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# Plant Performance and Added Value of Soybean Farming by Tillage and Plant Spacing

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**Abstract.** This study aimed to determine plant performance and added value of soybean farming by applying tillage and plant spacing. This study was conducted by two treatments, namely treatment I: no-tillage and scatter planting system on soybean farming, and treatment II: tillage and plant spacing on soybean farming. Primary data were in the form of plant performance, production, and soybean farming. The data were analyzed descriptively using average plant growth and productivity, RCR, BCR, and MBCR. The results of the study showed that the soybean farming with tillage and plant spacing resulted in better growth, a higher number of branches, number of pods, and productivity than the existing farmer. The soybean productivity increased by 19.73%. Tillage and plant spacing were proven to provide added value, i.e., increasing farmers' income by IDR 3,808,000/ha (an increase of 19.72%) and farmers' profits by IDR 2,523,682/ha (an increase of 26.61%). Even though the proportion of costs increased by 13.07%, there was a higher increase in the proportion of profits by 21.01%. The MBCR value of 1.96 showed that when the farming cost increased by IDR 1,000 due to tillage and plant spacing, the profit increased by IDR 1,960.

## 1 Introduction

The price of imported soybeans that keeps increasing has caused fluctuation price in Indonesian. The community's purchasing power of soybean-based products is declining, while soybean entrepreneurs make efforts to sell their products by reducing the volume of their products. To resolve the high demand for soybeans and to suppress imports, the government tries to increase domestic soybean production at the farmers' level. The increase in soybean production focuses more on increasing productivity by applying soybean technology innovations.

Soybean technology innovations have been widely disseminated, but not all the technological components have been adopted by farmers. [1] stated that from 21 innovations disseminated in India, only 8 innovations have been adopted by more than 50 % of farmers.

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The soybean technological components that have not been commonly adopted in soybean centers, particularly in Grobogan Regency, include tillage and plant spacing. Until recently, many soybean farmers still implement no tillage and scatter planting system. However, to increase soybean productivity, tillage and plant spacing are highly recommended. The findings of some research show that the application of tillage and plant spacing, followed by the application of other technological components, can increase soybean productivity.

Tillage allowing for a good soil structure and aeration. A study by [2] and [3] showed that conventional tillage and minimum tillage systems produce a higher soybean production than no-tillage. Agronomic Optimal Plant Density (AOPD) is defined as the required minimum number of plants per unit area for maximum yield [4]. The findings of studies on the effect of plant spacing on agronomic performance and soybean production vary. In [5] showed that plant spacing affected soybean leaf area and shoot biomass but did not have a significant effect on production. [6] reported that the application of 12.5 cm and 25 cm row spacing led to a higher soybean seed production compared to 37.5 cm spacing. On the other hand, a study by [3] showed that plant density i.e., 70 x 5 cm resulted in a higher soybean production than plant density of 35 x 5 cm and 55 x 5 cm. In fact, each region has different characteristics, so it is recommended that the plant spacing system for soybean farming is adjusted to the environmental conditions in every region for maximum yield [7].

A revenue cost ratio (RCR) and benefit cost ratio (BCR) analysis of soybean farming showed that applying the plant spacing system is more profitable than the scatter planting system [8]. The RCR and BCR in the row planting system were also higher than those in the scatter planting system. [9] stated that the average income per ha of soybean farming with tillage was higher than that with no tillage. Farmers perceive that soybean farming with no-tillage and scatter planting system is more financially profitable because it is more economical (no labor costs for tillage and planting required), offers efficient planting time, and avoids rotten seeds [10]. Based on the abovementioned description, the study aimed to evaluate plant performance and added value of soybean farming by tillage and plant spacing (row planting system).

## 2 Methodology

### 2.1 Site and time of study

The study was conducted in Tanjungharjo Village, Ngaringan Subdistrict, Grobogan Regency. The site was selected purposively because Grobogan Regency is a soybean development center in Central Java. The study was carried out during Planting Season (MT) III in June - September 2021 which covered a 2-ha area at the farmers' land.

### 2.2 Tools and materials of study

The tools used in the study on soybean production technology innovations were tractors, *blak* (a tool for manual rice planting using the *jajar legowo* planting system), hoe, sickle, sprayer, bucket, thresher, scale, moisture meter, sack, tarpaulin, and meter. The materials used were soybean seeds of Anjasmoro variety, 60 kg/ha Urea, 150 kg/ha NPK Phonska, 1,200 kg/ha organic fertilizer, 3 kg/ha MKP leaf fertilizer, 64.5 kg/ha Fertiphos, Pesticides, Herbicides, and sex-pheromone.

### 2.3 Method of study implementation

The study was carried out with two treatments, namely i) treatment I (P1): soybean farming with scatter planting system and no tillage (the farmer existing) and ii) treatment II (P2):

soybean farming with tillage and plant spacing (row planting system). The technological components applied to the two treatments are shown in Table 1. Points 2 and 4 of Table 1 show the different technological components between the two treatments. Treatment is the existing farmer condition in Tanjungharjo Village. In this village, the farmers planted soybeans with no-tillage and scatter planting system. No-tillage means that soybean seeds are sown directly into soil not tilled after the harvest of rice. Scatter planting system means that soybean seeds are directly spread without preparing any planting beds or spacing. On the other hand, treatment II was introduced to soybean cultivation technology by applying tillage, using drainage channels, implementing plant spacing, and making planting beds with the row planting system.

**Table 1**. Soybean farming technological components with the ICM approach applied to both treatments.

| No | Technological Components | Treatment | |
|---|---|---|---|
| | | Treatment I | Treatment II |
| 1 | Soybean Superior Varieties, certified seeds | Anjasmoro, certified seeds | Anjasmoro, certified seeds |
| 2 | Tillage | No tillage, no drainage | Tillage, drainage channels |
| 3 | Organic fertilization | Organic fertilizer | Organic fertilizer |
| 4 | Planting system and plant spacing | Scatter planting system, without spacing | Tugal planting system, plant spacing of 35 cm x 10-15 cm |
| 5 | Balanced fertilization | Balanced use of organic and inorganic fertilizer, site-specific fertilization | Balanced use of organic and inorganic fertilizer, site-specific fertilization |
| 6 | Control of weeds and pests | An integrated system according to the control threshold | An integrated system according to the control threshold |
| 7 | Harvest | Harvest on time | Harvest on time, for prospective seeds |

The primary data used are plant growth performance data, productivity data, and input-output data. The soybean plant growth and productivity data were obtained through direct observation at the study site. Moreover, the input-output data were obtained from all costs incurred issued and farmers' income. Observations of 90 plants were conducted in order to determine the performance of plant growth, while productivity data and seedling growth rate data were obtained as many as 3 plots per treatment, the number of plants per plot was 243 plants.

The secondary data were obtained from various sources, including the Central Bureau of Statistics, the Ministry of Agriculture, websites, and other sources. The plant performance and increase in soybean yield were analyzed descriptively based on the average for each agronomic component. The agronomic components observed were growth rate, plant height, number of productive seedlings, number of pods, and productivity. The added value was calculated quantitatively based on the farming data for financial analysis, including production costs (variable costs and fixed costs), income, and profits from the soybean farming. The financial feasibility was assessed from the Revenue Cost Ratio (RCR), Benefit Cost Ratio (BCR), and Marginal Benefit Cost Ratio (MBCR). The financial feasibility analysis was done by adopting several previous studies, including [11], [12], [13] and [14] with the following formula:

$$TC = \sum (Pxi.\ Xi) \tag{1}$$

$$TR = \sum (Py.\ y) \tag{2}$$

$$\prod = TR - TC \tag{3}$$

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$$R/C=\frac{TR}{TC} \tag{4}$$

$$B/C=\frac{TB}{TC} \tag{5}$$

Where:

| | | |
|---|---|---|
| TC | = | Total cost (IDR/ha) |
| *Pxi* | = | Price of inputs to-i |
| *Xi* | = | Inputs to-i |
| TR | = | Total revenue (IDR/ha) |
| *Py* | = | Soybean price (IDR/kg) |
| *y* | = | Quantity of soybean (kg) |
| $\prod$ | = | Profits (IDR) |
| TB | = | Total Benefit (IDR) |
| R/C | = | Farming is considered efficient if RCR >1 [15, 16, 17] |
| B/C | = | Farming is considered viable if BCR >1 |

Marginal Benefit Cost Ratio (MBCR) is useful to determine whether a new technology used by farmers can bring added value. MBCR value > 1 means that the introduced technology has the potential to be developed because it is economically feasibility. The MBCR value was calculated using the formula according to [18] as follows:

$$\text{MBCR} = \frac{\text{new technology revenue} - \text{existing technology revenue}}{\text{cost of new technology} - \text{cost of existing technology}} \tag{6}$$

# 3 Result and discussions

## 3.1 Agricultural performance of soybean

Table 2 shows the parameters of soybean plant agronomic performance with two treatments. In terms of the parameters of soybean seed growth rate, tillage and plant spacing were able to grow soybean seeds by 95 %, higher than the farming with scatter planting system and no tillage by 90 %. Tillage by utilizing drainage channels was able to prevent the soil from excess or lack of water. Water can be adjusted according to the needs of seeds to germinate optimally. After a heavy rain, puddles will form on land with neither tillage nor drainage, causing rotten soybean seeds, thus reducing germination. Soybean seeds sown directly after conventional rice fields (flooded rice system) tend to have lower productivity than soybean seeds cultivated using a tillage system which will have higher productivity even without the application of organic fertilizers [19]. The land on which plant beds are made allow for easier water management because there is no puddle and water keep flowing, preventing it from interfering with the germination of the seeds sown.

Seed growth is also affected by planting systems. Soybean seeds that are sown by plant spacing and by row planting system will be more well managed compared to those planted by scatter planting system method. Scatter planting (scatter planting system) methods cause irregular, uneven plant spacing, in which some are quite close to each other, some are quite far from each other, some are scattered. Yield maximization of seeds is also associated with better spatial distribution of plants, reflecting an increase in solar radiation absorption and a decrease in competition between plants [20]. Sowing seeds evenly on the planting beds can increase seed yield through an increased use of environmental resources, such as solar radiation, temperature, photoperiod, and atmospheric $CO_2$ levels, combined with water and nutrient restrictions [21].

**Table 2.** Soybean plant performance in two treatments in Tanjungharjo Village, Ngaringan Subdistrict, Grobogan Regency in 2021.

| **Parameter** | **Treatment** | |
|---|---|---|
| | **Treatment I** | **Treatment II** |
| 1. Seedling growth rate (%) | | |
| a. Minimum | 78 | 90 |
| b. Maximum | 92 | 98 |
| c. Average | 90 | 95 |
| 2. Plant height (cm) | | |
| a. Minimum | 76 | 58 |
| b. Maximum | 85 | 78 |
| c. Average | 77 | 73 |
| d. Standard Deviation | ± 1.62 | ± 5.90 |
| 3. Number of branches (branches) | | |
| a. Minimum | 2 | 3 |
| b. Maximum | 4 | 6 |
| c. Average | 3 | 5 |
| d. Standard Deviation | ± 1.62 | ± 1.62 |
| 4. Number of pods (pods) | | |
| a. Minimum | 25 | 50 |
| b. Maximum | 45 | 65 |
| c. Average | 35 | 58 |
| d. Standard Deviation | ± 1.62 | ± 1.62 |
| 5. Productivity (kg/ha) | | |
| a. Minimum | 1,590 | 1,904 |
| b. Maximum | 2,272 | 2,720 |
| c. Average | 1,931 | 2,312 |

In terms of the parameter of soybean plant height, treatment II resulted in shorter height than treatment I. The row planting system was done by managing plant spacing, ensuring space between the planting beds. The presence of the space at regular intervals allows light to enter the planting area evenly, so during the growth process, the plants get sufficient light. Sufficient light optimizes normal plant growth. Table 3 shows that at each growth phase, the plant height in the scatter planting system treatment was higher. Scatter planting system cause uneven plant spacing, in which plants may be quite close to each other, causing them to absorb lack of light because the plant spacing is too close. This can lead to increased upward growth or etiolation. Plants will show an elongated growth rate, reflecting their effort to optimize the absorption of sunlight for photosynthesis. Most of the plants in the scatter planting treatment were etiolated and there were no dwarf plants.

**Table 3**. Soybean plant height based on growth phase in Tanjungharjo Village, Ngaringan Subdistrict, Grobogan Regency in 2021.

| **Plant Age (DAP)** | **Plant (cm)** | |
|---|---|---|
| | **Treatment I** | **Treatment II** |
| 23 | 35 | 25 |
| 38 | 40 | 35 |
| 53 | 77 | 73 |

Where: DAP= Days After Planting

The parameter of the number of branches of soybean plants is influenced by the planting method. In the row planting system, regular planting distance allows for the soybean plant branches to grow optimally before generative growth or pod formation. The Anjasmoro variety in this study showed its potential by producing 3-6 branches in treatment II, but only 2-4 branches in treatment I. [22] reported an increase in the number of lateral branches with an increased space in the planting row. Plant spacing with wider gaps allows for a higher sunlight level, providing an opportunity for the plants to grow sideways and affecting the formation of branches.

In terms of the parameter of the number of pods per soybean plant, those sown with tillage and row planting system produced 50-65 pods, higher than soybean plants in scatter planting system and no tillage which only produced 25-45 pods. This shows that plant spacing affects the number of pods produced by soybean plants. Even distribution of plants in rows reduces competition between plants, thus increasing seed production per plant [23]. When there is a decrease in plant density in soybean cultivation, [24] mentioned that plants tend to produce more branches and more pods and have higher productivity.

In terms of the parameter of productivity, treatment II had higher productivity than treatment I. [25] stated that too wide plant spacing resulted in different growth and production in different soybean varieties.[26] stated that planting distance had a significant effect on soybean yield per area but had no significant effect on dry weight and soybean yield per plant. The planting distance in rows increased the number of side branches, the number of nodes, and the number of fruits per plant; the plant spacing of up to 61.6 cm did not reduce the productivity of soybean plants. Pods per plant and the number of live nodes per plant on the lateral branches are the two factors most affected by plant spacing in rows. Even at a wider plant spacing, there is no decrease in soybean yield [27]. In addition to plant spacing, tillage in soybean cultivation is highly important because soybean plants in Indonesia are generally planted in the dry season. A challenge to soybean cultivation in the dry season is low water availability, thus tillage is highly required.

### 3.2 Financial added value of soybean farming

Table 4 presents the financial analysis and added value of soybean farming in both treatments. The farmers' income in treatment II was greater than that in treatment I, affected by higher soybean production in treatment II, reaching 2,312 kg/ha compared to treatment I of 1,931 kg/ha. With the soybean price of IDR 10,000/kg, the farmers' income in treatment II was IDR 23,120,000, higher than that in treatment I i.e., IDR 19,312,000. The application of tillage and plant spacing in soybean farming resulted in an added value to farmers' income of IDR 3.808.000 or an increase of 19.72 %. This is in line with research by [9], showing that soybean yield per ha with plough tillage was 9.85 % higher than that with no tillage, increasing farmers' income by 17.25 %.

The cost of farming in treatment II was higher than that in treatment I. The cost differences were found in some variables, including the cost of seeds, non-family labor and family labor. The added value of using seeds in treatment II was to save costs of IDR 150,000. The row planting system saved 10 kg of seeds due to the plant spacing applied. This is in line with a study by [8], showing that the row planting system saved 10 kg of seeds, equivalent to IDR 61,701 than scatter planting system. In the scatter planting system, the seeds are scattered directly by farmers so more seeds are needed. In fact, there was an increase in family and non-family labor costs in treatment II by IDR 1,434,318 (an increase of 33.88%), especially for tillage and planting labor (making planting beds and sowing). In general, the no-tillage cost of treatment II increased by IDR 1,284,318 (an increase of 13.07 %) compared to treatment I. This finding is also in line with a study by [8], showing that the row planting system increased labor costs by 8.83 – 22.05 % compared to the scatter planting system, especially for tillage.

The farmers’ profit in treatment II was IDR 12,009,203, higher than that in treatment I i.e., IDR 9,485,521. The added value of the farmers' profit due to tillage and plant spacing was IDR 2,523,682 (an increase of 26.61 %), in line with research by [8] and [9]. The RCR value in both treatments was greater than 1, meaning that both treatments were profitable and efficient. However, the soybean farming with tillage and plant spacing had a higher RCR value of 2.08, compared to the RCR value of the existing farmer condition of 1.97.

**Table 4.** Comparison of financial added value analysis of soybean farming in 1-hectare area in Tanjungharjo Village, Ngaringan Subdistrict, Grobogan Regency, 2021.

| Variables | | Treatment I | | | Treatment II | | | Added value |
|---|---|---|---|---|---|---|---|---|
| | | No-tillage | Unit price | Value | No-tillage | Unit price | Value | |
| **A.** | **Income** | | | **19,312,000** | | | **23,120,000** | **3,808,000** |
| | Production (Kg/ha) | 1,931 | 10,000 | 19,312,000 | 2,312 | 10,000 | 23,120,000 | 381 |
| **B.** | **Cost** | | | **9,826,479** | | | **11,110,797** | **1,284,318** |
| **1)** | **Variable Costs** | | | **9,701,479** | | | **10,985,797** | **1,284,318** |
| | a. Seeds (Kg) | 60 | 15,000 | 900,000 | 50 | 15,000 | 750,000 | 150,000 |
| | b. Seed treatment (sachet) | 12 | 10,000 | 120,000 | 12 | 10,000 | 120,000 | 0 |
| | c. Urea (Kg) | 60 | 6,200 | 372,000 | 60 | 6,200 | 372,000 | 0 |
| | d. NPK Phonska (Kg) | 150 | 8,200 | 1,230,000 | 150 | 8,200 | 1,230,000 | 0 |
| | e. Organic fertilizer (Kg) | 1,200 | 900 | 1,080,000 | 1,200 | 900 | 1,080,000 | 0 |
| | f. MKP leaf fertilizer (Kg) | 3 | 41,500 | 124,500 | 3 | 41,500 | 124,500 | 0 |
| | g. Fertiphos (Kg) | 64.5 | 4,600 | 296,700 | 64.5 | 4,600 | 296,700 | 0 |
| | h. Pesticide (100 ml/btl) | 9 | 88,889 | 810,667 | 9 | 88,889 | 810,667 | 0 |
| | i. Herbicide (500 ml/btl) | 6 | 89,000 | 534,000 | 6 | 89,000 | 534,000 | 0 |
| | j. non-family labor (main days) | 62 | 62,259 | 3,860,058 | 84 | 62,977 | 5,290,068 | 1,430,010 |
| | k. family labor (main days) | 6 | 62,259 | 373,554 | 6 | 62,977 | 377,862 | 4,308 |
| **2)** | **Fixed Costs** | | | **125,000** | | | **125,000** | **0** |
| | a. Tax (IDR) | | 40,000 | 40,000 | | 40,000 | 40,000 | 0 |
| | b. Contribution group (IDR) | | 60,000 | 60,000 | | 60,000 | 60,000 | 0 |
| | c. Drainage Cost (IDR) | | 25,000 | 25,000 | | 25,000 | 25,000 | 0 |
| **C** | **Profits** | | | **9,485,521** | | | **12,009,203** | **2,523,682** |
| **D** | **R/C Ratio** | | | **1.97** | | | **2.08** | **0.12** |
| **E** | **B/C Ratio** | | | **0.97** | | | **1.08** | **0.12** |
| **F** | **MBCR treatment I to II** | | | **1.96** | | | | |

The BCR value of treatment II was 1.08 or BCR > 1, indicating that the soybean farming with tillage and plant spacing was feasible to be done. On the other hand, treatment I had a BCR value of 0.97 or BCR < 1, making it not quite feasible to be done. These findings are in line with a study by [8] that the RCR and BCR values in row planting and tillage systems were higher than those in scatter planting system. This means that the application of row planting and tillage systems is more profitable and more efficient.

The added value to RCR and BCR was 0.12 (RCR increased 5.88 % and BCR increased 11.97 %). The application of tillage and plant spacing in the soybean farming resulted in an MBCR value of 1.96 or > 1, meaning that both technological components have the potential to be developed because they are economically feasible. A farming cost addition of IDR 1,000 due to the application of tillage and plant spacing will increase farmers' income by IDR 1,960. The added farmers' income is still greater than the added costs incurred due to using both technological components.

## 4 Conclusion

Tillage and plant spacing are part of the technological components to increase soybean production and productivity, which are expected to bring added values for farmers. The application of tillage and plant spacing can improve the agronomic performance of soybean plants, including higher growth percentage, higher number of branches, higher number of pods, and higher productivity levels than soybean farming with scatter planting system and no tillage. The soybean production after applying tillage and plant spacing reached 2.312 kg/ha, while the production in the existing farmer condition only reached 1,931 kg/ha, meaning that the productivity increased by 381 kg/ha (19.73%). The application of these two technological components was also able to provide added financial value to farmers because it increased farmers' income by IDR 3,808,000/ha (an increase of 16.47%) and increased farmers' profits by IDR 2,523,682/ha (an increase of 21.01%). Although the proportion of farming costs increased by IDR 1,284,318/ha (11.56%), it resulted in a higher increase in the proportion of profits to IDR 2,523,682/ha (21.01%). The MBCR value was 1.96, meaning that a farming cost addition of IDR 1,000 due to applying tillage and plant spacing increases a profit by IDR 1,960.

## References

1. P. Sharma, B.U. Dupare, R.M. Patel. Agricultural Economics Research **31,** 2 (2018)
2. L. Kovac, J. Jakubová, D. Šariková. Agriculture 60 (2014)
3. F. Ozturk, T. Sogut. International Scientific Journal "Mechanization In Agriculture **xii,** 2 (2016)
4. W.D. Carciochi, R. Schwalbert, F.H. Andrade, G.M. Corassa, P. Carter, A.P. Gaspar, J. Schmidt, I.A. Ciampitti. Agronomy Journal, **111** (2019)
5. S. Bhagirath, Chauhan, J.L. Opeña. American Journal of Plant Sciences, **4** (2013)
6. M. Flajšman, I. Šantavec, A. Kolmanič, A.d. Kocjan. International Journal of Plant Production, 13 (2019)
7. A. Masino, P. Rugeroni, L.Borrás, L. Rotundo. European Journal of Agronomy, 98 (2018)
8. W.A. Setyandari, Darsan, D. Su'udi. Jurnal Agribisnis dan Pertanian Berkelanjutan (Oryza) **3**, 2 (2018)
9. D. Gawęda, A. Nowak, M. Haliniarz, A. Woźniak. International Journal of Plant Production, 14 (2020)
10. J.B. Supriyono, S. Nyoto, P. Harsono. Seminar Nasional dalam Rangka Dies Natalis ke-44 UNS Tahun 2020, **4** 1 (2020)

11. J. K. Bajkani. *IOSR Journal of Agriculture and Veterinary Science*, **6**, 1 (2013)
12. M. Bajracharya, M Sapkota. *Agriculture and Food Security*, **6**, 1 (2017)
13. P. Kharumnuid, S. Sarkar, P Singh, S. Priya, B.S. Tomar, D.K Singh, N. K. Pandey. *Indian Journal of Horticulture*, **74**, 3 (2017)
14. K. D Ahmed, O Burhan, A. Amanuel, I. Diriba, A. Ahmed. *Journal of Development and Agricultural Economics*, **10**, 7 (2018)
15. W.J. Bonabana, B. Mugonola, S. Ajibo, J. Kirinya, E. Kato, R. Kalibwani, V. Kasenge, S. Nyamwaro, S. Tumwesigye, W. Chiuri, J. Mugabo, B. Fungo, M. Tenywa. *African Journal of Agricultural and Resource Economics*, **8**, 3 (2017)
16. L.F.L. Pratiwi, S. Hardyastuti, L.R. Waluyati. *Agricultural Science*, *1*, 1 (2016)
17. C.N. Muhammad, Y Hariyati. *Agricultural Social Economic Journal*, **21**, 1 (2021)
18. Soekartawi. Farming Analysis. UI Press. Jakarta. 2002
19. W. Wangiyana, N. Farida. 2019. AIP Conference Proceedings, Indonesia (2019)
20. N.A.M. Fantin, L. Meert, A. Hanel, L.P. Petean. Applied Research and Agrotechnology **9**, 3 (2016)
21. E.L. Tagliapietra, A.J. Zanon, N.A. Streck, D.S. Balest, S.L. da Rosa, K.P. Bexaira, G.L. Richter, G.G. Ribas, M.R. da Silva . Agronomy Journal (2021)
22. C.J. Basso, D.S. Muraro, A.C.M. Aguiar, M. Lira. Revista Cultivando o saber 9**,** 4 (2016)
23. J.A.A. Balbinot, S.D.O Procopio, H. Debiasi, J.C. Franchini, F. Panison. Ciencias Agrarias **36** (2015)
24. A.S. Ferreira, J.A.A. Balbinot, F. Werner, J.C. Franchini, C. Zucareli. Revista Brasileira de Engenharia Agricola e Ambiental **22**, 3 (2018)
25. S. Kadir, Wulanningtyas, H. Suci. 2017. Prosiding Seminar Nasional Hasil Penelitian Tanaman Aneka Kacang dan Umbi, 157–161 (2017)
26. K. Triyono. Fakultas Pertanian Universitas Slamet Riyadi Surakarta (2012)
27. C.J. Basso, W.B. Pertile, M.J.R. Sangiovo, F.M de Souza, D.R.O da Silva. African Journal of Agricultural Research **17,** 7 (2021)