Test packages technology of soybean cultivation in acid dry land on yield and farming income

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Abstract. This study aims to obtain a package of soybean cultivation technology that provides the highest seed yield and profits on the acid dry land of West Sumatra. Implemented in Pulau Punjing District, Dharmasraya Regency, West Sumatra Province, Indonesia, from June to December 2018. Arranged in the form of OFAR (Onfarm Research), involving cooperative farmers who are members of farmer groups. Using Randomized Block Design (RBD), with six treatments and three replications. The treatments are: (1) Farmer Technology Package with Burangrang variety; (2) Recommended Technology Package with Burangrang variety; (3) Specific location Technology Package with Demas-1 variety; (4) Specific Location Technology Package with Burangrang variety; (5) Specific Location Technology Package with Anjasmorvariety; and (6) Specific Location Technology Package with Argomulyo variety. The treatment using a specific location technology package with the Demas-1 variety provided the highest seed yield (2.20 t/ha) followed by the recommended technology package with Burangrang variety (2.04 t/ha). Revenues from each treatment amounted to Rp.9,610,000/ha and Rp.9,120,000/ha. Both of these technology packages are financially feasible, with a ratio of R/C > 1 and MBCR > 2.

1. Introduction
Soybeans become a food commodity that needs to be accelerated in an effort to increase production, because until now national production is only able to meet 35-40% of domestic demand. In recent years, domestic soybean production has only reached 600-700 thousand tons per year, while demand has more than 2.2 million tons. So, the government must always import soybeans throughout the year [5].

At present, the government has targeted self-sufficiency in soybeans in 2020. In the period of 2016-2019, the direction of developing soybeans is aimed at controlling imports and accelerating self-sufficiency, while for 2020-2024 it is directed at production stability and quality improvement. Based on the projected population growth and average consumption per capita per year, Indonesia's soybean needs in 2020 reached 2.6 million tons [3]. If the productivity of soybeans is still below 1.3 t/ha, it will require a planting area of 2.1 million ha to meet soybean needs in 2020. However, if productivity can be increased to 1.5 t/ha and 2.0 t/ha, the planting area needed is 1.8 million ha and 1.3 million ha respectively.

One effort is being made to achieve soybean self-sufficiency targets through increasing soybean productivity with intensification of crops. The problem is that most of the total land area available in Indonesia for agricultural areas (190,946,500 hectares) is classified as Ultisols (47,526,000 hectares or...
24.89%), Histosols (24,158,000 hectares or 12.65%), Oxisols (18,382,000 hectares or 9.63%), and complexes (mostly Ultisols 56,426,000 hectares or 29.55%). These soils generally react sour with high Al status, cation exchange capacity and low elemental content. Meanwhile, in the West Sumatra Province the potential land for soybean plantations was 1,299,718 ha, consisting of: 861,220 ha with high potential, medium potential 78,011 ha, and 360,487 ha with low potential [8]. This low potential land generally reacts sourly so that cultivation techniques are needed by combining adaptive varieties technology on acid dry land with liming/amelioration of land. Acid soil amelioration techniques can be done by: (1) Liming to increase pH and overcome Al poisoning; (2) Amelioration in sub-soil using gypsum; (3) Soil phosphate enrichment with high-dose P fertilization; (4) enrichment of organic matter; (5) Potassium enrichment; and (6) Micro nutrient enrichment [15].

IAARD (Indonesian Agency for Agricultural Research and Development), in addition to recommending a package of soybean cultivation technology for acid dry land in Indonesia has also recommended adaptive varieties in acid soils (Demas-1). In addition, Anjasmoro and Agromulyo varieties have been developed which show good performance on acid dry land although they are not released as adaptive varieties on acid soils. Meanwhile, Assessment Institute for Agricultural Technology (AIAT) West Sumatra has also recommended specific location technology packages on acid dry land [2; 9]. However, these recommended packages need to be examined in a specific area. This study aims to obtain a package of soybean cultivation technology that provides the highest seed yield and profits on the acid dry land of West Sumatra.

2. Materials and Methods
Experiments were carried out on acid dry land in the Harapan Farmers Group, Nagari Sikabau, Pulau Punjung District, Dharmasraya Regency, West Sumatra Province, Indonesia, from June to December 2018. Soil nutrient content at the study sites was: pH H$_2$O (4.76), pH KCl (3.83), organic C (0.67%; very low), N (0.19%; low), C/N (3.25; very low), P$_2$O$_5$ Bray I (0.77 ppm; very low), K-dd (0.09 Cmol/kg; very low), and Al-dd (3.08 Cmol/kg).

Experiments arranged in the form of OFAR (Onfarm Research), involving cooperative farmers who are members of farmer groups. Using Randomized Block Design (RBD). The treatment consists of five types, with three replications. To determine the feasibility of the technology being tested, it will be compared with existing technology (farmers' technology) so that the number of treatments becomes six, as follows: (1) Farmer Technology Package with Burangrang variety; (2) Recommended Technology Package with Burangrang variety; (3) Specific Location Technology Package with Demas-1 variety; (4) Specific Location Technology Package with Burangrang variety; (5) Specific Location Technology Package with Anjasmoro variety; and (6) Specific Location Technology Package with Argomulyo variety.

The technological components for farmer technology package is: (1) perfect tillage (1-2 land piracy) and rake; (2) planting hole system, spacing (20x35 cm), 2 seeds/hole; (3) 750 kg of lime/ha is given spread, without cow manure; (4) fertilizer as much as 125-125-125 kg Urea-SP36-KCl/ha, given spread at the time of planting; (5) without seed treatment with rhizobium; (6) weed control 2 times; (7) drainage channels are made irregular, irrigation depends on the rain; and (8) pest control without Carbofuran 3% at planting time, spray 1x2 to 1x4 weeks. The technological components for Specific Location Technology package is: (1) perfect tillage (1-2 land piracy) and rake; (2) planting hole system, spacing (40x10 cm), 2 seeds/hole; (3) 500 kg of lime/ha is given an array in the row of plants, cow manure as much as 2.5 t/ha as a cover for planting holes; (4) fertilizer as much as 25-150-100 kg Urea-SP36-KCl/ha, given during planting in the rows of plants; (5) on land that has never been planted with soybeans, the seeds are mixed with Ultra Rhizo (rhizobium), the dosage as recommended; (6) weed control when plants are 15 and 45 days after planting (DAP) or depending on weed growth, manually or using herbicides as recommended; (7) drainage channels are made every 2-5 meters in width and depth of 20-30 cm; and (8) pest control using Carbofuran 3% at planting time, then sprayed based on the principle of IPM. The technological components for Recommended Technology package is: (1) land piracy is carried out 1-2 times (depending on soil condition); (2) planting hole system,
spacing (40x15 cm), 2 seeds/hole; (3) liming ½ times Al-dd (1.5 t/ha) is given spread, without cow manure; (4) fertilizer as much as 75-100-100 kg Urea-SP36-KCl/ha, given spread at the time of planting; (5) on land that has never been planted with soybeans, the seeds are mixed with Agrisoy (rhizobium), the dosage as recommended; (6) weed control when plants are 15 and 45 DAP or depending on weed growth, manually or using herbicides as recommended; (7) drainage channels are made every 4 meters with a width of 30 cm and a depth of 20-25 cm; and (8) pest control using Carbofuran 3% at planting time, then sprayed based on the principle of IPM.

The variables observed were: growth component (plant height, number of main branches), yield components (weight of 100 seeds, number of seeds per pod, number of pods per stem, number of seeds per stem, percentage of empty pods), and yield. Furthermore, the data were analyzed by variance and Duncan's New Multiple Range Test (DNMRT) [10] and correlation analysis [14]. Another observation is farming input/output to determine business feasibility through Revenue Cost Ratio and MBCR (Margin Benefit Cost Ratio).

3. Result and Discussion

3.1. Component of Growth

In Table 1, it can be seen that technological package treatment has a significant effect on plant height and the number of main branches. The highest crop was obtained in the recommended technology package with the Burangrang variety (63.0 cm). It turned out that only this package treatment had plant height according to the description of the Burangrang variety (60-70 cm) [6]. Furthermore, the highest number of main branches was obtained from the specific location technology package treatment with Demas-1 variety (4.3 branches/stem). Apparently, all technological package treatments have a number of main branches according to even exceeding the description of the variety. In the description of varieties, the number of main branches of Demas-1 variety is 4-6 branches/stems and Burangrang varieties are 1-2 branches/stems [6].

Table 1. Plant height and number of main branches in the treatment of various packages of soybean cultivation technology on acid dry land. Dharmasraya, West Sumatra, 2018.

| Treatment of Technology Packages | Plant Height (cm) | Number of Main Branches (branch/stem) |
|---------------------------------|------------------|--------------------------------------|
| Farmers with Burangrang variety | 48.5 ab           | 3.5 ab                                |
| Recommendations with Burangrang variety | 63.0 a          | 3.8 ab                                |
| Specific location with Demas-1 variety | 45.8 b         | 4.3 a                                 |
| Specific location with Burangrang variety | 44.5 b         | 2.8 b                                 |
| Specific location with Anjasmoro variety | 45.7 b        | 2.8 b                                 |
| Specific location with Argomulyo variety | 49.7 ab       | 1.3 c                                 |
| CV (%)                          | 15.42            | 23.78                                 |

The numbers in each column followed by lowercase letters that are equally different are not significant at the level of 5% DNMRT.

3.2. Yield Components

In Table 2, it can be seen that the technology package treatment significantly affected the number of pods, number of seeds per stem, and weight of 100 seeds, but not significantly different from the number of seeds per pod, number of pods and the highest number of seeds obtained in specific location technology treatment packages with varieties Demas-1, each with 110.8 pods/stem and 199.5 seeds/stem. In the specific location technology package treatment with Argomulyo variety, the heaviest 100 seeds were obtained (17.31 g). Then, the location-specific technology package treatment with the Demas-1 variety gave the highest number of empty pods (4.00 pods/stem) compared to other treatments. Apparently, the number of empty pods was significantly positive with the number of pods.
per stem \( (r = 0.99) \). In conclusion, the more number of pods per stem, the number of empty pods per stem is also increasing.

When compared with the description of the variety, it turns out that all technological package treatments that use the Burangrang variety, the weight of 100 seeds under the description of the variety. Meanwhile, the treatment of other technology packages, the weight of 100 seeds of the varieties is the same as the description of the variety. In the description of varieties, the weight of 100 seeds of the varieties of Burangrang, Demas-1, Anjasmoro, and Argomulyo were 17 g, 13 g, 14.8-15.3 g, and 16 g [6], respectively. The difference in weight of 100 seeds in addition to the genetic characteristics of each variety is also closely related to the number of main branches, number of pods per stem, and number of seeds per stem. Apparently, the number of main branches and number of pods per stem were significantly negatively correlated with a weight of 100 seeds, with the correlation coefficient \( (r) \) values of -0.91 and -0.92 respectively. While the number of seeds per stem was negatively correlated with a weight of 100 seeds \( (r = -0.77) \). That is, the more number of main branches or number of pods per stem, the weight of 100 seeds decreases. Meanwhile, the more number of seeds per stem, the weight of 100 seeds tends to decrease.

**Table 2.** Number of pods, number of seeds per stem, number of seeds per pod, and weight of 100 seeds in the treatment of various packages of soybean cultivation technology on acid dry land. Dharmasraya, West Sumatra, 2018.

| Treatment of Technology Packages | Number of Pods (pod/stem) | Number of Seeds per Stem (seed/stem) | Number of Seeds per Pod (seed/pod) | Number of Empty Pods (pod/stem) | Weight 100 Seeds (g) |
|----------------------------------|---------------------------|-------------------------------------|-----------------------------------|-------------------------------|---------------------|
| Farmers with Burangrang variety  | 40.5 bc                    | 79.5 b                               | 1.99 a                            | 0.67 bc                       | 15.81 ab            |
| Recommendations with Burangrang variety | 57.8 b                    | 122.2 b                              | 2.11 a                            | 1.83 b                        | 14.99 ab            |
| Specific location with Demas-1 variety | 110.8 a                   | 199.5 a                              | 1.75 a                            | 4.00 a                        | 13.72 b             |
| Specific location with Burangrang variety | 27.8 c                    | 54.5 b                               | 1.96 a                            | 0.33 c                        | 16.23 ab            |
| Specific location with Anjasmoro variety | 32.3 c                    | 61.8 b                               | 1.92 a                            | 0.67 bc                       | 16.82 a             |
| Specific location with Argomulyo variety | 30.2 c                    | 65.7 b                               | 2.14 a                            | 0.17 c                        | 17.31 a             |
| CV (%)                           | 21.71                     | 35.64                                | 15.65                             | 53.30                         | 9.77                |

The numbers in each column followed by lowercase letters that are equally different are not significant at the level of 5% DNMRT.

3.3. Yield and Increased Yield
In Table 3, it can be seen that the treatment of technological packages has a significant effect on yields. The highest yield and increased yield were found in specific location technology package treatment with Demas-1 variety, each of which was 2.20 t/ha and 89.66%. The technology package treatment was followed with Burangrang variety, each of which was 2.04 t/ha and 75.86%.
Table 3. Yield and increased yield in the treatment of various soybean cultivation technology packages on acid dry land. Dharmasraya, West Sumatra, 2018.

| Treatment of Technology Packages         | Yield (t/ha) | Increased Yield (%) |
|-----------------------------------------|--------------|--------------------|
| Farmers with Burangrang variety         | 1.16 b       | -                  |
| Recommendations with Burangrang variety | 2.04 a       | 75.86              |
| Specific location with Demas-1 variety  | 2.20 a       | 89.66              |
| Specific location with Burangrang variety| 1.80 ab      | 55.17              |
| Specific location with Anjasmoro variety| 1.18 b       | 1.72               |
| Specific location with Argomulyo variety| 1.87 ab      | 61.21              |

**CV (%)** 22.88

The numbers in each column followed by lowercase letters that are equally different are not significant at the level of 5% DNMRT.

When compared with the description of the variety, it turns out that the technology package treatment of farmers with Burangrang variety and specific location technology packages with Anjasmoro variety has yields below the description of the variety. While other technological package treatments have yields that match the description of the variety. In the description of varieties, the yield potential of the varieties of Burangrang, Demas-1, Anjasmoro, and Argomulyo are 1.6-2.5 t/ha, 1.7 t/ha, 2.03-2.25 t/ha, and 1.5-2.0 t/ha [6].

The increased yield, besides being caused by the effect of treatment, is also closely related to the yield component, in this case the number of pods per stem and the number of seeds per stem. Thus, the number of pods per stem and the number of seeds per stem are positively correlated with the seed yields, with the correlation coefficient (r) 0.60 and 0.80, respectively. That is, the more the number of pods per stem or the number of seeds per stem the higher the yield of the seeds.

In general, it can be seen that the selection of tolerant varieties alone cannot increase seed yield. Demas-1 variety is an adaptive variety on acid dry land. Whereas the Burangrang variety, although released not as an adaptive variety on acid dry land, shows good performance on acid dry land [6]. Other studies also found that the use of soybean varieties tolerant to acid land (Tanggamus and Sibayak) alone did not contribute significantly to the increase in soybean yield [17]. The best way is to combine varieties with other technological components, such as: spacing, liming, manure and chemical fertilizers.

Furthermore, the spacing is related to the plant population and has an effect on seed yield [11; 13]. Recommended plant population ranges from 350,000-500,000 plants/ha (175,000-250,000 hills/ha) [4]. Meanwhile, giving lime (dolomite) can reduce the content of Al-dd in the soil so that soybean seed yields get better [18; 17]. It is recommended to give lime as much as 1.5 t/ha scattered or 500 kg/ha in the row of plants [7] or on land that has pH 4.9 and Al saturation of 19%, it is necessary to add lime (dolomite) ½ Al-dd, but if accompanied with 2.5 t/ha of cow manure, dolomite is given ¼ Al-dd [17]. Giving organic fertilizer (cow manure) is also needed in order to meet the nutrient needs of plants for soybean production [12]. Fertilization packages have a significant effect on soybean growth and yield [1]. Addition of lime (dolomite), fertilizer P and K increase nutrient uptake of P, K, Ca and Mg in soybean plants at flowering, while increasing yield [16].

Based on the above, it can be concluded that the low yield in the technology package treatment of farmers with Burangrang variety is suspected because of the loose spacing so that the plant population is small (<150,000 hills/ha), low lime dosage and improper giving technique (spread), not given manure, and chemical fertilization that is not in accordance with the recommendations. In addition, the low yield in the specific location technology package treatment with the Anjasmoro variety was caused by the variety being released not as an adaptive variety on acid land, such as the Demas-1 variety [6].

The main insect pest attacks found in this study were: bean seed flies (*Ophiomya phaseoli* Tryon), bean stem flies (*Melanagromyza sojae* Zehntner), leaf destroyers (*Spodoptera litura* Fabricius,
Chrysodexis chalsites Esper, Lamprosema indicata Fabricius), pod borer (Etiella spp), and pod sucker (Riptortus linearis Fabricius, Nezara viridula Linnaeus, Piezodorus rubrofasciatus Fabricius). While the main disease is leaf rust (Phakopsora pachyrhizi). However, the level of damage to soybean plants due to pests and diseases is quite low due to intensive control in accordance with the concept of IPM in the treatment of recommendation packages and site-specific packages, as well as periodic control in the treatment of farmer packages.

3.4. Farming Analysis
In Table 4, it can be seen that the location-specific technology package treatment with the Demas-1 variety provides the highest income (IDR 9,610,000.00) and the R/C ratio and MBCR values of 2.20 and 3.21 respectively. The recommended technology package treatment was followed by Burangrang variety in the amount of IDR 9,120,000.00 and the R/C ratio and MBCR respectively 2.27 and 4.93. That is, for every additional investment of IDR 1.00 in the both treatment of this technology package, additional revenues of IDR 3.21 and IDR 4.93 were obtained. Financially, the two technology packages are also worth the effort because of the ratio R/C> 1 and MBCR> 2.

Table 4. Economic analysis of farming on acid dry land in various soybean cultivation technology packages. Dharmasraya, West Sumatra, 2018.

| Treatment of Technology Packages | Cost (IDR 000) | R/C Ratio | MBCR |
|----------------------------------|----------------|-----------|------|
| Farmers with Burangrang variety  | 3,062.5        | 1.54      | -    |
| Recommendations with Burangrang variety | 3,750.0     | 2.27      | 4.93 |
| Specific location with Demas-1 variety | 4,440.0      | 2.20      | 3.21 |
| Specific location with Burangrang variety | 4,440.0     | 1.80      | 1.59 |
| Specific location with Anjasmoro variety | 4,440.0     | 1.18      | -0.92 |
| Specific location with Argomulyo variety | 4,440.0     | 1.87      | 1.87 |

Note: The selling price of soybean seeds = IDR 8,000/kg.

4. Conclusion
The treatment of several cultivation technology packages significantly affected all variables observed, namely: plant height, number of primary branches, weight of 100 seeds, number of seeds per pod, number of pods per stem, number of seeds per stem, percentage of empty pods, and yield.

On acid dry land, the specific location technology package treatment with Demas-1 variety obtained the highest yield, increase in yield and income, respectively at 2.20 t/ha; 89.66%; and IDR 9,610,000/ha. Followed by recommendation technology package with Burangrang variety treatment, each of which was 2.04 t/ha; 75.86%; and IDR 9,120,000.00/ha. Financially, the specific location technology package with the Demas-1 variety and the recommended technology package with Burangrang variety is feasible to be cultivated on acid dry land, because of the ratio R/C> 1 and MBCR> 2.

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