nugrahaeni, Kartika Noerwijati, Kurnia Paramita Sari, Siti Mutmaidah, Pratanti Haksiwi Putri, Didik Harnowo

Indonesian Legume and Tuber Crops Research Institute
Jl. Kendalpayak KM 8, Kendalpayak, Pakisaji, Malang 65101

E-mail: gatut_wahyu2016@yahoo.com

Abstract. Research to assess soybean yields planted under palm oil trees was conducted in North Sumatera, Indonesia. This research aimed to provide information on soybean varieties that were most suitable for planting under palm trees. Two experiments were conducted in the palm tree areas i.e. under one-year-old (IP 1) and two years old (IP 2) of the palm tree. In each site, the experiment was arranged in a split-plot design with two replications. The main plot was spacing row arrangements, i.e. double-spacing (50 cm x (30 cm x 20 cm) and single-spacing (40 cm x 15 cm), whereas the subplot was soybean varieties consisted of Dega 1, Dena 1, Argomulyo, and Anjasmoro. Research results showed that the average seed yield obtained in IP 1 was higher than IP 2, and soybean planted in a single-spacing produced higher seed yield compared to double-spacing. Argomulyo variety was superior in IP 1 with a seed yield of 3.66 t/ha and Dena 1 was the most superior in IP 2 with a seed yield 2.17 t/ha, both in single-planting arrangements.

1. Introduction
Crops development target had expanded not only utilization of paddy field but also reproductive annual cropland/forest utilization. Plant development in agroforestry was a combination of annual plant and one or several types of annual crops. It has existed for a long time such as in the United States [1] including in Indonesia [2]. Agroforestry aims to conserve soil and water, biodiversity, ecosystem health, and carbon sequestration [3-4].

In Indonesia, the development of food crops could be conducted on the potential lands, including under palm oil tree. This cropping pattern could maintain the farmers’ income as long as the palm tree had not been produced [5]. Palm oil tree land total area in Indonesia was 14,327,100 hectares (ha) in 2018 [6]. The Ministry of Agriculture continued to trigger soybean production to achieve national demand targets, such as through planting area addition, increased production, and gradually reduced soybean imports. Soybean planting area for 2020 was targeted around 1 million hectares, consisted of 700,000 ha intercropping systems and 300,000 ha monoculture planting systems.

One of the provinces that develop soybean under palm oil trees land was North Sumatra which had 1,745,900 ha potential land area. Immature plantation (IP) covering 48,620 ha among palm oil tree cultivation [6], which could still be intercropped with other plants, including soybean. North Sumatra Agriculture Service report in 2014 showed that soybean average yields in young palm oil trees were 1.8 t/ha [7]. Soybean potential yield could still be improved by using improved varieties and cultivation technology. The main constraints for developing soybeans on palm oil trees land were soil acidity and shade. Soil acidity could be overcome by calcification and organic fertilizer (N, P, and K) while shade plants could be overcome by using shade-tolerant soybean improved varieties [8]. Sunlight optimization in the presence of a shade plant could also be done through spacing row [9].
The objective of this research was to determine the potential and average yield of four soybean improved varieties with two spacing row arrangements under the palm oil trees. The research result was useful for soybean farmers in the selection of varieties that are suitable for palm oil tree shades and land conditions.

2. Materials and Methods

The research area was an immature plantation (IP) palm oil tree in Tanjungjati, Langkat, Binjai, North Sumatra. Immature plantation is palm oil tree which have not produce yet. The research was conducted during the first dry season, February to April 2018. Two environments were conducted in the palm tree areas i.e. under one-year-old (IP 1) and two-years-old (IP 2) palm oil trees. The research was arranged in a split-plot design with two replications in each site. The main plot was spacing row models (T), i.e. double spacing/T 1 (50 cm x (30 cm x 20 cm) and single spacing/T 2 (40 cm x 15 cm), whereas the subplot was soybean varieties consisted of Dega 1, Dena 1, Argomulyo, and Anjasmoro. Palm oil trees plantation was arranged with 9 m x 8 m spacing row. The lane that could be planted with soybeans in IP 1 was 7 m wide (1 m distance from the rows of palm tree) and in IP 2 was 4.5 m wide (1.75 m distance from palm oil tree plants row). Research activities at IP 1 and IP 2 locations are listed in Table 1.

| Table 1. Research activities at IP 1 and IP 2 area in Tanjungjati, Langkat Binjai North Sumatra, on February-April 2018 |
|---------------------------------------------------------------|
| Component | Explanation |
| Design | split plot design with two replications. |
| Treatment | Main plot was spacing arrangement. There were double spacing (50 cm x (30 cm x 20 cm) and single spacing (40 cm x 15 cm). The subplots consisted of soybean varieties (Dega 1, Dena 1, Argomulyo and Anjasmoro). |
| Seed treatment | Agrisoy mixed with seeds before planting, a dose of 20 g/10 kg of seed |
| Plot measurement | 90 m² |
| Plantation setup | The rest of the corn plant was cleaned and treated, weeds were sprayed with contact herbicides. |
| Organic Fertilizer | 1.0 t/ha (given before planting by spreading) |
| NPK fertilizer compound | 250 kg NPK/ha + 100 kg SP36/ha, given by pulling 5 cm from soybean plants and covered with soil |
| Planting Technique | Seeder, 2-3 seeds / hole |
| Weeding | 1st weeding at 15-20 days. 2nd weeding at 28-30 days. |
| Pest/disease control | Preventive with chemical pesticides |
| Harvest | physiological mature |

Observed parameters in IP 1 and IP 2 for each replication were soybean plant yield components consisting of stem height (cm), number of filled pods, number of nodes, and weight of seeds (g) taken from 10 random sample plants. Seed yields were measured from 2.5 m x 10 m tiles (converted in hectares (ha)) and weights of 100 seeds from the yield of tiles. Seeds moisture content was predicted to be around 14%.

3. Results and Discussion

Palm oil tree plantation was a rain-fed dry land, in which the water supplies were depended on rainwater. Water seeped into the soil if it rained, then the land surface would be dry in two days. Soil acidity (pH) average was 6.2. Maximum shade condition under palm oil tree in IP 1 was 5% at the time of planting soybeans and 15% at harvest time. While in IP 2 was around 15% and more than 30% respectively, depended on oil palm growth.
3.1. Research in IP 1 plantation

Statistical analysis results showed interactions effect (spacing row models with varieties) in IP 1 using 5% maximum standard error (Table 2). Based on these criteria, it was known that seed yield and number of nodes in soybean were interrelated with plant spacing model (T). The most seed yield was Argomulyo using single space model/T 2 (3.66 t/ha). Secondly was Dega 1 using double space model/T 1 (3.40 t/ha) which was equivalent to Anjasmoro and Dega 1 using T 2 (3.33 t/ha and 3.27 t/ha). The third was Anjasmoro using T 1 (3.12 t/ha). Single space model had a relatively higher yield than double space model in all varieties. Argomulyo varieties had higher yield in T 2 (3.66 t/ha) compared to T 1 (2.25 t/ha), in line with seeds yield per plant (26.85 g per plant). Dega 1 showed balanced seed yield between different space models, although no significant differences in seeds yield per plant and 100 seeds weight.

Dega 1 obtained higher seed yield per plant compared to others, this was supported by the ability to produce large seed sizes (22.17 to 22.64 g per 100 seeds). Nevertheless, the yield of Dega 1 was lower than Argomulyo. According to [10], these conditions could occur because the assimilation rate among varieties is different. [11] also explained that seed weight was determined by assimilating supply into the seeds during the reproductive phase. It was further explained that defoliation of two lateral leaves in the R1-R3 phase inhibited seed filling rate, decreased seed weight per plant, and prolongs seed filling. This condition showed that there was a positive relationship between seed filling rate and seed weight. On the other hand, there was a negative relationship between the effective seed filling period and seed weight.

Seed yield supporting components such as plant height, number of branches, and fertile nodes were widely diverse. Dena 1 had the highest stem (76 cm) while Dega 1 was the lowest (53 cm). The most number of fertile nodes was found in Dena 1, while the others were similar. Number of filled pods production was not affected by spacing model and did not show diversity with a range of 39 to 46 units.

3.2. Research in IP 2 plantation

Interaction effect (varieties with T) in IP 2 plantation had an impact on number of branches, seeds weight per plant, and yield (Table 3). The highest seeds yield in IP 2 plantation was achieved by Dena 1 using T 2 i.e 2.17 t/ha, while the lowest was Anjasmoro using T 1 i.e 1.66 t/ha. Shade level in IP 2 plantation was around 30%, and Dena 1 as shade-tolerant improved variety performed higher seed yield (> 2.0 t/ha) compared to the others (< 2.0 t/ha). Dena 1 had a net assimilation rate which tended to remain high even though it was shaded to 50% [12], therefore it still showed high yields compared to others. This showed soybean varieties specifications for certain conditions. Dega 1, Argomulyo, and Anjasmoro showed similar yield in both spacing models.

Soybean was a shade sensitive plant that will have longer stems in shade condition [13-14]. Anjasmoro variety were shade sensitive, showed by longer stem development (61.7 cm) than other varieties in T 1. Quickly elongated stems growth in the vegetative period resulted in prone to collapse so that fewer flowers were formed which ultimately affected the number of pods.

The interaction affected Dega 1 seed weight per plant which showed the highest yield in T 1. Likewise, subplots treatment showed that Dega 1 had the highest seed weight per plant and the highest 100 seeds weight compared to the others. The interaction effect on number of branches did not show a large contribution to yield. This could be seen from a similar number of branches on Anjasmoro and Dena 1 which have different yields.

Subplots treatments (varieties) showed diversity in plant height, number of filled pods, number of nodes, and 100 seeds weights. Anjasmoro and Dena 1 had similar plant height, higher than Dega 1 and Argomulyo significantly. Double spacing models showed higher plants, number of filled pods, and number of nodes than single spacing models. Anjasmoro had the most filled pods and number of nodes, similar to Argomulyo. Plant height character was not followed by number of pods on Anjasmoro. It was caused by longer internodes of Anjasmoro.

Dega 1 had the largest seed size compared to other varieties. Even though it had a large seed size, its productivity level was less than Dena 1. Yield level of more than 3.0 t/ha could be achieved by
supporting more than 40 filled pods or more than 12 g of seeds weight per plant and more than 330,000 plant population. Based on the aforementioned narrative, productivity level in IP 1 plantation should reach more than 3.0 t/ha. Unfortunately, this was not achieved in this study. It was suspected because of heterogeneous seed weight per plant in a dense population.
### Table 2. Soybean yield and supporting components at IP 1 plantation, Binjai, Langkat. Dry season (DS) I 2018

| Treatment | Height (cm) | Number of branches | Number of filled pods | Number of fertile nodes | Seed weight per plant (g) | 100 seeds weight (g) | Seed yield (t/ha) |
|-----------|-------------|---------------------|-----------------------|-------------------------|----------------------------|---------------------|------------------|
| **Spacing (T)** | | | | | | | |
| Double (T1) | 65.1 | a | 3 | a | 41 | a | 18 | a | 17.17 | b | 17.79 | b | 2.90 | b |
| Single (T2) | 63.6 | a | 3 | a | 46 | a | 19 | a | 21.36 | a | 18.55 | a | 3.06 | a |
| **Pr > F** | 0.2732 | 0.3475 | 0.1004 | 0.2192 | 0.0022 | 0.0001 | 0.0011 |
| **Variety (V)** | | | | | | | |
| Dena 1 (V1) | 76.5 | a | 4 | ab | 46 | a | 23 | a | 16.61 | b | 15.83 | d | 2.41 | d |
| Dega 1 (V2) | 53.4 | d | 3 | b | 43 | a | 19 | b | 24.26 | a | 22.41 | a | 3.33 | a |
| Argomulyo (V3) | 59.2 | c | 2 | c | 39 | a | 17 | b | 18.72 | b | 17.68 | b | 2.95 | c |
| Anjasmoro (V4) | 68.3 | b | 4 | a | 45 | a | 17 | b | 17.48 | b | 16.75 | c | 3.22 | b |
| **Pr > F** | 0.0001 | 0.0083 | 0.2689 | 0.0027 | 0.0022 | 0.0000 | 0.0001 |
| **T x V** | | | | | | | |
| T1 x V1 | 76.4 | a | 3 | ab | 40 | bc | 20 | b | 12.85 | c | 14.54 | f | 2.83 | d |
| T1 x V2 | 52.3 | c | 3 | ab | 42 | abc | 20 | b | 21.67 | b | 22.64 | a | 3.40 | b |
| T1 x V3 | 57.1 | bc | 2 | b | 34 | c | 17 | bc | 15.30 | cd | 17.15 | d | 2.25 | e |
| T1 x V4 | 74.6 | a | 4 | a | 48 | ab | 18 | bc | 18.86 | bc | 16.82 | de | 3.12 | c |
| T2 x V1 | 76.7 | a | 4 | a | 53 | a | 26 | a | 20.36 | b | 17.13 | d | 2.00 | f |
| T2 x V2 | 54.5 | c | 3 | ab | 45 | abc | 19 | bc | 26.85 | a | 22.17 | b | 3.27 | b |
| T2 x V3 | 61.3 | b | 2 | b | 44 | abc | 18 | bc | 22.14 | b | 18.21 | c | 3.66 | a |
| T2 x V4 | 62.1 | b | 4 | a | 41 | abc | 16 | c | 16.10 | cd | 16.68 | e | 3.33 | b |
| **Pr > F** | 0.094 | 0.3644 | 0.966 | 0.0312 | 0.0146 | 0.0001 | 0.0001 |

Note: Pr > F = P value or significance indicated by probability value > F, the limit in the study ≤ 0.05, the value listed was statistical analysis result; numbers followed by the same letter indicated no significant difference. Moisture content of seeds was around 14%
Table 3. Soybean yields and supporting components in IP 2 plantation, Binjai, Langkat, DS 1 2018

| Treatment | Height (cm) | Number of branches | Number of filled pods | Number of nodes | Seed weight per plant (g) | 100 seeds weight (g) | Seed yield (t/ha) | Pr > F |
|-----------|-------------|--------------------|-----------------------|-----------------|---------------------------|----------------------|-------------------|--------|
| Spacing (T) | Double (T1) | 54.0 a | 3 a | 30 a | 13 a | 8.32 b | 17.05 a | 1.75 b |
| | Single (T2) | 48.0 b | 3 a | 27 a | 12 a | 10.17 a | 17.22 a | 1.87 a |
| Pr > F | 0.0020 | 0.8763 | 0.1659 | 0.0975 | 0.0031 | 0.0795 | 0.0050 |
| Variety (V) | Dena 1 (V1) | 55.4 a | 3 b | 26 bc | 12 b | 8.01 b | 16.73 b | 1.95 a |
| | Dega 1 (V2) | 44.3 b | 3 ab | 20 c | 9 c | 10.78 a | 21.17 a | 1.75 bc |
| | Argomulyo (V3) | 47.8 b | 2 c | 31 ab | 13 ab | 9.05 b | 16.85 b | 1.85 b |
| | Anjasmoro (V4) | 56.6 a | 3 a | 37 a | 15 a | 9.13 b | 13.79 c | 1.70 c |
| Pr > F | 0.0007 | 0.0028 | 0.0027 | 0.0043 | 0.0135 | <0.0001 | 0.0028 |
| T x V | T1 x V1 | 55.6 b | 2 e | 28 ab | 13 ab | 6.35 d | 16.69 c | 1.74 cd |
| | T1 x V2 | 48.3 cd | 3 bc | 20 c | 9 c | 9.48 bc | 20.96 b | 1.80 bcd |
| | T1 x V3 | 50.5 bcd | 2 de | 35 ab | 15 a | 7.74 cd | 16.69 c | 1.82 bc |
| | T1 x V4 | 61.7 a | 4 a | 37 a | 15 a | 9.70 b | 13.86 d | 1.66 d |
| | T2 x V1 | 55.2 b | 4 ab | 24 c | 12 bc | 9.67 b | 16.77 c | 2.17 a |
| | T2 x V2 | 40.3 e | 3 c | 21 c | 10 c | 12.09 a | 21.37 a | 1.71 ed |
| | T2 x V3 | 45.1 de | 2 de | 28 bc | 12 bc | 10.37 ab | 17.02 c | 1.88 b |
| | T2 x V4 | 51.6 bc | 2 ed | 36 ab | 14 ab | 8.57 bc | 13.73 d | 1.74 ed |
| Pr > F | 0.1009 | 0.0007 | 0.4522 | 0.2013 | 0.0240 | 0.1971 | 0.0029 |

Note: Pr > F = P value or significance indicated by probability value > F, the limit in the study ≤ 0.05, the value listed was statistical analysis result; numbers followed by the same letter indicated no significant difference. Moisture content of seeds was around 14%
3.3. Combine analysis

Combined statistical analysis of two plantations (IP 1 and IP 2) showed that the average soybean yield in IP 1 plantation was higher than IP 2 with a difference of 1.17 t/ha (Table 4). The obstacles in IP 2 plantation were higher shade level and the palm oil tree roots that spread to the middle of the lane. Shading decreased photosynthetic rate in soybean [15], causes yield and its supporting components decline [16], decreased dry matter accumulation [17], increased the number of deciduous flowers and decreased the number of pods per plant [18-19]. The root system between annual and one-year crops in agroforestry planting patterns could be complementary if the annual crop root system was under the one-year crop root zone and competitive if it was in the same zone [20]. Palm oil tree had a fibrous root type with primary root depth reaching 100 cm, while secondary and tertiary root distribution was dominant at 0-20 cm depth [21]. It means that palm oil roots will be developed further at the surface of the soil, and tend to compete with soybean roots.

The main plot treatment (T) showed that T 2 had a higher average seed yield. The 40 cm apart soybean planting lanes were significantly different from the double SM, although it was easier based on plant maintenance. Single spacing increased light competition and caused the plants to grow taller, fertile pods and nodes became more abundant [22-23]. Subplots treatment (soybean varieties) showed real differences. Dega 1 showed the highest average yield (2.54 t/ha), while the lowest was Dena 1 (2.18 t/ha). However, the average yield level of soybean varieties tested was able to reach more than 2.00 t/ha. The soil that could be planted with food crops in IP 1 reached 80%, while in IP 2 was 60%. The research provided information on soybean varieties that were most suitable for under palm trees plantation

Table 4. Combined analysis results for seed yield in two plantations (IP 1 and IP 2), Binjai, Langkat. DS 1 2018

| Treatment                  | Pr>F | Seed Yield (t/ha) |
|----------------------------|------|------------------|
| Plantation (P)             |      |                  |
| IP 1                       | <0.0001 | 2.98 a            |
| IP 2                       | <0.0001 | 1.81 b            |
| Main Plot (T)              |      |                  |
| Double                     | <0.0001 | 2.32 b            |
| Single                     | <0.0001 | 2.47 a            |
| Sub Plot (Varieties)       |      |                  |
| Dena 1                     | <0.0001 | 2.18 d            |
| Dega 1                     | <0.0001 | 2.54 a            |
| Argomulyo                  |      | 2.40 c            |
| Anjasmoro                  |      | 2.46 b            |
| Interactions               | <0.0001 |                  |

Note: Pr > F = P value or significance indicated by probability value > F, the limit in the study ≤ 0.05, the value listed was statistical analysis result; numbers followed by the same letter indicated no significant difference. Moisture content of seeds was around 14%.

4. Conclusion

The average seed yield in IP 1 was higher than IP 2, and the single space model produced higher seed yield compared to double space model Argomulyo variety was superior in IP 1 with a seed yield of 3.66 t/ha, and the lowest one was Dena 1 with 2.83 t/ha. Dena 1 was the most superior in IP 2 with seed yield 2.17 t/ha (14% seed moisture content). Dena 1 could be preferred to conducted soybean plantation under palm oil tree with shade level into 30%.
Acknowledgement

This research was supported by Indonesian government under the work of Indonesian Legume and Tuber Research Institute. We also thanks to Mr. Sagitarius for his technical support in field.

References

[1] Mason A, Wallace D, Straight R. 2014. An overview of agroforestry. Agroforestry Note, May 2014. United States (US): USDA National Agroforestry Center. https://www.fs.usda.gov/nac/assets/documents/agroforestrynotes/an01g01.pdf. Accessed 2020 July 16th

[2] Utami AR, Verbis B, van Noordwijk M, Hairiah K, Sardjono MA. 2003. The Prospect of Agroforestry Research and Development in Indonesia. Bogor (Indonesia).http://old.worldagroforestry.org/sea/Publications/files/lecturenote/LN0009-04.pdf. Accessed 2020 July 17th

[3] Atangana A, Khasa D, Chang S, Degrande A. 2014. Tropical Agroforestry. Springer Science + Business Dordrecht. https://www.springer.com/gp/book/9789400777224. Accessed 2020 July 15th

[4] Elevitch CR, Mazaroli DN, Ragon D. 2018. Agroforestry standards for regenerative agriculture. Sustain

[5] Herman M, Pranowo D. 2012. Produktivitas jagung sebagai tanaman sela pada peremajaan sawit rakyat di Bagan Sapta Permai Riau [Corn productivity as an intercropped plant on plasma farming palm oil tree regeneration at Bagan Sapta Permai Riau]. In: Seminar Nasional Serealia 2011. Proceedings: 2011 October 3-4; Maros. Jakarta (Indonesia): Badan Litbang Pertanian. pp. 213-19

[6] BPS. 2020. Central Bureau of Statistic. https://www.bps.go.id/dynamictable/2015/09/04/838/luas-tanaman-perkebunan-menurut-propinsi-dan-jenis-tanaman-indonesia-000-ha-2011-2018-.html. Accessed 2020 July 15th

[7] BPS North Sumatra. 2017. North Sumatra Central Bureau of Statistic. https://sumut.bps.go.id. Accessed 2020 July 15th

[8] Marwoto, Taufiq A, Suyamto. 2012. Potensi pengembangan tanaman kedelai di perkebunan kelapa sawit [Potential of soybean development in palm oil plantation]. J Lit Bang Pert. 169-74

[9] Wardhana S, Mawarni L, Barus A. 2014. Kajian penanaman kedelai di bawah kelapa sawit umur empat tahun di PTPN III Kebun Rambutan [Study of soybean planting under four-year old palm oil tree at PTPN III Kebun Rambutan]. Agroecotech Online J. doi: 10.32734/jaet.v2i3.7457

[10] Manshuri AG. 2011. Laju pertumbuhan vegetatif dan generatif genotipe kedelai berumur genjah [Vegetative and generative growth rate of early maturity soybean genotype]. J Lit Tan Pangan. doi 10.21082/jpptp.v3n3.2011

[11] Manshuri AG, Nugrahaeni N, Harnowo H. 2016. Ideotipe tanaman kedelai gejah berdaya hasil tinggi [Idiotype of high yield early maturity soybean]. In: Rahmianna AA, editor. Prosiding Seminar Nasional Hasil Penelitian Tanaman Aneka Kacang dan Umbi 2015. Proceedings: 2015 May 19; Malang. Jakarta (Indonesia): Indonesia Agency for Agricultural Research and Development (IAARD). pp. 124-35

[12] Pratiwi H, Artari R. 2018. Respon morfo-fisiologi genotipe kedelai terhadap naungan jagung dan ubikayu [Morpho-physiology response of Soybean Genotypes under maize and cassava shading]. J Agron Indonesia [Ind J Agron]. https://dx.doi.org/10.24831/jai.v46i1.15441

[13] Wu Y, Gong W, Yang F, Wang X, Yong T, Yang W. 2016. Responses to shade and subsequent recovery of soya bean in maize-soya bean relay strip intercropping. Agron & Crop Eco https://doi.org/10.1080/1343943X.2015.1128095. Accessed 2020 July 18th

[14] Wu YS, Yang F, Gong WZ, Ahmed S, Fan YF, Wu, XL, Yong TW, Liu WG, Shu K, Liu J, Du JB, Yang WY. 2017. Shade adaptive response and yield analysis of different soybean
genotypes in relay intercropping systems. *J Integrative Agric.*
https://doi.org/10.1016/S2095-3119(16)61525-3. Accessed 2020 July 18th

[15] Fan Y, Chen J, Cheng Y, Raza MA, Wu X, Wang Z. 2018. Effect of shading and light recovery on the growth, leaf structure, and photosynthetic performance of soybean in a maize-soybean relay-strip intercropping system. PLoS ONE. https://doi.org/10.1371/journal.pone.0198159

[16] Kurosaki H, Yumoto S (2003) Effects of low temperature and shading during flowering on the yield components in soybeans. Plant Prod. Sci. tandfonline.com. doi: 10.1626/pps.6.17

[17] Bing L, De-Ning Q, Xiao-Mei Z (2015) The shoot dry matter accumulation and vertical distribution of soybean yield or yield components in response to light enrichment and shading. *Emir. J. Food Agric.* http://www.ejfa.info/ doi: 10.9755/ejfa.v27i3.18889

[18] Liu B, Larsson L, Caballero A, Hao X, Oling D, Grantham J, Nyström T. 2010. The polarisome is required for segregation and retrograde transport of protein aggregates. Cell. doi: 10.1016/j.cell.2009.12.031

[19] Fan Y, Chen J, Wang Z, Tan T, Li S, Li J, Wang B, Zhang J, Cheng Y, Wu X, Yang W, Yang F. 2019. Soybean (Glycine max L. Merr.) seedlings response to shading: leaf structure, photosynthesis and proteomic analysis. *BMC Plant Biology.*
https://doi.org/10.1186/s12870-019-1633-1. Accessed 2020 July 16th

[20] van Noordwijk M, Lawson G, Hairiah K, Wilso J. 2015. Root distribution of trees and crops: competition and/or complementarity [Chapter 8]. In: Ong CK, Black CR., Wilson, Julia (eds.) Tree-crop Interactions: Agroforestry in A Changing Climate. 2nd ed. CAB International, Wallingford (UK), pp. 221-57

[21] Pradiko I, Hidayat F, Darlan NH, Santoso H, Winarna, Rahutomo S, Sutarta ES. 2016. Distribusi perakaran kelapa sawit dan sifat fisik tanah pada ukuran lubang tanam dan aplikasi tandan kosong sawit yang berbeda [Root distribution of oil palm and soil physical properties in different planting hole and empty fruit bunches application]. *J Pen Kelapa Sawit* 24(1):23-38

[22] Chauhan BS, Opena JL. 2013. Effect of plant spacing on growth and grain yield of soybean. American J Plant Sci

[23] Sundari T, Pratiwi H. 2018. Effects of planting pattern on the performance of soybean genotypes. *Planta Tropika: J Agro Sci* 16(1):9-48. DOI: 10.18196/pt.2018.079.39-48