The productivity of paddy rice with the method of five seedlings clump⁻¹ STSS used PHP mulch and furrow irrigation compared with several cultivation technology packages

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Abstract. Various cultivation technique innovations such as the SRI method with AWD irrigation system have been able to increase the productivity of paddy rice, but farmers are still reluctant to implement it because they are faced with weed problems. This study aimed to test the productivity level of several paddy rice cultivation technology packages. The treatment was 6 types of cultivation technology packages, namely: the SRI method, the method with 5 seedlings clump⁻¹ of STSS, the legowo system 4:1, the SBSU, the method of 5 seedlings clump⁻¹ STSS with PHP mulch and furrow irrigation, and conventional system. The seedling was planted at 12 DAS ages, except for the conventional system at 26 DAS ages with 4 seeds attached clump⁻¹. The results showed that the type of paddy rice cultivation technology package generally affected the growth and yield components of paddy rice, except for the percentage of productive tillers, the number of grain panicle⁻¹, and the harvest index. The method of 5 seedlings clump⁻¹ STSS with PHP mulch and furrow irrigation resulted more in almost all parameters compared to all packages technology tested. The grain production is 7,250 t MDG ha⁻¹ it higher than other technology packages production.

Keywords: conventional system; furrow irrigation; legowo system; one-one cropping system; silver black plastic mulch

1. Introduction
Paddy rice cultivation technological is currently able to increase grain production. One technique is the system of rice intensification [SRI] method with planting 1 young seedling clump⁻¹ [1]. However, the use of 1 young seedlings clump⁻¹ is at high risk of the death of the seedlings due to pests and weather factors. The use of a higher number of seedlings clump⁻¹ by attaching in conventional systems causes competition between plant tillers in the clump [2,3,4]. So the need for a one-one planting system or STSS, which planting 2 or more seedlings clump⁻¹ which are planted separately [2,3]. The use of 2-5 seedlings clump⁻¹ STSS resulted in higher growth and yield component to using 1 seedling clump⁻¹, but the highest productivity was obtained when using 5 seedlings clump⁻¹ STSS [4;5].

The difficulty controlling weeds in the SRI method is the main problem the farmers to adopt the SRI method. The use of black silver plastic or PHP mulch can be an alternative for controlling rice weeds. Plastic mulching can significantly increase crop yield and water use efficiency [WUE], especially in
dryland agriculture [6]. To facilitate the installation of mulch, rice cultivation needs to be made plots with a furrow irrigation system.

Rice cultivation in non-inundated conditions can make water use more efficient [7] and increase rice productivity [8], the grain production in the temperate area is more than 9 t ha⁻¹ but in tropical areas below 8 t ha⁻¹ [7], and irrigation AWD with water depth 5-10 cm could save water 33.53-19.55%, with crop production increasing 29.83-21.39% greater than conventional method [9]. The use of 5 seedlings clump⁻¹ STSS with PHP and furrow irrigation, being able to increase grain production significantly, also solve the problem of weeds and golden snail attacks on paddy rice [4]. This study aimed to test the productivity level of several paddy rice cultivation technology packages.

2. Research Methods

The experiment used the treatment of the 6 types of cultivation technological package [S]: SRI method [S1], modification of the SRI method with 5 seedlings clump⁻¹ STSS according to the method [4;5] [S2], legowo type 4:1 [S3], SBSU type III according to [10] [S4], modification of SRI with 5 seedlings clump⁻¹ STSS using PHP mulch and furrow irrigation according to [4;5] [S5], and The conventional system is the use of 3-week old seedlings with 4 attached seedlings clump⁻¹ and a flooded system [S6]. Seedlings were planted at 12 days after sowing [DAS] ages for S1 to S5, while S6 was planted at 26 DAS ages with 4 seedlings attached clump⁻¹. S1 package, planting 1 seedling clump⁻¹, spacing 25 cm x 25 cm. S2 package, planting 5 seedlings clump⁻¹ STSS with planting point spacing 30 cm between rows x 25 cm in rows using a planting hole mall board tool [4;5], begins with 4 seeds at the corner of the planting hole and 1 seedling in the center of the planting hole. S3 package planting with spacing 25 cm between rows and 15 cm in rows. S4 package planting 4 seedlings clump⁻¹ with a pattern of 30 x 30 cm ([7.5 x 7.5 cm] x 30 cm [7.5 x 7.5 cm]). Package S5, planting uses beds [1.10 m x 30 m high 10 cm] with PHP mulch and furrow irrigation. PHP mulch is given an equilateral rectangular hole of 10 cm x 10 cm with a distance between the edges of the holes 20 cm x 15 cm [4;5]. S6 package: 4 seedlings clump⁻¹ are planted attached with spacing 20 cm x 20 cm. Irrigation for S1 to S4 was carried out by AWD in the vegetative phase and inundated in the generative phase. S5 package is always inundated in the furrow during vegetative and generative phases. S6 package is carried out inundation during the vegetative and generative phases. All crops were given cow manure compost at a dose of 15 t ha⁻¹ and NPK fertilizer [16:16:16] 300 kg ha⁻¹. Observations were made on the components of growth, yield, and production of paddy rice. Data were analyzed by ANOVA and DNMRT test with a real level of 5% and or 1%.

3. Results and Discussion

3.1. The plant height, number of tillers, number of panicles, and percentage of productive tillers

The type of technological package affected the plant height, number of tillers, and number of panicles clump⁻¹, but did not affect the percentage of productive tillers. The paddy rice plant height of the SRI method and its modification [S1 to S5 package] is higher than that of the conventional system [CS] [S6 package]. The S5 package produced higher plants than other packages [Table 1]. The S1 to S5 package produced more tillers than the S6 package [Table 1]. The use packages S2, S5, and S4 resulted in a higher number of tillers than the S1, S3, and S6 packages. Furthermore, the highest number of panicles clump⁻¹ was obtained in the S5 package which an average of 42.9 tillers, while the least number was obtained in the s6 package, namely an average of 27.8 panicles [Table 1]. The increased number of tillers is due because transplanting young seedlings can maintain the plant's potential for large tiller formation and root growth because there is no lag phyllochron period [12]. Phyllochron rice plants are related to the aged transfer of seedlings, varieties, and cultivation systems. The younger seedlings are faster in the formation of tillers, so the formation of tillers in the SRI method is faster than the CS [11:13]. There was a positive correlation between panicle number m⁻² and maximum tiller number m⁻²[14]. Attached planting systems in CS and the SRI method can lead to early competition in plants for nutrients, water, and sunlight, will produce a dense canopy structure with low sunlight interception, but with STSS method has the advantage of producing a greater number of mother plants and main tillers which avoid early competition,
reducing the risk of embroidery, producing a clump canopy structure that is more effective and efficient at capturing sunlight, all of which will lead to increased productivity \[2,3\]. Furthermore, \[1\] wide spacing and good soil aeration, furrow irrigation is better than inundated irrigation, replacing paddy rice fields that are always inundated with soil that is well aerated during the vegetative growth phase. The alternate wet and dry [AWD] technique saves water usage during the growing period by a range between 13-16% compared to continuous irrigation techniques \[9\]. The use of PHP mulch increases grain production and prevents crops from competing with weeds \[4;5\].

Table 1. The comparison of plant height, number of tillers and panicles, and percentage of productive tillers of several rice cultivation technological packages.

| Technological Packages          | Plant Height [cm] | Number of Tillers [tiller clump\(^{-1}\)] | Number of Panicles [panicle clump\(^{-1}\)] | Productive Tillers [% clump\(^{-1}\)] |
|--------------------------------|-------------------|-------------------------------------------|-------------------------------------------|--------------------------------------|
| SRI Standard [S1]              | 102.5c            | 82.6b                                     | 33.6c                                     | 42.8                                 |
| Modification of SRI 5 seedlings clump\(^{-1}\) STSS [S2] | 106.3c           | 78.6abc                                   | 39.2b                                     | 50.4                                 |
| Legowo System 4:1 [S3]         | 97.2cb            | 61.6d                                     | 29.5d                                     | 48.6                                 |
| Main Square System [SBSU][S4]  | 103.1c            | 93.6a                                     | 37.1b                                     | 41.7                                 |
| Method of 5 seedlings clump\(^{-1}\) STSS mulch PHP and Furrow Irrigation [S5] | 122.8a            | 93.9a                                     | 42.9a                                     | 46.9                                 |
| Conventional System [S6]       | 91.2b             | 51.7e                                     | 27.8d                                     | 55.0                                 |
| Average                        | 103.9             | 77.0                                      | 35.0                                      | 47.6                                 |

In column number followed by the same letter did not differ according to the DNMRT test at the level of \(\alpha\) 0.01

The percentage of productive tillers for the six technology packages is not different \[Table 1\], this is because plants that produce a large number of tillers are also balanced by an increase in the number of productive tillers, and vice versa, in plants that produce a small number of tillers, will result in less the number of productive tillers so that the percentage will be balanced with plants that produce more tillers. Overall the percentage of tillers decreased with the increase in the number of tillers but the number of panicles produced increased \[Table 1\]. This percentage decrease indicates that there has been competition between tillers in the clump for water, nutrients, space, and sunlight \[15; 16\].

3.2. Length of panicle, number of panicle branches, and number of grain panicle\(^{-1}\)

The technological packages resulted in differences in panicle length and the number of panicle branches produced, but not for the number of grains panicle\(^{-1}\) \[Table 2\]. Panicle production was longer for the S2, S3, S4, and S5 packages compared to S1 and S6 packages, but the shortest panicle length was obtained on the S6 package. In the panicle branches, the more number was obtained in the S1, S2, S4, and S5, and followed by the S3 package, while the least number was obtained in the S6 package. This is because the soil conditions are aerobic in packages S1 to S5, while in the S6 package are anaerobic. In aerobic conditions, the roots develop well, so that they can absorb water and nutrients better to support plant growth which more vigorous plants and longer panicles, while in anaerobic conditions the root system is less developed \[1; 2; 3; 13\]. Meanwhile, the number of grains panicle\(^{-1}\) was not influenced by the cultivation technological package tried \[Table 2\].
Table 2. Comparison of panicle length, number of panicle branch, and number of grains of several paddy rice cultivation technological packages.

| Technological Packages       | Panicle Length [cm] | Number of Panicle Branch [branch panicle⁻¹] | Number of Grains [grain panicle⁻¹] |
|------------------------------|---------------------|---------------------------------------------|-----------------------------------|
| SRI Standard [S1]            | 22.2b               | 11.4a                                       | 145.1                             |
| Modification of SRI 5 seedlings clump⁻¹ STSS [S2] | 23.6a               | 11.2a                                       | 147.2                             |
| Legowo System 4:1 [S3]       | 23.6a               | 10.7b                                       | 145.2                             |
| Main Square System [SBSU] [S4] | 23.7a               | 11.6a                                       | 149.0                             |
| Method of 5 seedlings clump⁻¹ STSS mulch PHP and Furrow Irrigation [S5] | 23.2a               | 11.8a                                       | 163.9                             |
| Conventional System [S6]     | 21.7c               | 9.9c                                        | 143.8                             |
| Average                      | 23.0                | 11.1                                        | 149.0                             |

Column number followed by the same letter did not differ according to the DNMRT test at the level of α 0.01

3.3. Weight of 1000 grain, the weight of yield grain, grain production, harvest index

The technological package affects grain yield clump⁻¹ and grain production but does not affect the weight of 1000 grain and harvest index [HI]. The highest grain yield weight was obtained in the group of SRI methods such as sequentially S5, S4, S2, S1, and S3, and lowest by S6 packages [Table 3]. The success of SRI is based on synergistic relations between tiller development and roots, with more vigorous root growth, plants can become fuller and taller and can have better access to the nutrients and water they need to produce more tillers and more yields [1;3]. The basic strategy of the SRI method is to create soil, water, and nutrient conditions for young plants that are more suitable for their growth [11], there is an accelerated development of tillers and grains replenishment, which is driven by the use of young seedlings and land conditions are not inundated which results in a strong root system, forming a canopy architecture which will allow greater interception of sunlight so that photosynthesis will be more active and maximum grain filling [3]. The SRI method increasing leaf area distribution, light distribution, plant dry weight, and biomass accumulation [12].

Table 3. The comparison of the weight of 1000 grain, grain yield weight of clump⁻¹, grain production ha⁻¹, and HI of several rice cultivation technological packages.

| Technological Packages       | Weight of 1000 Grain [g DMG] | Grain Yield Weight [g DMG clump⁻¹] | Grain Production [t DMG ha⁻¹] | Harvest Index |
|------------------------------|-------------------------------|----------------------------------|------------------------------|---------------|
| SRI Standard [S1]            | 20.668                        | 72.709b                          | 5.772b                       | 0.47          |
| Modification of SRI 5 seedlings clump⁻¹ STSS [S2] | 19.319                        | 77.109b                          | 6.225b                       | 0.49          |
| Legowo System 4:1 [S3]       | 20.449                        | 65.736bc                         | 5.529b                       | 0.47          |
| Main Square System [SBSU][S4] | 20.668                        | 79.640ab                         | 5.746b                       | 0.48          |
| Method of 5 seedlings clump⁻¹ STSS mulch PHP and Furrow Irrigation [S5] | 20.836                        | 88.152a                          | 7.250a                       | 0.45          |
| Conventional System [S6]     | 21.068                        | 59.981c                          | 4.449c                       | 0.46          |
| Average                      | 20.501                        | 73.888                           | 5.828                        | 0.47          |

In column number followed by the same letter did not differ according to the DNMRT test at the level of α 0.01; DMG = dry milled grain

Furthermore, the HI values of all experimental results are in the range 0.45 - 0.49 and rounded off to 0.5. The HI value for rice 0.17 – 0.56 [17]. The high HI value obtained in this experiment indicates that
the plant growth has reached the optimum. The HI value is a parameter that is directly related to the grain yield clump\(^1\) because the HI value represents the ratio of the dry or assimilate material accumulated into the grain with the assimilate accumulated to the vegetative part. HI is closely associated with WUE and grain yield in cereals [17]. If the value is high, it means that many parts of the assimilate are accumulated to the seeds or grain so that the grain yield increases.

4. Conclusion

In general, the S5 technological package resulted more in the component of growth and yield, grain yield weight, and highest grain production compared to all technological packages tested. The grain production of S5 was 7,250 t DMG ha\(^{-1}\) and was followed by S2, S1, S4, S3, and S6 technological package, respectively with 6,225 t, 5,772 t, 5,746 t, 5,529 t, and 4,449 t DMG ha\(^{-1}\). The method of 5 seedlings clump\(^1\) STSS with PHP mulch and furrow irrigation [S5] can be used as a paddy rice cultivation technological package that high grain production, efficient use of water, and free from weeds.

Acknowledgments

We wish to thank DRPM-Brin for funding this research by Research Contract Number: 014/LL.10/AMD/PG-JL/2020, May 27, 2020. Thank you also to Mr. Reski Ardiansyah as chairman of the Kelompok Tani Saiyo. as partners in this research, and to Sudirman and Rumambi who have helped researchers in the field.

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