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The feasibility of large-seeded soybean cultivation

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Abstract. National soybean production needs to be increased for meeting domestic soybean demand and suppress soybean import, through improving cultivation techniques including using improved varieties. Study aims to evaluate the feasibility of improved large-seeded soybean cultivation. The study was carried out in 2021 in Tegaldlimo Sub-district, Banyuwangi Regency, East Java, Indonesia. Data were collected through survey and field observation on the application of existing and recommended technologies. The results showed that 5 new improved large-seeded soybean varieties introduced, namely Dega 1, Devon 1, Denasa 1, Denasa 2, and Detap 1 resulted in higher production than local Martoloyo. The recommended technology was more profitable than the existing as indicated by B/C ratio >1. The introduction of new varieties that are different from Martoloyo attracted 100% of farmers to adopt. In terms of crop and seed physical appearances, farmers prefer to Devon 1 due to its similarity appearance to Martoloyo, except the seed size. In term of economic feasibility, Devon 1 is profitable to be cultivated with B/C ratio of 1.5.

1 Introduction

Soybean is the third most important food crop after rice and corn. Soybean is safe for consumption, inexpensive, and has high nutritional value as a source of protein and several essential elements for human [1]. The demand of soybean in 2018 was 2.5 million tons, while soybean production in Indonesia was only 982,598 tons or 43 percent of the demand, and even only around 800,000 tons according to [2]. The Ministry of Agriculture noted that to meet domestic soybean demand, Indonesia imports an average of about 2.49 million tons per year [3]. The domestic soybean production needs to be continuously increased for reducing soybean import, both through intensification [4] and extensification on dry land, paddy field, and tidal land [5].

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Banyuwangi Regency is one of soybean production center in East Java Province. In the 2016 to 2020 period, the harvested area and soybean production in Banyuwangi Regency showed a downward trend except for 2017. In 2017, the soybean harvested area in Banyuwangi Regency reached 25,414 ha or 19.0% of the total harvested area of East Java with a production of 45,737 tons or 22.8% of the total production of East Java [6]. However, in the following years the harvested area and soybean production in Banyuwangi Regency continued to decline until in 2020 the soybean harvested area was recorded to be only 5,135 ha or decreased to 79.8% from 2017, with a production of 10,347 tons or decreased to 76.3% from production in 2017 [7].

Production improvement through intensification can be done by improving cultivation techniques, including the application of appropriate planting time, cropping pattern setting, fertilization, crop protection from pests and diseases, and utilization of soybean improved varieties [8,9]. Selection of improved varieties is one of the important factors that must be considered in soybean farming due to for achieving high productivity is also dependent on the genetic potential of variety. Improved soybean varieties have advantages compared to local varieties, including superior growth characteristics and production level [10,11]. Therefore, to increase soybean productivity, one effort can be taken is the utilization of agricultural technology innovations in form of improved soybean varieties having wide agroecosystems adaptation [12].

The Indonesian Agency for Agricultural Research and Development (IAARD) noted that to increase national soybean production, the role of improved varieties cannot be separated. Improved varieties have a strategic role as a means of carrying new technologies' advantages, including: (1) high yield, (2) resistance to pests and diseases to support cropping system and integrated pest control, (3) early maturity age to increase cropping index, and (4) superior yield which meets the users' demands and needs [13,14] Therefore, in order to increase national soybean production, it is necessary to provide adequate seeds of improved soybean varieties, comprehensively design of soybean productivity improvement program, and focused on potential lands which can increase soybean productivity more than the average national production.

In providing qualified soybean seeds, the seed industry plays an important role. However national seed producers and local breeders have not contributed much. In contrast to rice and corn commodities, the business of soybean seeds is still lagging. Farmers mostly still use the seeds from the previous crop yields. The use of certified seeds is still less than 10% of the total soybean planted area. This is one of the causes of the low national soybean productivity [15]. From the description above the research was carried out with the aim to evaluate the feasibility of improved large-seeded soybean cultivation applying the recommended technology.

2 Methodology

2.1 Research Location

The research was conducted in Tegaldlimo Sub-district, Banyuwangi Regency, East Java Province, Indonesia in the 2021 planting season. The research location was determined intentionally using purposive sampling method. According to data from [7], two sub-districts still cultivating soybean are Purwoharjo and Tegaldlimo, with harvested areas of 3,884 ha and 3,180 ha, respectively, and production reached 8,351 tons and 5,826 tons in 2019 [6]. Total soybean harvested area in two sub-districts covers 71.5% of soybean harvested area in Banyuwangi Regency with production reaching 73.6% of soybean production of Banyuwangi Regency.

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Five large-seeded soybean varieties released by the Indonesian Agency for Agricultural Research and Development (IAARD), namely Dega 1, Detap, Denasa 1, Denasa 2, and Devon 1 were planted by applying the recommended soybean cultivation technology of Iletri (Table 1). The study involved 25 cooperative farmers from "Dewi Sri" farmer group in Purwoagung Village. As a comparison, local soybean variety commonly used by farmers, namely Martoloyo was also planted using existing soybean cultivation (Table 2).

Table 1. Some components of recommended soybean cultivation technology of Iletri**.**

Technology components	Description of recommended technology components
Land preparation	Without tillage, after planting rice; or minimal tillage, after planting soybean or corn
Seed preparation	Using seeds with growth viability of > 80% are used, required 50 kg seeds /ha
Soybean variety(s)	Using Iletri's improved large-seeded soybean varieties of Devon 1, Dega 1, Detap 1, Denasa 1 and Denasa 2
Planting method	Using traditional dibbler seed, 2 – 3 seeds/ planting hole
Plant spacing	30 x 15 cm
NPK fertilizer	75-250 kg/ha of NPK and 50-125 kg /ha of SP 36
ZPT (plant hormones)	Using dose of 400 g/ha at 20 days after planting (DAP); sprayed with Gandasil D at 30 DAP and Gandasil B at 40 DAP at the dose of 400 liter/ha
Pests and diseases control	Using inorganic pesticides
Harvesting	After 90% of pods have browned
Processing	Using a threshing machine; applying seed production requirements

Table 2. Some components of existing soybean cultivation in Purwoagung Village, Tegaldlimo Sub-district, Banyuwangi Regency, East Java.

Technology components	Description of technology components	
	on first dry season (MK1)	on second dry season (MK2)
Land preparation	Without tillage	Minimal tillage
Seed preparation	Using seeds with good growth viability, required 50 kg seeds /ha	
Soybean variety(s)	Local varieties of Cacik or Martoloyo	
Planting method	Spread out	Using traditional dibbler seed, 2 – 3 seeds/ planting hole
Plant spacing	Irregular	Regular; 30 x 20 cm
Seed treatment	Not applied	Reagen with a dose of 1.25 l/ha
Inorganic fertilizers	50 kg of SP (before planting); 50 kg of Urea (45 DAP, spread)	
ZPT (plant hormones)	ZPT 625 g/ha and Gandasil B 625g/ha	
Liquid organic fertilizer	Dose of 2.5 l/ha at 15 DAP	
Foliar fertilizer	Dose of 500 g/ha (3 times spray)	
Pests and diseases control	Using inorganic pesticides	
Harvesting	Harvested after the leaves fall and the pods dry	
Processing	Cut with sickle, spread on the land and sun-dried, threshed, sorted, packed in sacks, then sold in form of field dry seed; yield of 1.625 t/ha	

2.2 Data Collection

The primary data collection in this research used survey or interview using a list of structured questions on 25 respondents at the same time. The data collected included the general characteristics of respondents, inputs and outputs of soybean farming, cost structure, revenue, feasibility of improved large-seeded soybean, and farmers' preference.

2.3 Data Analysis

The data obtained were presented descriptively quantitative and qualitative. Analysis of farming included analysis of production costs, revenue, income, and the feasibility of soybean farming, while farmers' preference to the improved large-seeded soybean were simply analyzed using ranking analysis.

Analysis of total costs (TC) in soybean farming is done by adding up total fixed cost (TFC) and total variable costs (TVC) with the formula of [16]:

$$TC = TFC + TVC \tag{1}$$

Where:
TC = Total production costs (IDR)
TFC = Total fixed costs (IDR)
TVC = Total variable costs (IDR)

Total revenue (TR) is the amount of production multiplied by the selling price per unit of production, with the formula:

$$TR = Y \, x \, Hy \tag{2}$$

Where:
TR = Total revenue (IDR)
Y = Production quantity
Hy = Selling price per unit (IDR)

Income (I) comes from the total revenue (TR) minus the total costs (TC), using the formula:

$$I = TR \, x \, TC \tag{3}$$

Where:
I = Income (IDR)
TR = Total revenue (IDR)
TC = Total costs (IDR)

The feasibility of improved large-seeded soybean, is analyzed by using Benefit Cost Ratio (B/C ratio) which is calculated based on the formula of [17]:

$$B/C = \frac{Income\ (I)}{Total\ production\ cost\ (TC)} \tag{4}$$

Where:
If the B/C ratio > 0, means that improved large-seeded soybean farming is financially feasible to be developed,
If the B/C ratio = 0, means that improved large-seeded soybean farming is at the break-even point (BEP),
If the B/C ratio < 0, means that improved large-seeded soybean farming is not financially feasible to be developed

3 Results and Discussion

3.1 General Characteristics of Respondents

The age of farmer is the factor that is most closely related to the strength and ability of farmer in carrying out farming activities. The increasing of farmers' age also increases their experience in farming and increases their awareness of the benefits of technology. Most soybean farmers in Purwoagung Village, Tegaldlimo Sub-district are in the range of 41-60 years (46.67%). Based on the ages grouping by BPS-Statistics Indonesia, most respondents are in the group of productive age, i.e., 15-64 years.

The age of household head can be a measurement of experience in managing a household business to generate income and resources availability for the family [18]. Older household heads are assumed to be more experienced in making better production decision. The implication is that farmers with longer experience will be more able to adopt soybean production technology than farmers with less experience. However, another study from [19] shows that older farmers tend to be less responsive to changes in technological innovation.

Table 3. Characteristics of cooperative farmers in Purwoagung Village, Tegaldlimo Sub-district, Banyuwangi Regency, 2021.

General characteristics	**Percentage (%)**
Age: (years)	
< 30	13.33
31 – 40	30.00
41 – 60	46.67
≥ 61	10.00
Level of education:	
Undergraduate	3.33
High school	23.33
Junior High School	16.67
Elementary School	56.67
Soybean farming experience: (years)	
5 – 15	60.00
16 – 30	36.67
30 – 50	3.33
>50	0.00

Most of respondents' formal education is in elementary school (56.67%) (Table 3). The formal education of farmers will affect farmers' knowledge and thinking ability. The level of education will also affect farmers' perceptions on their farming business development. The higher the formal education, the higher the farmers' ability to accept, filter, and apply the innovations introduced to them. [20] asserted that formal education will affect farm productivity, information access, and technology absorption, which will also have an impact on participation and adoptability.

Most respondents are farmers with new and quite long experience in soybean farming (60.00%) (Table 3), reflected that farmers have already mastered soybean cultivation techniques. Farmers' experience in running farming can be used as a benchmark for the business development in the future. The longer people are involved in their work, the better and more perfect they are in carrying out their duties, so it is expected that the longer farming experience in soybean could show the success of farmers in soybean farming [21].

3.2 Cost Structure and Feasibility of Improved Large-Seeded Soybean Farming

3.2.1 Soybean Production

Five large-seeded soybean varieties with recommended cultivation resulted in higher production than the existing soybean cultivation (Table 4). These production yields in farmer level also tend to be higher than the average yields of research described in the description of improved soybean varieties [22]. Compared to the yields of other soybean varieties, Detap

1 was the highest with the yield of 3.34 t/ha due to this variety was more resistant to high rainfall in research location.

Table 4. Soybean production in Purwoagung Village, Tegaldlimo Sub-district, Banyuwangi Regency, 2021.

Soybean varieties	**Yields in farmer level (t/ha) (Moisture level of 11%)**	**Average yields of research (t/ha) (Moisture of 12%) [22]**
Dega 1	2.81	2.78
Devon 1	2.76	2.75
Denasa 1	2.12	2.25
Denasa 2	2.58	2.31
Detap 1	3.34	2.70
Average (t/ha)	2.72	
As comparison:		
Local Martoloyo (spread-out method)	1.2	
Local Martoloyo (traditional dibbler seed method)	2.2	

3.2.2 Soybean Production Costs

Labor costs took up the largest portion of soybean farming production costs. This is in accordance with the research of [23]. The highest labor costs were for the existing soybean cultivation using traditional dibbler seed method which was 61.58% of the total production cost, followed by the labor input costs for the recommended and existing soybean cultivation using spread-out method which respectively reach 58.06% and 51.95% of the total production costs (Table 5). The high labor costs for the three types of cultivation, particularly for harvest and post-harvest costs, which reached 32.90-52.89% of the total labor costs. The highest (52.89%) are for the existing cultivation using spread-out method, because at harvest time there are additional costs that must be incurred by farmers in the 'ngerit' (in Javanese) process, namely cutting manually with a sickle to separate crops from grass or wild plants.

The other high labor cost for recommended and existing soybean cultivation using traditional dibbler seed is the planting cost, which is 4.08-4.28 times higher than the existing cultivation using spread-out method (Table 5). By using traditional dibbler seed, more labor required for the planting process with a longer time allocation compared to the spread-out method. The weeding cost on the recommended soybean cultivation is also much higher than the existing cultivation, reaching 4.11 times because it was carried out regularly and more often than it was done in the existing cultivation. The cost of hay cutting at the beginning of planting in the existing cultivation using traditional dibbler seed method was high, reaching 2.5-4.0 times higher than the recommended cultivation and the existing spread-out cultivation method because farmers still carry out the process manually using a sickle.

Meanwhile, for production input costs, the largest expenditure was for the purchase of fertilizers which reached 37.71-45.38% of the total production input costs (Table 5). In recommended cultivation, production input costs for seeds are quite high compared to existing cultivation because it used certified improved soybean varieties of IAARD obtained from seed source management unit (UPBS) of Iletri; while, in existing cultivation, farmers are not accustomed to using certified seeds. Farmers are usually use local seeds of Cacik or Martoloyo obtained from their own plantings in the previous planting season or buying from other farmers or buying from kiosks in the traditional market.

Table 5. The structure of soybean production cost in Purwoagung Village, Tegaldlimo Sub-district, Banyuwangi Regency, 2021.

Description of production cost	Soybean cultivation technology		
	Recommended (IDR)	Existing Spread-out method (IDR)	Existing Traditional dibbler seed method (IDR)
Production input costs:			
Seeds	900,000*)	750,000**)	475,000***)
Fertilizers	1,607,858	1,374,500	1,374,500
Herbicides	824,857	625,000	625,000
Pesticides:	780,000	735,000	1,120,000
Water fee	40,000	40,000	40,000
Village tax	10,000	10,000	10,000
Total production input costs	4,162,715	3,534,500	3,644,500
Labor costs:			
Hay cutting Tillage	250,000 -	400,000 -	1,000,000 240,000
Planting	1,142,857	280,000	1,200,000
Fertilizing	571,429	360,000	360,000
Weeding	1,150,000	280,000	280,000
Pests and diseases controlling	550,000	480,000	840,000
Harvesting and post-harvesting	2,097,333	2,100,000	1,922,000
Total labor costs	5,761,619	3,900,000	5,842,500
Total production costs	9,924,334	7,434,500	9,486,500

Notes: *The IAARD's improved soybean varieties from seed source management unit (UPBS) of Iletri for class of Foundation Seed (FS) with the price of IDR 15,000/kg; **)Local soybean seeds which was bought from shop or kiosk in traditional market with the price of IDR 12,500/kg; ***)Local soybean seeds which was bought from other farmers from the previous planting season with the price of IDR 9,500/kg

3.3 Feasibility of Soybean Farming

The results of feasibility analysis of recommended (Table 6) and existing (Table 7) soybean cultivation technologies indicated that if farmers switched their cultivation technique from existing to the recommended, there would be an increase in production costs of 4.41-25.88%. However, this increase in production costs was followed by an increase in the profit of recommended cultivation, which was 8.86 times compared to the existing with spread-out method and 1.79 times compared to the existing with traditional dibbler seed method. Detap 1 gave the highest revenue and profit, i.e., IDR 30,060,000 and IDR 19,869,666/ha, respectively of the five varieties introduced.

In addition to high production, price is also a factor that affects farmers' income. At the time of study, the price of improved soybeans at famer level reached IDR 9,000/kg, while the price of local soybeans was in the range of IDR 7,500-8,000/kg. The improved soybeans produced by recommended cultivation were more attractive in terms of seed color and size (large seed) and are preferred by traders.

In terms of farming feasibility, the recommended cultivation showed a B/C ratio of more than 1 which indicated that soybean farming using the recommended technology components was more profitable and feasible than the existing technology which had a B/C ratio of less than 1 (Tables 6 and 7), except for Denasa 1 which showed the B/C ratio value equal to 1 or is at the break-even point. The results of this study are in accordance with the study of [24] which stated that to change the farming strategy carried out from conventional soybean farming to recommended one will increase farmers' income and give feasible profit.

Table 6. Feasibility of recommended soybean cultivation with large-seeded soybean varieties in Purwoagung Village, Tegaldlimo Sub-district, Banyuwangi Regency, 2021.

Description	Large-seeded soybean varieties					Average
	Dega 1	Devon 1	Denasa 1	Denasa 2	Detap 1	
Production input costs (IDR/ha)	4,162,715	4,162,715	4,162,715	4,162,715	4,162,715	4,162,715
Labor costs (IDR/ha)	5,800,952	5,784,286	5,520,952	5,674,286	6,027,619	5,761,619
Total production costs (IDR/ha)	9,963,667	9,947,001	9,683,667	9,837,001	10,190,334	9,924,334
Production (kg/ha)	2,810	2,760	2,120	2,580	3,340	2,722
Price (IDR/kg)	9,000	9,000	9,000	9,000	9,000	9,000
Revenue (IDR/ha)	25,290,000	24,840,000	19,080,000	23,220,000	30,060,000	24,498,000
Profit (IDR/ha)	15,326,333	14,892,999	9,396,333	13,382,999	19,869,666	14,573,666
B/C Ratio	1.5	1.5	1.0	1.4	1.9	1.5

Table 7. Feasibility of existing soybean cultivation in Purwoagung Village, Tegaldlimo Sub-district, Banyuwangi Regency, 2021.

Description	Existing cultivation with	
	Spread-out method on first dry season (MK1)	Traditional dibbler seed method on second dry season (MK2)
Production input costs (IDR/ha)	3,534,500	3,644,500
Labor costs (IDR/ha)	3,821,000	5,842,000
Total production costs (IDR/ha)	7,355,500	9,486,500
Production (kg/ha)	1,200	2,200
Price (IDR/kg)	7,500	8,000
Revenue (IDR/ha)	9,000,000	17,600,000
Profit (IDR/ha)	1,644,500	8,113,500
B/C Ratio	0.2	0.9

3.4 Farmers' Preference to the Improved Large-Seeded Soybean Farming

The farmers' preferences rank on the soybean crop agronomic appearance characteristics were Devon 1, Detap 1 and the existing variety, Denasa 1, followed by Dega 1 (Table 8). Farmers did not choose the Denasa 2 at all. According to farmers, Devon 1 was chosen because in terms of crop agronomic appearances, Devon 1 had the same appearances as the local variety they used to grow, except for the seed size. Farmers already have market for the local Martoloyo. Therefore, they expect will have no difficulties on soybean market and get better profit by using Devon 1. Dega 1 got a better preference rank than Denasa 2 which did not get any attention from farmers. But unfortunately, Dega 1 had not optimal growth characteristic because it could not tolerate an environment with high rainfall so that many cases of Dega 1 fail to grow in Purwoagung Village.

The results of preference rank on crop agronomic appearance were strengthened by the average percentage of farmers' preferences for each characteristic of crop agronomic appearance. In general, Devon 1 was preferred by farmers compared to other large-seeded varieties and local varieties commonly used by farmers (Table 8).

Table 8. Farmers' preferences on new large-seeded soybean varieties

Varieties	Respondents' preferences on the characteristics of						
Agronomic crop appearance	Plant height (%)	No of productive branches (%)	No of pods (%)	No of seeds (%)	Fall resistant (%)	General appearance (%)	Rank[1)]
Dega 1	0	0	0	0	0	0	2.83 (4)
Detap 1	28.6	28.6	21.4	21.4	30.8	36.4	1.67 (2)
Denasa 1	21.4	21.4	21.4	21.4	23.1	27.3	2.00 (3)
Denasa 2	0	0	0	0	0	0	0
Devon 1	50.0	42.9	50.0	50.0	462	36.4	1.60 (1)
Existing	0	7.7	7.1	6.7	0	0	1.67 (2)
Soybean seeds appearance	Color (%)	Size (%)	Shape (%)	Weight (%)	General appearance (%)		Rank[1)]
Dega 1	19.2	23.1	32.0	19.0	222		1.36 (1)
Detap 1	15.4	34.6	20.0	28.6	33.3		1.94 (3)
Denasa 1	3.8	7.7	8.0	9.5	22.2		2.44 (4)
Denasa 2	0	0	0	4.8	0		2.67 (5)
Devon 1	19.2	34.6	40.0	38.1	22.2		1.80 (2)
Existing	0	0	0	0	0		0

Note: [1)] Numbers in brackets indicate the order of preference ranking

In general, farmers' preferences on soybean seed appearances had the same result as farmers' preferences for crop agronomic appearances, where Devon 1 was the most preferred by respondents in terms of color, size, shape, and weight (Table 8). However, the preference rank results showed that although in terms of crop agronomic appearances, farmers were not interested in Dega 1, but when they saw the appearance of Dega 1 seeds, quite a lot of farmers were also interested in. The results of study were agreed to previous study of [12] which is stated that when selecting the preferred soybean genotypes, farmers consider important attributes included early maturity, disease tolerance, high yield, large seed size, and attractive seed coat colour.

4 Conclusion

The introduction of new large-seeded soybean varieties that are different from local soybean of Martoloyo attracted 100% of farmers to adopt. In terms of crop and seed physical appearances, farmers prefer to Devon 1 due to its similarity appearance to the local Martoloyo, except the seed size. In term of economic feasibility, Devon 1 is profitable to be cultivated with B/C ratio 1.5.

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