**Difference in planting time lag after rice harvesting on growth and yield of no tillage soybean (Glycine max L.)**

B T Ariyanto¹, Supriyono², S Nyoto² and P Harsono²

¹Undergraduate of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Indonesia
²Lecturer of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Indonesia

Corresponding author: supriyono_uns@yahoo.com

**Abstract.** Increasing soybean yields needs to be done with innovation in cultivation techniques, one of which is by applying the right planting time. This study aims to obtain planting time that can increase the growth and yield of soybeans in a system without tillage. The study was conducted from June to September 2019 on the former rice field land. This research was conducted using a Randomized Completed Block Design 1 factor with 5 treatments (2, 4, 6, 8 and 10 days after rice harvest) and repeated 5 times. Data from observations were analyzed using analysis of variance based on the 5% F test followed by Duncan's Multiple Range Test of 5% and a correlation test was performed to determine the relationship between soybean planting time difference and the yield. The results showed that the difference 2 days after harvest was able to increase the growth variables, namely plant height, leaf area, number of branches and increase the yield variable, namely the number of pods, seed weight per plant, seed weight per plot. Besides increasing soybean yield to 1.41 tons / ha compared to a longer gap.

1. Introduction

Soybean is the third important food source after rice and corn in meeting the nutritional needs of the community. This is because soy has a relatively inexpensive source of vegetable protein. In Indonesia, the need for soybeans continues to increase along with the increase in population numbers, while the production achieved has not been able to offset the needs. Soybean production data for 2018 is 982,598 tons but Indonesia must import as much soybeans 2,585,809.1 tons for meet domestic soybean needs [1].

Soybean planting after rice harvesting is a major problem in some areas, this is due to planting too long so that the land is dry. Choosing the optimal time for planting dates is an effective way to increase growth and development, and increase yield potential. However, the effect of planting date on soybean yield depends on genetic and environmental conditions [2]. Based on these problems increasing soybean yields needs to be done with innovations in cultivation techniques one of which is by applying the difference in planting time after rice harvest.
2. Materials and methods
The study was conducted from June to September 2019 on the former rice field land in Pengkok Village, Kedawung District, Sragen Regency, Ecology Laboratory and Plant Production Management and Soil Chemical Laboratory, Faculty of Agriculture, UNS. This research was conducted using a Randomized Complete Group 1 factor design with 5 treatments and repeated 5 times. The treatments that were tried were, difference of 2 days after rice harvest, difference of 4 days after rice harvest, difference of 6 days after rice harvest, difference of 8 days after rice harvest and difference of 10 days after rice harvest. Variables observed included soil moisture content, plant height, number of leaves, leaf area, number of branches, number of plants, stover fresh weight, stover dry weight, number of pods per plant, number of seeds per pod, seed weight per plant, number of seeds per plant, and weighs 100 seeds. Observation data were analyzed using analysis of variance based on the F test of 5%, followed by Duncan's Multiple Range (DMRT) is 5% and a correlation test is performed to determine the relationship between soybean planting time difference and the results.

3. Results and discussion

3.1. Initial moisture analysis
Soil moisture content is the water content contained in soil pores. Unit for expressing soil moisture content in the form of percent by weight or volume [3]. Moisture content is measured with a soil terter which is then equalized with the results of the gravimetric method. The benefits of doing moisture analysis are estimating water requirements for rice fields, estimating water requirements during the irrigation process, and knowing the ability of a type of soil to store moisture or water.

Based on table 1 moisture content for each treatment showed different results. The magnitude of moisture is directly affected by the distribution of soil pores. The more porosity of the soil increases the lower the weight of the soil, so that more space is available for water [4]. The impact of plants on water shortages can be known from metabolic activity, morphology, plant growth and crop yields. Judging from the physiological effects, lack of water can reduce photosynthesis, due to reduced leaf area, whereas if viewed from the biochemical aspect, a decrease in soil moisture will reduce enzyme activity [5].

| Treatment                        | 0 Days after planting (%) | 30 Days after planting (%) | 88 Days after planting (%) |
|----------------------------------|---------------------------|----------------------------|-----------------------------|
| Difference 2 days after harvesting rice | 63.67                     | 37.04                      | 33.35                       |
| Difference 4 days after harvesting rice | 63.33                     | 38.88                      | 30.67                       |
| Difference 6 days after harvesting rice | 60.15                     | 38.55                      | 31.68                       |
| Difference 8 days after harvesting rice | 55.63                     | 36.20                      | 30.84                       |
| Difference 10 days after harvesting rice | 52.11                     | 35.70                      | 28.50                       |

3.2. Growth and yield

3.2.1 Plant height. The results of the analysis of variance showed that the difference in planting time had a significant effect on plant height. Table 2 Difference in 2 days after rice harvest has higher plant height than difference in 4 days after rice harvest, difference in 6 days after rice harvest, difference in 8 days after rice harvest, difference in 10 days after rice harvest. The difference in plant height values may be due to different water absorption due to different water availability thus affecting cell elongation. Water conditions in optimal conditions stimulate vacuole formation so that plants can grow well [6]. Difference 10 days after harvesting rice has the lowest plant height. This might be due to low moisture levels causing the plants to have a water deficit. Water deficit is a condition of plants experiencing a decrease in water potential in the soil, leaf roots so that the rate of water and nutrient
transport decreases. This decrease causes the growth of plants disturbed, especially in the growing tissue [7].

3.2.2. Number of leaves. The results of the analysis of variance showed that the difference in planting time treatment did not significantly influence the number of leaves but gave different results. This might be due to differences in the level of water availability for plants. For plants water functions as a solvent of nutrients carried or that is in the soil that is used for photosynthesis. The availability of sufficient nutrients results in the process of photosynthesis taking place properly and the photosynthesis produced a lot so that the process of leaf formation can be carried out [8]. Difference 2 days after the harvest time of rice which has higher moisture content than the difference 4 days after harvest time but will have a smaller number of leaves although it does not make a significant difference. One of the causes of slow plant growth is due to excess water in the soil, which causes root development to be inhibited due to lack of oxygen in the soil [9].

**Table 2. Effects of the difference in planting time after rice harvest on soybean growth and yield**

| Observation variable       | Treatment          |
|----------------------------|--------------------|
|                            | S1   | S2     | S3     | S4     | S5     |
| Plant Height (cm)          | 27.03 b | 22.30 a | 22.20 a | 20.10 a | 18.38 a |
| Number of leaves (strands) | 10.40 | 10.66 | 9.46 | 8.73 | 8.46 |
| Leaf area (cm²)            | 2.44 b | 2.44 b | 1.85 ab | 1.35 a | 1.04 a |
| Number of branches         | 7.73 b | 7.26 ab | 6.80 ab | 6.66 ab | 6.20 a |
| Number of plants           | 20.00 b | 19.60 b | 19.00 b | 18.00 ab | 12.20 a |
| Fresh Stover Weight (g)   | 21.99 | 21.42 | 21.45 | 19.27 | 14.67 |
| Stover Dry Weight (g)     | 8.77 | 9.04 | 8.99 | 7.95 | 6.09 |
| Number of pods per plant  | 33.44 c | 18.64 ab | 15.20 a | 28.13 cb | 22.46 cb |
| Number of seeds per pod   | 1.77 | 1.73 | 1.82 | 1.63 | 1.63 |
| Seed weight per plant (g) | 9.77 b | 5.89 a | 5.00 a | 5.07 a | 4.71 a |
| Seed weight per plot (g)  | 340.19 b | 179.41 a | 141.02 a | 176.59 a | 143.06 a |
| Weight of 100 seeds (g)   | 19.69 b | 19.42 b | 17.06 a | 18.33 ab | 17.92 a |

Information: The numbers followed by different letters in the lines show significantly different in the Duncan test (DMRT level 5%), S1 (Difference 2 days after harvesting rice), S2 (Difference 4 days after harvesting rice), S3 (Difference 6 days after harvesting rice), S4 (Difference 8 days after harvesting rice), S5 (Difference 10 days after harvesting rice).

3.2.3. Leaf area. The results of the analysis of variance showed that the difference in planting time treatment had a significant effect on leaf area. Table 2 the difference of 2 days after rice harvest and the difference of 4 days after rice harvest has significantly higher leaf area than the difference of 8 days after rice harvest and the difference of 10 days after rice harvest. Differences 10 days after harvesting rice have lowest leaf area. This might be due to the difference 10 days after harvesting rice which has low moisture content. The response of plants that experience water shortages will experience changes at the cellular and molecular levels as indicated by a decrease in growth rate, reduced leaf area, and an increase in root ratio [10]. Changes in leaf area to smaller function to reduce the rate of transpiration, stomata closure, or increase root lengthening and density and increase water use efficiency [11].

3.2.4. Number of branches. The results of the analysis of variance showed that the difference in planting time treatment had a significant effect on the number of branches. Table 2 the difference of 2 days after the rice harvest has an average number of branches 1.532 higher than the difference of 10 days after the rice harvest, besides giving a significant difference. Differences in moisture content due to the difference in planting time have an effect on the number of branches. Plants that experience water stress cause adequate photosynthesis flow to be disrupted so that it will inhibit the growth and development of plants to mature and plants will experience a decrease in the number of branches [12].
3.2.5. Number of plants. The results of the analysis of variance showed that the difference in planting time treatment significantly affected the number of plants. Table 2 differences of 2 days after rice harvest, difference of 4 days after rice harvest, difference of 6 days after rice harvest has a significantly higher number of plants than the difference of 10 days after rice harvest. The difference of 2 days after the rice harvest has a greater number of plants than the difference in the days after the other harvests. This is because the difference 2 days after harvesting rice has moisture levels higher so that it can help the plant through the germination cycle properly. Water is one of the most important external factors in germination, because water absorption is the initial stage of seed germination. Water plays an important role in activating embryonic cells in the seeds, softening the seed coat and developing embryos and endosperm, facilities for the entry of oxygen into the seeds, thinning the protoplasm and food transport media from the endosperm or cotyledon to the growing spots [13].

3.2.6. Weight of fresh crop stover. The results of the analysis of variance showed that the difference in planting time treatment did not significantly influence the fresh weight of plant stover. The low organic matter content in the soil causes the ability of the soil to retain low water. Cell growth is the plant's most sensitive function for lack of water, if lack of water causes a reduction in protein synthesis, cell wall synthesis and cell development so that it will affect the fresh weight of stover [14]. The fresh weight of plants is also strongly influenced by the water content in the soil because water is one of the factors that plants need in large quantities for the process of growth and development [15].

3.2.7. Plant stover dry weight. The results of the analysis of variance showed that the difference in planting time did not significantly influence the dry weight of the crop stover. Water is a solvent for nutrients available in the soil, so that there will be an ion mass flow and diffusion of nutrient solutions in the soil or to the roots of plants. Water also affects the opening of the stomata [16]. On plants planted in low soil moisture conditions, the opening of stomata is relatively smaller, so that CO2 absorption is low. As a result of photosynthesis that occurs relatively little and stunted plant growth. So the fresh and dry stover weight produced is also low [17].

3.2.8. Number of pods per plant. The results of the analysis of variance showed that the difference in planting time treatment significantly affected the number of pods per plant. Table 2 the difference of 2 days after rice harvest has a significantly higher number of pods per plant than the difference of 4 days after rice harvest and the difference of 6 days after rice harvest. Decreased pod yields under water stress conditions due to a decrease in the number of photosynthesis available and their distribution into pods is reduced. Water stress inhibits photosynthesis and the distribution of assimilates into the reproductive organs. The size of the pod affects the weight of seeds per plot, so it takes a large pod to increase the number of seeds per plot [18].

3.2.9. Number of seeds per pod. The results of the analysis of variance showed that the difference in planting time treatment did not significantly influence the number of seeds per pod but gave a different number of seeds per pod. Soybean seed production decreases with increasing water stress [19]. Water stress causes the adaptation of plants which reduces the number of leaves and leaf area so that the photosynthetic field becomes less. Plants also adapt by reducing stomata openings and folding the leaves so that the exchange of CO2 and H2O in the leaves becomes obstructed. The mechanism of plant adaptation to stress causes the inhibition of photosynthesis so that it affects the production of dry matter and seed yield in soybean plants [20]. Additionally, lack of water during the filling period reduces seed yield due to a decrease in photosynthesis rate [21]. The presence of straw in former rice fields can increase the soil infiltration capacity so that water loss can be reduced and maintain soil temperature and humidity [22].
3.2.10. Seed weight per plant. The results of the analysis of variance showed that the difference in planting time treatment had a significant effect on the weight of seeds per plant. Table 2 Difference in 2 days after rice harvest has significantly higher seed weight per plant than difference 4 days after rice harvest, difference in 6 days after rice harvest, difference in 8 days after rice harvest, difference in 10 days after rice harvest. The decreasing number of seeds due to the difference in planting time is due to low soil moisture content. A decrease in soil moisture levels causes nutrients to be dissolved slightly so that water and nutrient absorption is also small. As a result, the process of photosynthesis and hormone synthesis, especially gibberellins, will induce relatively little flower formation [23]. Plants grown at low soil moisture levels will experience drought stress. To adjust to these stresses, the plant will increase ABA synthesis which will increase the miscarriage of leaves and reproductive organs. Resulting in pod contents and seed weight decreases [24]. The low yield of seed weight per plant difference of 10 days after the rice harvest time may also be caused by disruption of nutrient absorption due to low moisture levels. A decrease in the availability of water during drought stress will usually reduce nutrient uptake by plants and cause a reduction in nutrient concentrations in plant tissue [25].

3.2.11. Seed weight per plot. The results of the analysis of variance showed that the difference in planting time treatment gave a significant effect on the weight of seeds per plot. Table 2 Difference in 2 days after rice harvest has a real weight of seeds per plot higher than the difference 4 days after rice harvest, difference of 6 days after rice harvest, difference of 8 days after rice harvest, difference of 10 days after rice harvest. When converted into tons / ha each difference 2, 4, 6, 8, and 10 days after harvesting the rice weighs 1.41 tons / ha, 0.74 tons / ha, 0.58 tons / ha, 0.743 tons / ha and 0.59 tons / ha. Based on these results there was a decrease in each treatment after the difference 2 days after the rice harvest. The decrease in yield from 2 days (1.41 tons / ha) to 4 days (0.58 tons / ha) was 30.94%.

The critical period of soybean plants for water needs, which will reduce crop yields is in the generative phase (pod filling), because lack of water in this phase will reduce the retention of flowers and pods [15]. Difference 2 days after harvesting rice has a higher yield due to humidity and soil temperature is still in optimal condition. Optimal soil moisture and soil temperature, will affect the availability of subsurface water. This condition is very beneficial for plants, which affects the phase of filling pods so as to increase seed yield [16]. Meanwhile, soybean seed production decreases with increasing water stress [19].

3.2.12. Weight of 100 seeds. The results of the analysis of variance showed that the difference in planting time treatment significantly affected the weight of 100 seeds. Table 2 the difference of 2 days after rice harvest and the difference of 4 days after rice harvest has a weight of 100 seeds higher than the difference of 6 days after rice harvest. The difference between soybean planting time and rice harvest gives an effect on the weight of 100 seeds. This is because the longer the soybean planting from rice harvest the soil moisture content decreases and causes the growth process and crop yield to be disrupted. Soybean production is very sensitive to water shortages during the reproductive phase [15]. Meanwhile, the limited availability of water resulted in lower production of dry matter or plant assimilation [27].

3.3. The correlation between difference in planting time and yield variables

Correlation is one analysis to look for relationships between two variables that are quantitative. Pearson product moment correlation has a distance between -1 to +1. If the coefficient is -1 then the two variables have a perfectly negative linear relationship. If the coefficient is +1 then the two variables have a perfectly positive linear relationship. If the coefficient shows the number 0 then there is no relationship between the two variables [28].

Table 3 the correlation between the time difference between planting and yield variables including number of pods, number of seeds per pod, weight of 100 seeds, weight of seeds per plant, and weight of seeds per plot were negatively correlated. Based on the research results, the difference in planting
time is inversely related to changes in soil moisture content. The less time difference for planting soybeans after the rice harvest will cause high moisture levels, and vice versa, the more time difference for planting soybeans after rice harvest will cause low moisture content values. So that the increase in moisture content can increase the number of pods and soybean seeds. Soybean crop production is directly proportional to the increase in moisture content [8]. The phase of pod formation and seed filling requires sufficient water availability. If the availability of water is sufficient, the photosynthate accumulation in soybean pods will run well [29].

Table 3. Recapitulation of the correlation value between the difference in planting time and the yield variable

|     | PT  | NP    | NSP     | W100S | WSP  | WSPP  |
|-----|-----|-------|---------|-------|------|-------|
| PT  | 1   |       |         |       |      |       |
| NP  | -0.160 | 1     |         |       |      |       |
| NSP | -0.019 | -0.479 * | 1       |       |      |       |
| W100S | -0.410 * | 0.352 | -0.316 | 1     |      |       |
| **WSP** | **0.668** | **0.517** **0.143** | **0.478** * | 1 | **0.605** **0.232** | **0.574** **0.970** **1** |

Note: ** = very strong correlation, * = strong correlation. PT = planting time, NP = number of pods per plant, NSP = number of seeds per pod, W100S = weight of 100 seeds, WSP = weight of seeds per plant, WSPP = weight of seeds per plot.

4. Conclusion
The conclusions of this study are soybean planting 2 days after rice harvest time can increase growth variables, namely plant height, leaf area, number of branches, number of plants, and yield variables, namely the number of pods per plant, weight of seeds per plant, weight of seeds per plot, and weight of 100 seeds compared to a longer interval. Planting soybeans 2 days after rice harvest increases the soybean yield to 1.41 tons/ha compared to a longer interval.

References
[1] Kementerian Pertanian Republik Indonesia 2020 Last five years data Available from https://www.pertanian.go.id/home/?show=page&act=view&id=61
[2] Egli D B and Cornelius P L 2009 J. Agron 101 330–5
[3] Ferri R 2011 Moisture content Available from Rendika-Ferri-k.blog.ugm.ac.id.
[4] Nurmi O H, Arsyad S and Yahya S 2009 Forum Pascasarjana 32 21–31
[5] Budisantoso I and Proklamasiningsih 2003 J. Pembangunan Pedesaan 3 91–9
[6] Jafar S H, Thomas A, Kalangi J I and Lasut M T 2013 COCOS 2
[7] Taiz L and E Zeiger 2002 Plant physiology third edition (Massachusetts: Sinauer Associate Inc Publisher Sunderland) p 667
[8] Nugraha, Yoga S, Titin S and Roedy S 2014 J. Produksi Tanaman 2
[9] Nyakpa M Y, Lubis A M, Pulung M A, Amrah A G, Munawar A and Hakim G B H N 1988 Soil fertility (Lampung: Universitas Lampung)
[10] Song A N and Banyo Y 2011 J. Ilmiah Sains 11 166–73
[11] Ramanjulu S and Bartels D 2002 J. Plant Cell and Environment 25 141–51
[12] Marzukoh, Umamil R, Sakya A T and Rahayu M 2013 J Penelitian Agronomi 15 12–6
[13] Ai N S and Ballo M 2010 J Ilmiah Sains 10 190–5
[14] Lia W, Titin S and Ariffin 2019 J Produksi Tanaman 1 486–95
[15] Maynard G H and D M Orcott 1987 The physiology of plants under stress (New York: Inc. New York 206)
[16] Iman B and Elly P 2003 J Pembangunan Pedesaan 3 91–9
Budisantoso and Hari H 2001 J Biosfera 18 30–5
Harnowo D 1993 Response of soybean plants (Glycine max L Merrill) to potassium fertilization and drought stress in the reproductive phase (Bandung: Program Pascasarjana IPB)
Candogan B N, Sinci M, Buyukcangaz H, Demirtas C, Goksoy A T and Yazgan S 2013 Agricultural Water Management 118 113–21
Taufiq, Abdullah and Sundari T 2014 Buletin Palawija 23 13–26
Gardner F B, Pearce R B and Mitchel R L 1985 Physiology of crop plants (Iowa: Iowa State University Press) p 327
Mulyatri 2003 Prosiding Seminar Nasional Hasil Penelitian dan Pengkajian Teknologi Spesifik Lokasi 90–5
Aminah, Nirwana and Marlyana S P 2017 J Agrotek 1 14–23
Adisarwanto T 2008 Tropical soybean cultivation (Jakarta: Penebar Swadaya).
Farooq M, Wahid A, Kobayashi N, Fujita D and Basra S M A 2009 J Agron. Sustain 29 185–212
Mimbar S M 1991 Effect of density on miscarriage of reproductive organs, pod retention and soybean yield (Malang: Skripsi S1 Fakultas Pertanian Universitas Brawijaya Malang) p 59
Suhardianto, Karyawan A S and Sitompul S M 2019 J Produksi Tanaman 6
Sarwono and Jonathan 2012 Quantitative approach thesis research method using spss procedures PT Elex Media Komputindo.
Fachruddin L 2000 Cultivating nuts (Yogyakarta: Kanisius)