CULTURAL PRACTICES DIFFERENCES AND ITS IMPACT ON THE EFFICIENCY OF WETLAND SOYBEAN

The Case of Japanan Village, East Java

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Abstrak

Analisis tentang perilaku produksi sering diasumsikan bahwa teknik budidaya yang dilakukan petani relatif homogen. Namun demikian, banyak indikasi empirik menunjukkan bahwa petani melakukan teknik budidaya yang bervariasi walaupun mereka menerima rekomendasi yang sama. Tulisan ini bertujuan untuk menganalisa variasi teknik budidaya tersebut dan sampai sejauh mana dampaknya terhadap produksi dan pendapatan usahatani. Hasil penelitian menunjukkan bahwa dari 25 peubah teknik budidaya yang dianalisis, 10 peubah diantaranya secara signifikan bisa membedakan satu kelompok petani dari kelompok lainnya. Produktivitas hasil kedelai bukan hanya ditentukan oleh jumlah input tetapi juga metoda teknik budidaya dan waktu pelaksanaan kegiatan. Selanjutnya diperoleh petunjuk bahwa, kelompok petani yang memakai jumlah masukan lebih tinggi ternyata memperoleh pendapatan bersih lebih rendah karena biaya yang dikeluarkan lebih tinggi.

INTRODUCTION

One of the main constraints in increasing soybean production in Indonesia is that most farmers still apply traditional technology. The transfer of improved technology is considered relatively stagnant. Although explanation to this phenomenon is so complex, but one explanation is that the recomendation is too general to be applied in a specific environment. In the contrary, soybean is very sensitive to the variation on production environment. As a consequence, it is not surprising that soybean yield varies across location. In a given location, soybean yield also varies across farmers due to socio-economic constraints faced by farmers in adopting the new technology.

Based on the above mentioned problems, ESCAP-CGPRT Center has conducted on-farm research to adapt soybean technology to specific environmental conditions. The project was undertaken in Karawang (West Java), Wonogiri (Central Java), and Jombang (East Java), in 1988-1991. Recomended technology was basically a modification from the general recomendation issued by Dinas Pertanian considering specific environmental characteristics in the respective location.

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To implement its program, the project collaborates with 45-60 farmers who were willing to apply the improved technology under supervision of the local staff. A credit scheme was offered to finance the necessary expenses. In 1991, 30 farmers who did not apply the improved technology were also monitored for purposes of comparison.

Despite close supervision by the local staff, cooperator farmers showed variation on the cultural practices. Among non-cooperator farmers, these variation were even larger. Variation on these cultural practices, of course, lead to the variation on soybean yield.

The purpose of this paper is to assess the impact of cultural practices variation on yield, stability of yield, and profitability of soybean farming.

METHODOLOGY

Conceptual Framework

In the heart of production economics theory, production function approach has been widely used to tackle wide range of production issues. The function basically specifies functional relationship between output and the quantity of inputs. Some other relevant variables are usually included in an *ad-hoc* manner. These are some proxies of environmental factors such as irrigation or farmer characteristics such as tenure status or education.

The model specified above assumes that other things being equal or homogenous across farmers. In accordance with this assumption, it is also assumed that farmers apply a uniform technology. On the other hand, variation on cultural practices is frequently reported, despite the fact that farmers receive the same information regarding technology package.

There are many factors causing this variation. On one hand, farmer may adjust the recomended practice based on environmental constraints. For instance, a farmer cannot fully apply the recomended irrigation schedule if his field is situated in remote areas. On the other, socio-economic constraints such the availability of family labor or working capital induce some farmers to adjust technology package accordingly.

Variation on the cultural practices, provide additional explanation on the observed variation on yield across farms. In addition to the quantity of input use, further elaboration on the impact of cultural practices applied by farmer is a fruitfull exercise.

Principal Componen Analysis

Before assessing the impact of cultural practices variation on yield, the first question arises is that whether or not this variation exist and what set of variables contributing to this variation. If we can find a set of variables differentiating farmers, it is possible to group sample farmers having different characteristic one to another. The set of variables which differetiate different farmer groups may be selected on the basis of contribution of those variables to the overall variation on cultural practices.

One of the statistical procedure to deal with our problem is the principal component analysis. The main idea of the principal component analysis is discussed briefly in the succeeding paragraph and is synthesized primarily from Johnston (1972). A simplified description of this approach may also be found in Susilowati (1989).

Suppose we have an X variable matrix, with $n \times k$ dimension. The nature of principal component is to construct a linear combination of this matrix into a new set of variables (Z) which pairwise uncorrelated. The first new variable (Z_1) will have the highest maximum variance, the second will have the second largest variance, and so on. Thus,

$$Z_1 = Xa_1 \quad \ldots\ldots (1)$$

where Z_1 is an-element vector and a_1 is a k-element vector. The sum of squares of Z_1 is:

$$Z'_1Z_1 = a'_1X'Xa_1 \quad \ldots\ldots 2)$$

To find a_1, maximize Z'_1Z_1 subject to the constraint that $a'_1a_1 = 1$. This constraint is necessary to limit Z'_1Z_1 to be less than infinity. To solve the problem, we may define:

$$\theta = a'_1X'Xa_1 - \lambda 1\,(a'_1a_1 - 1) \quad \ldots\ldots (3)$$

where $_1$ is lagrange multiplier. At the maximum value of Z'_1Z_1:

$$\frac{\partial \theta}{\partial a_1} = 2\,X'Xa_1 - 2\,\lambda_1 a_1 = 0$$

$$\text{or } (X'X)a_1 = \lambda_1\, a_1 \quad \ldots\ldots (4)$$

Equation (4) indicates that a_1 is a latent vector of $X'X$ corresponding to the root

From equation (2) and (4) we see that:

$$Z'_1Z_1 = \lambda_1\, a'_1a_1 = \lambda_1$$

Since $X'X$ matrix is positive definite and thus have positive latent roots, then the first principal component of X is Z_1.

To determine the second principal component, define:

$$Z_2 = Xa_2 \quad (5)$$

To choose a_2, we have to maximize $Z'_2Z_2 = a'_2X'Xa_2$ subject to $a'_1a_1 = 1$ and $a'_1a_2 = 0$. The second constraint indicates that Z_2 is uncorrelated with Z_1. Next, define:

$$\theta = a'_2X'Xa_2 - \lambda_2(a'_2a_2 - 1) - \mu(a'_1a_2) \quad (6)$$

where $\lambda_2 =$ are lagrange multipliers.

At the maximum value of Z'_2Z_2 :

$$\frac{\partial\theta}{\partial a_2} = 2X'Xa_2 - 2\lambda_2a_2 - \mu a_1 = 0 \quad (7)$$

If we premultiply (7) by a_1', then :

$$2a_1'X'Xa_2 - 2\lambda_2a_1'a_2 - \mu a_1'a_1 = 0$$

or $$2a_1'X'Xa_2 - \mu = 0$$

However $(X'X)a_1 = \lambda_1a_1$ which implies that $a_2'(X'X)a_1 = \lambda_1a_2'a_1 = 0$ and thus $\mu = 0$. Finally $(X'X)a_2 = \lambda_2a_2$ and λ_2 is chosen as the second largest latent roat of X'X.

The same procedure can be continued to get on dathagonal matrix of $A = [a_1, a_2 \ldots\ldots ak]$ and the $n \times k$ principal component matrix $Z = XA$.

Total variation in X matrix :

is equal to :

$$\sum_{i=1}^{k} \lambda_i = Z'_1Z_1 + \ldots\ldots\ldots + Z'_kZ_k$$

and $\lambda_i/\Sigma\lambda_i$ represent proportionate contribution of the i^{th} component to the total variation of X.

For practical purposes, one may decide on the number of principal component to be retained for further analysis on the basis of their contribution to the total variation of X.

The Data

Informations presented in this paper is part of SYGAP project in Jombang, East Java. These data refer to first dry season 1991 (March to July), which were collected by interview method except for yield data which was measured directly in the farmer field. For this purpose, 30 farmers applying recomended techniques and 30 farmers applying traditional practices were chosen randomly. Data collection was conducted every two or three weeks.

Information collected refers to only one selected plot. If farmer grew soybean in more than one plot, then the largest size of the plots was chosen. The recorded data include type of inputs use, quantity of inputs and their prices, method of culture practices and timing of these practices.

Based on the availability of data, there are 25 technological variables divided into three categories: (1) quantity of input, (2) method of application, and (3) timing of application. To apply a principle component method, all variables must be measured in continuous scale. However some variables particularly method of application are recorded only in discrete scale. To transform those variables, we assume that method of application is in direct relation to the quantity of labor use. Thus, quantity of labor was used as a proxy to the different method of application. Description of those variables and their measurement are presented in Annex 1. Principal component analysis is applied by using PROC PRINCOMP in SAS program (SAS Institute, 1988).

Having grouped sample farmers by cultural practices variables, the succeeding analysis is to test whether each cultural practices variable differs across groups. For this purpose, the t-student test was applied. Finally, differences on yield and profitability across farm groups are also discussed.

COMPARISON OF CULTURAL PRACTICES BETWEEN COOPERATOR AND NON-COOPERATOR FARMER

Farmers in Jombang usually grow soybean in wetland during first dry season (after rice). In the second dry season some farmers also grow soybean or other "palawija" crops but rice is planted in limited areas since water is not adequate. The most popular soybean variety grown is "willis" due to its superior productivity and stronger demand in market compared to other varieties.

With regard to land preparation, farmers usually do only cleaning of rice straw. There are two methods of straw cleaning commonly practiced by farmers, i.e. complete cleaning and light cleaning. By the complete cleaning method, the straw is cut completely at the ground while by the light cleaning method, the straw is cut about 10 cm above the ground. Difference on this method lead to the difference on labor requirement. The complete cleaning method require more than 150 hours of labor per hectare, while the light cleaning require only a half of that.

The choice between those two cleaning method depend on moisture content in the field at planting time. If there is too much water in the field due to heavy rain, in appropriate drainage canal or compact soil structure, farmers usually do only light cleaning and do planting by broadcasting method. On the other hand, those farmers without water problem in their field, use complete cleaning and do planting with dibble method.

Those combination of straw cleaning and planting methods were commonly practiced by farmers because they believe that the combination will result in the optimal seed germination process. When there is too much water, they cannot use complete cleaning and dibble the soil to plant soybean because the seed will be rotten. In the contrary, if the field relatively dry farmers can not use light cleaning and apply dibble method of planting because it is difficult to dibble the soil in a field which is not clean. This phenomenon indicates that moisture content is a key variable for farmer in deciding which method of cleaning and planting to apply in growing soybean.

As presented in Annex 2, almost all cooperator farmers use complete cleaning and dibble method with rope. Light cleaning followed with broadcast method in planting is used by more than 60 percent of non-cooperator farmers. Threefore it is not surprising if cooperator farmers use more labor than non-cooperator farmers for those activities (Table 1). Dibble with rope in planting requires more labor compared to broadcast or dibble method without rope. The dibble with rope method require labor more than 2 hours per kg of seed, while the broadcast method require only less than one hour per kg of seed.

Table 1. Labor and other inputs requirements per agricultural operation by farmer group

Labor and inputs	Non-Cooperator	Cooperator
Labor (hours/ha)		
Cleaning field	74	160
Canal digging	118	166
Planting	62	94
Fertilizing	11	12
Weeding	180	296
Spraying	39	91
Irrigating	32	49
Total	516	968
Other inputs		
Seed (kg/ha)	51	44
Urea (kg/ha)	60	55
TSP (kg/ha)	43	51
KCl (kg/ha	13	47
Pesticide (lt/ha)	1.1	4.4
Liquid fertilizer (lt/ha)	0.6	0.4

In soybean farming, construction of drainage canal is very important because soybean is very sensitive to water lodging. In Annex 2, it can be seen that in term of canal spacing, cooperator farmers do not differ much from non-cooperator farmers. However, labor use for making canal is significantly higher for cooperator farmers (166 hours/ha) compared to non-cooperator farmers (118 hours/ha). The gap of labor use between those two groups of farmers is due to the fact that cooperator farmers make deeper canals than non-cooperator.

With respect to fertilizing, there are two types of granular fertilizer commonly used by farmer, i.e. Urea and TSP. Those fertilizer are used by both group of farmers in almost the same quantity, i.e. about 50 kg/ha. The KCl fertilizer is used only by limited number of non-cooperator farmer, while all cooperator farmers use this kind of fertilizer. In addition, farmers also use liquid fertilizer which is usually applied by spraying when they apply insecticides. Most farmers use broadcast method in applying fertilizer. This is true for both cooperator and non-cooperator farmer. The main reason for choosing this method is to save time and labor.

Insects infestation is one of major problem in soybean farming. To control the insects infestation, farmers usei many different types of insecticides. More than 20 insecticide types commonly used by farmers with sprying method. Mostly, more than three times of spraying application is applied during the crop season. In one application sometime they mix two or three types of insecticides. Farmers feel this practice will be more effective to control the insects in their field. The cooperator farmers use pesticide about four times (4.35 liter/ha) compared to non-cooperator farmers (1.13 liter/ha).

In term of irrigation, soybean requires at least three application during the crop cycle, i.e. on planting time, on the flowering stage and during the period of pods formation (Radjit, 1990). For Wilis variety, the three stages of soybean growth are about 15-20 days, 40-45 days and 60-65 days after planting respectively. As presented in Annex 3 , on the average, irrigation dates of cooperator farmers does not so much differ compared to non-cooperator farmers. Both of farmer groups irrigate their field about 23, 40, and 60 days after planting respectively. About 10% of farmer also applied the fourth application about 75 days after planting.

FARMER GROUPING BY MAJOR CULTURAL PRACTICES

The result of the Principle Component analysis is presented in Table 2. The table indicates that among the 25 variables of cultural practices, there are 10 selected variables which can be used for farmer grouping. Variation of the 25 variables across farmers can be explained by those 10 selected variables. The rest 15 variables may be assumed to be similar across farmers.

As presented in Table 2, combination of those 10 variables explains about 68% of total variation in cultural practices across farmers. The principle component (1) explains about 36 percent of variation on cultural practices while principle componen (2) and (3) contribute about 18 percent and 15 percent to total variation.

Table 2. Coefficient of the principle components and its correlation with the main variables

Cultural practice variables	Coefficient of principle component		
	(1)	(2)	(3)
Pesticide quantity (Q6)	0.4768	-0.0824	-0.0794
	(0.9010)	(-0.1091)	(-0.0963)
Methods of :			
– cleaning straw (M2)	0.3893	0.2210	0.1249
	(-0.7355)	(0.2926)	(0.1516)
– planting (M3)	0.4251	-0.1529	0.1795
	(0.8033)	(-0.2025)	(0.2178)
– fertilizing (M4)	-0.0534	-0.0727	0.6735
	(-0.1009)	(-0.0963)	(0.6171)
– weeding (M5)	0.0716	-0.0563	0.6473
	(0.1352)	(-0.0745)	(0.5785)
– spraying (M7)	0.4657	-0.0325	-0.2041
	(-0.8800)	(-0.0430)	(-0.2476)
Application dates of:			
– planting (D1)	0.1405	-0.5710	0.0668
	(0.2654)	(-0.7559)	(0.0810)
– first fertilizing (D2)	-0.4254	-0.0652	0.0657
	(-0.8038)	(-0.0864)	(0.0797)
– irrigation 2 (D10)	0.1101	0.5139	0.0897
	(0.2080)	(0.6803)	(0.1089)
– irrigation 3 (D11)	0.0522	0.5631	0.1214
	(0.0987)	(0.7455)	(0.1473)
Total of variance (%)	35.71	17.53	14.72
Cumulative of variance (%)	35.71	53.23	67.95

( ) indicates coeficient of correlation with the main variables.

As indicated by the Pearson Correlation Coefficients, the principle component (1) is strongly correlated with 5 variables, namely: quantity of pesticide (Q6), methods of cleaning field (M2), planting (M3), spraying (M7) and application date of first fertilization (D2). The principle component (2) is strongly correlated with variables date of planting (D1), date of first irrigation (D10) and second irrrigation (D11) while the principle component (3) is higly correlated with the variables of fertilizing method (M4) and weeding method (M5).

The results above indicate that the grouping of farmer could be done in three combinations of the principle component. The farmer grouping can be done based on the combination of principle component (1) and (2) or (1) and (3) or (2) and (3). Considering the combination of principle component (1) and (2) in aggregate can explain more variation (53%) of production technique compared to other

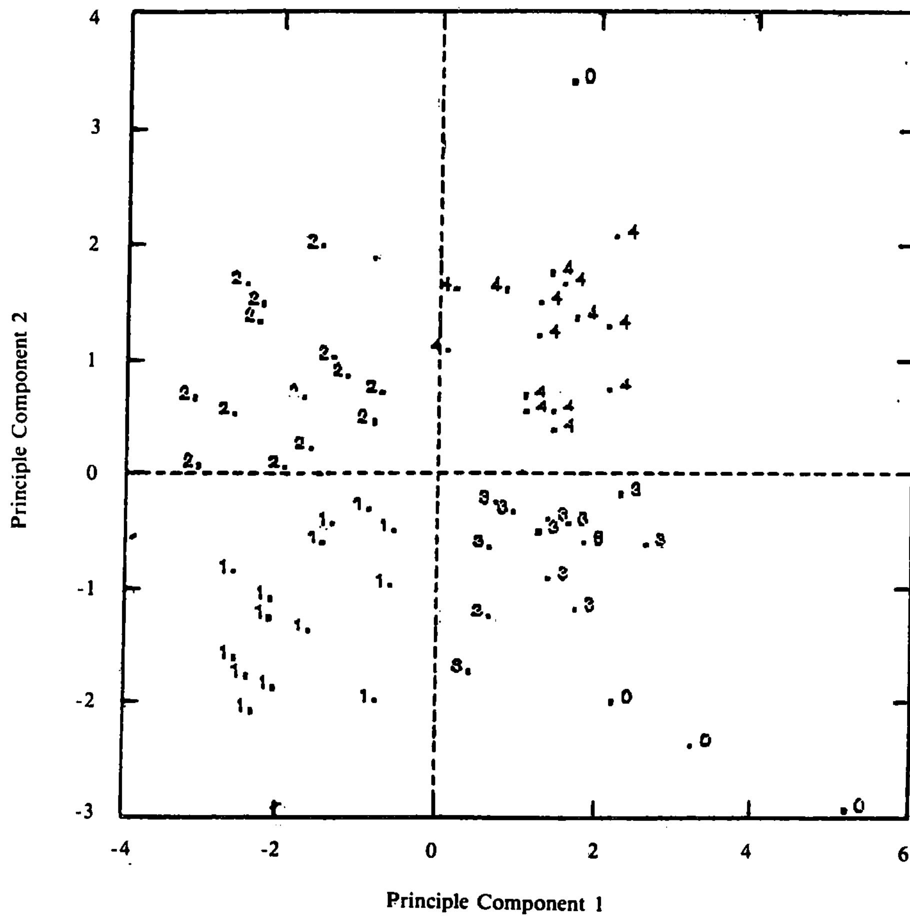

Figure 1. Distribution of farmers across principle component (1) and (2).

combinations, the farmers were grouped according to those of two principle components. Distribution of farmers according to those two principle components is presented in Figure 1.

In Figure 1, it can be seen that there are four big groups of farmer having relatively homogen values of principle component (1) and (2). The first group includes 14 farmers while group (2), (3) and (4) include 14, 13 and 15 farmers respectively. The rest of farmers (4 farmers) were distributed in the extreme value of principle component (1) or (2). In the following analysis those four farmers are excluded and the analysis was based only on the four big groups of farmer.

For purposes of identifying how far the differences of cultural practices among those four groups of farmer, the t-student test was applied. This procedure was applied to test the mean values of the 25 variables included in the analysis. The result indicates that there are 9 variables of cultural practices which are significantly different at the probability of 0.05 across farmer groups. The rest of variables (16 variables) are not significantly different across farmer groups. The mean values of those 9 variables are presented in Table 3.

Table 3. The average value of cultural practices variables by farmer group

Cultural practices	Farmer group			
	(1)	(2)	(3)	(4)
Quantity of inputs:				
– pesticide (lt/ha)	1.29	0.95	4.71	3.98
– KCl (kg/ha)	21.55	15.36	47.76	45.74
Methods of:				
– cleaning straw (hour/ha)	62.90	72.60	135.30	176.90
– planting (hour/kg of seed)	0.79	1.16	6.29	5.97
– spraying (lt/application)	0.42	0.32	1.04	0.96
Application dates of:				
– planting (*)	41.90	30.5	44.70	33.50
– first fertilizing (DAP)	17.30	19.9	0.40	1.00
– irrigation 2 (DAP)	36.30	42.7	32.00	46.50
– irrigation 3 (DAP)	52.40	63.5	54.90	65.90

(*) starting with 1 for the first date of March.

To identify major characteristics of cultural practices for each farmer groups, Table 4 sumarizes the result of t-student test. The result indicates that in the case of quantity of inputs and methods of culture practices there is no difference between group 1 and 2 and the same is true when comparing between group 3 and 4. Those two component of cultural practices can be distinguished if we compare group 1 or 2 to group 3 or 4. As presented in Table 3, group 3 or 4 has significantly greater value of pesticide quantity, KCl, labor for planting and straw cleaning and dosage of spraying compared to group 1 or 2.

The reverse is observed in comparing date of first fertilizing. Result of the analysis indicates that farmer group 3 or 4 apply fertilizer earlier compared to group 1 or 2. As presented in Table 3 farmers within group 3 or 4 apply fertilizer almost in the same time with the date of planting while farmers in group 1 or 2 put the first fertilizer more than 17 days after planting.

Table 4. Result of t-test for the average value of nine variables of cultural practices between farmer groups

Cultural practice variables	Comparison between groups					
	(1)vs(2)	(1)vs(3)	(1)vs(4)	(2)vs(3)	(2)vs(4)	(3)vs(4)
Quantity of inputs:						
- pesticide	—	(1) (3)	(1) (4)	(2) (3)	(2) (4)	—
- KCL	—	—	—	(2) (3)	(2) (4)	—
Mthods of:						
- cleaning straw	—	(1) (3)	(1) (4)	(2) (3)	(3) (4)	—
- planting	—	(1) (3)	(1) (4)	(2) (3)	(2) (4)	—
- spraying	—	(1) (3)	(1) (4)	(2) (3)	(2) (4)	—
Application dates of:						
- planting	(1) (2)	—	(1) (4)	(2) (3)	—	(3) (4)
- 1st fertilizing	—	(1) (3)	(1) (4)	(2) (3)	(2) (4)	—
- irrigation 2	(1) (2)	—	(1) (4)	(2) (3)	(2) (4)	(3) (4)
- irrigation 3	(1) (2)	—	(1) (4)	(2) 3)	—	(3) (4)

– not significantly different.
or significantly greater or lower at 0.05 leve.

Another configuration is revealed for dates of planting and irrigation application. In the case of planting date, farmer groups 2 and 4 plant their soybean earlier (about the end of March) compared to farmer groups 1 and 3 who plant their soybean about the second week of April. If we consider the rainfall data in the site, it can be said that farmer groups 2 and 4 showing more appropriate planting date than farmer groups 1 and 3. During the last week of March there are a lot of rainfall while during two weeks later there is no rainfall at all. For soybean, planting time is an important factor since it can determine the success of cropping. A delay in planting may reduce the yield because less water supply, degree of pest infestation and the incidence of plant diseases (Adisarwanto, 1991).

Irrigation is required at least three times namely during planting, at the flowering stage and at the stage of pods formation (Rajit, 1990). If we compare those three stage of water requirement with the irrigation date of each farmer group, it can be concluded that farmer groups 2 and 4 irrigate their fields in the right time while farmer groups 1 and 3 are too early. As presented in Table 3, farmer groups 2 and 4 irrigate their fields about 43-47 days after planting (DAP) and 64-66 DAP for the second and third irrigation respectively. For farmer in group 1 and 3 their date of irrigation are about 34-36 DAP and 52-54 DAP respectively.

In general, the farmers actually know the schedule of water requirement for soybean. However, as discused above, not all farmers are be able to irrigate their fields on the right time. This is because farmer does not have any control on their irrigation dates individually, since the arrangement of irrigation schedule is organized by sub block of irrigation. This arrangement of irrigation finally cause farmers fail to irrigate their fields as required.

Further investigation show that all farmers included in group 1 and 2 are non-cooperator farmers while more than 90 percent of farmers within groups 3 and 4 are cooperator farmers. This finding indicates that the farmer grouping can be shown also in term of intensity in input use. As discussed earlier, cooperator farmers who follow the SYGAP recommendation significantly use inputs and labor more intensively compared to the non-cooperator farmers. However, this grouping of farmer should consider also the dates of planting and irrigation aplication because those variables are different among those farmer groups. The final classification of farmers regarding the intensity on inputs use and dates of planting and irrigation is summarized in Table 5. Further analysis on the comparison of yield and profitability of soybean cropping will refer to this qualitative classification.

Table 5. The intensity on cultural practices of farmer with different group

Cultural practices	Farmer group			
	(1)	(2)	(3)	(4)
Quantity of inputs:				
– pesticide	less	less	more	more
– KCl	less	less	more	more
Methods of:				
– cleaning straw	less	less	more	more
– planting	less	less	more	more
– spraying	less	less	more	more
Application dates of:				
– planting	late	on time	late	on time
– irrigation 2	early	on time	early	on time
– irrigation 3	early	on time	early	on time

Note: less/more mean less or more intensive in labor and other inputs use.

PHYSICAL EFFICIENCY OF SOYBEAN FARMING

Production efficiency can be evaluated either in the physical or in economic terms. The physical efficiency is usually measured by the ratio of output to input. The types of inputs considered in the analysis may be farm size or fertilizer use, depend on the focus of the study. In this study the physical efficiency will be measured in term of output per hectare and output per kilogram of seed. The second criteria is applied because seed availability is one of the main constraints in expanding soybean farming. Therefore it is interesting to identify the impact of cultural practices differences on the seed productivity.

The average yield by farmer group across the groups is presented in Table 6. As indicated in this table, farmer group 4 shows the highest yield compared to the other three groups. The average yield for farmer group 4 is 1.112 kg per hectare or about 220-520 kg higher than the yield achieved by other farmer groups. If we compare farmer group 4 with farmer group 1, it can be seen that the yield of farmer group 4 is nearly twice of that the group 1.

Table 6. The average yield by farmer group and yield gap across the group

Farmer group	Average yield (kg/ha)	Average yield gap across groups (kg/ha)			
		1	2	3	4
1	588.9 (0.46)	0	-220.9*	-299.2**	-532.2**
2	809.8 (0.38)	220.9*	0	-78.3	-302.3**
3	888.1 (0.43)	299.2**	78.3	0	-224.0*
4	1112.1 (0.27)	523.2**	302.3**	224.0**	0

( ) coefficient of variation
** significantly different at 0.05 level
* significantly different at 0.10 level

The same pattern is also observed in term of yield stability as indicated by its coefficient of variation. Farmer group 4 shows the lowest coefficient of variation among the four groups. It can also be seen that coefficient of variation of farmer group 4 is nearly only a half compared to the same value for farmer group 1. This comparison indicate that the cultural practices under the farmer group 4 has produced yield more stable than those applied by farmer in group 1.

The difference in yield and yield stability between farmer group 1 and 4, is essentially the result of the differences in term of quantity of inputs used and the arrangement of planting and irrigation dates. As presented in Table 5, farmer group 4 has used more inputs, plant and irrigate their field in the right time. The opposite is true for the farmer group 1. This finding indicates that more intensive inputs use and the right planting and irrigation schedule simultaneously increase the yield and the yield stability of soybean about twice as much.

The yield stability among farmer groups 1, 2 and 3 (Table 6), is not so much different. The differences among those three groups of farmer are only in terms of average yield compared to farmer group 1. Between group 2 and 3 there is no significant differences on yield. However, farmer group 2 shows higher yield per hectare about 220 kg than farmer group 1, whereas the yield of farmer group 3 is about 300 kg higher than that of group 1.

Analysis on yield differences across farmer group indicates, at least, two things. First, the application of more inputs increase soybean yield about 300 kg per hectare.

This phenomenon is observed when we compare farmer group 1 versus farmer group 3. These two groups of farmer show the same dates of planting and irrigation but farmer group 3 apply more inputs. The same result is also true in the comparison between group 2 and 4. These groups show the same characteristic of planting and irrigation dates but farmer group 4 produce yield about 300 kg higher than that of group 2 because they use more inputs.

The second phenomenon is that appropriate timing of planting and irrigation can increase the yield around 220 kg per hectare. The result of comparison between farmer group 1 and 2 indicates this matter. These two groups of farmer apply lower inputs but farmer group 2 shows better timing of planting and irrigation.

The results above indicates that the efforts of increasing soybean yield can be achieved not only by applying more inputs but also by proper timing in planting and irrigation. As presented in Table 6, these approaches show nearly the same impact, i.e. by increasing yield at least about 25%. The proper timing of planting and irrigation show the important role on yield because the soybean is very sensitive to water availability. Agronomic research indicates that better timing of irrigation increase the yield about 40%-50% (Rajit, 1990).

In term of seed productivity, Table 7 indicates that comparison of result across farmer groups provide different pictures. Between farmer group 1 and 2 there is no difference on seed productivity and the same thing is true for comparison between group 3 and 4. This result indicates that the arrangement of planting and irrigation calendar has no impact on the seed productivity irrespective the intensity of inputs use. The seed productivity can be increased only under the intensif use of inputs.

Table 7. Average seed ratio (kg of seed per kg of yield) by farmer group and the gap across the group

Farmer group	Average seed ratio	Average gap across group			
		1	2	3	4
1	13 (0.58)	0	-2	-6**	-10*
2	15 (0.47)	2	0	4	-8*
3	19 (0.46)	6**	4	0	4
4	23 (0.36)	10*	8*	4	0

( ) coefficient of variation

* significantly different at the 0.05 level

** significantly different at the 0.10 level

Table 7 shows that farmer group 4 which is more intensive in inputs use and apply better planting and irrigation timing, significantly shows higher seed productivity than farmer group 1 and 2 which are less intensive in inputs use. The same result is also true when comparing between farmer group 3 and 1 which apply higher and lower input use respectively. These results indicate that if the seed avalability is one of the main constraints in increasing soybean production, the intensification of input use can be applied. Under this aproach, the same quantity of production can be achieved with less quantity of seed.

PROFITABILITY OF SOYBEAN FARMING

Table 8 sumarizes the comparison of profitability across farmer groups. From this table, it can be seen that the gross return per hectare for each farmer group is in direct relation with yield. Farmer group 4 shows the highest gross return per hectare while farmer group 1 is the lowest.

In term of cost, the pattern relates with the cultural practices followed by each farmer group, particularly in term of inputs use. Farmer group 3 and 4 which characterized by more intensive use of inputs compared to group 1 and 2, show the highest cost of production. As indicated in Table 8, the total cost of farmer groups 3 and 4 does not differ so much. This is not surprising because almost all farmers within those two groups are cooperator farmers and all of their activities on their field are under the guidance and controll of the SYGAP field assistants.

Table 8. The average cost and return per hectare of soybean farming by farmer group

Descriptions	Farmer groups			
	(1)	(2)	(3)	(4)
Gross return (Rp 000)	580.82	718.37	754.66	900.10
Cost (Rp 000):				
– seed	76.65	92.51	72.61	77.66
– fertilizer	41.89	26.80	40.58	38.20
– pesticide + liquid fertilizer	27.87	27.23	98.41	102.41
– labour	233.96	285.60	445.24	464.56
– total	380.38	432.14	656.84	682.83
Net return (Rp 000)	140.44	286.23	97.82	217.27
Return to:				
– labour (Rp/hour)	616.50	748.40	455.25	564.22
– investment (Rp/Rp)[1)]	0.38	0.68	0.18	0.37

[1)] Net return per rupiah invested.

Compared to farmer groups 1 and 2, the production cost of farmer groups 3 and 4 are almost twice. This large difference on production cost is observed because the inputs use of farmer group 3 and 4 are more intensive either in term of labor or other inputs. In term of inputs, farmer groups 3 and 4 are more intensive particularly in the use of KCl fertilizer and pesticide quantity. In term of labor, those farmer group are also more intensive compared to farmer groups 1 and 3 either in the land preparation or crop core activities. The average labor spent of each farmer group is presented in Table 9.

Table 9. Average labor requirement per cultural practices

Farmer group	Average labour use for (hour/ha)			Gap between groups (hour/ha)		
	Land preparation	Crop care	Harvest + post harvest	Land preparation	Crop care	Harvest + post harvest
(1)	221.5	238.8	171.6	—	—	—
(2)	253.3	280.5	243.6	—	—	—
(3)	594.4	475.4	195.4	—	—	—
(4)	587.7	431.6	249.6	—	—	—
(1)VS(2)	—	—	—	31.8	41.7	71.8
(1)VS(3)	—	—	—	372.9*	236.6*	23.8
(1)VS(4)	—	—	—	366.2*	192.8*	78.0*
(2)VS(3)	—	—	—	341.1*	194.9*	48.0
(2)VS(4)	—	—	—	334.4*	151.1*	6.2*
(3)VS(4)	—	—	—	6.7	43.8	54.2

*) Significantly different at the 0.05 level.

As presented in Table 8, the highest return to labor and return to investment is achieved by farmer group 2 followed with farmer group 1 and the lowest one are for farmer group 4 and 3. This result is reasonable because the gross return of farmer group 2 is quite high while production cost of this farmer group is quite small either in term of labor or total cost. In contrast, farmer group 3 and 4 show lower return. Although those two farmer groups receive larger gross return than farmer groups 1 and 2, but they spend more cost of labor and other inputs. It indicates that the soybean farming under the recommended technique is less efficient compared with farmer practices because the additional return under the recommended technique is less than the increase on production cost.

Refering to the characteristics of cultural practices of farmer group as presented in Table 5, the comparison between farmer groups 1 and 2 primarily indicates the differences on the timing of planting and irrigation. Farmer group 2 shows better timing of planting and irrigation. The same thing is also true for the comparison between farmer groups 3 and 4 in term of more intensive inputs use.

Farmer group 4 show better arrangement of those agricultural activities compared to farmer group 3.

In Table 8, it can be seen that net return and return to investment of farmer group 2 is nearly twice compared to farmer group 1. The net return for those farmer groups 1 and 2 respectively are 140 and 286 thousands rupiah. The comparison between farmer groups 3 and 4 is also shows the same result where the net return and return to investment of farmer group 4 is about twice compared with farmer group 3.

The results above lead to the conclusion that an appropriate timing of planting and irrigation increases the profitability of soybean cropping about twice as much. This result is observed because the proper timing of planting and irrigation increases the yield but this improvement of cultural practices has no implication on production cost. This conclusion is valid irrespective of the intensity on inputs use. This means that proper timing of planting and irrigation should be considered to boost soybean production.

CONCLUSION AND IMPLICATIONS

Technology applied by farmer is a highly significant instrument in increasing farm productivity. It is observed that the method of cultural practices vary across farmers. Among 25 variables considered in this study, there are 10 variables which significantly distinguish one farmer to another. The 10 variables are: quantity of pesticides, method of straw cleaning, planting, fertilizing, weeding, and spraying; appliction dates of planting, first fertilizing, second irrigation, and third irrigation. These 10 variables simultaneously explain about 68% of the total variation in cultural practices. Using these variables as criteria, enable us to categorize farmer to several groups which can be distinguished to one another on the basis of method of cultural practices.

The analyses of yield differences across farmer groups indicate that soybean yield can be increased not only by applying more inputs but also by proper timing in planting and irrigation. To speed up the effort of increasing soybean production, farmer should be encouraged to pay attention on small detail such as method of application and the corresponding timing.

Comparison on farm profit shows that farmer group applying more input and practising better cultural method received lower return. Although this group produce highest yield, the corresponding additional cost out-weight additional return. This observation partially explain why the adoption of improved technology is not as fast as expected. Improving the efficiency of recomended technology either by increasing productivity or reducing cost component require continuous effort.

The results also imply that conventional production function approach in analysing production behaviour is not sufficient without paying attention to the variability on cultural practices. Simply assuming homogenous cultural practices may end up to misleading conclusions.

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Annex 1. Description of cultural practices variables and its measurement

Cultural practices	Variables	Measurement
Inputs quantity	Q1 (seed)	kg/ha
	Q2 (urea)	kg/ha
	Q3 (TSP)	kg/ha
	Q4 (KCL)	kg/ha
	Q5 (Liquid fertilizer)	lt/ha
	Q6 (Pesticides)	lt/ha
Methods of cultural practices	M1 (Canal construction)	labor/ha for canal construction
	M2 (Cleaning straw)	labor/ha for cleaning straw
	M3 (Planting)	labor/kg of seed
	M4 (Fertilizing)	labor/kg of fertilizer
	M5 (Weeding)	number of weeding application
	M6 (Irrigation)	number of irrigation application
	M7 (Spraying)	liter of pesticide for each application
Dates of application	D1 (Planting)	date of planting starting with date = 1 for the first date of March
	D2 (first fertilizing)	number of day after planting
	D3 (first weeding)	number of day after planting
	D4 (second weeding)	number of day after planting
	D5 (first spraying)	number of day after planting
	D6 (second spraying)	number of day after planting
	D7 (third spraying)	number of day after planting
	D8 (forth spraying)	number of day after planting
	D9 (fifth spraying)	number of day after planting
	D10 (first irrigation)	number of day after planting
	D11 (second irrigation)	number of day after planting
	D12 (third irrigation)	number of day after planting

Annex 2. Distribution of cooperator and non-cooperator farmers by type of cultural practices (%)

Agricultural operation	Cultural practices	Non-cooperator farmer	Cooperator farmers
Cleaning fields	Light cleaning	60	3
	Complete cleaning	40	97
Drainage canal every	2 meters	20	0
	3 meters	50	77
	4 meters	20	23
	5 meters	7	0
	6 meters	3	0
Planting	Broadcast	63	0
	Dibble	37	0
	Dibble with rope	0	94
	Others	0	6
Fertilizer app	Broadcast	80	76
	Dibble	0	4
	Others	20	20
Number of weeding	0	27	10
	1	73	90
	2	43	30
	3	10	4
Number of spraying	1	100	100
	2	93	100
	3	73	96
	4	40	76
	5	17	40
	6	7	16
	7	3	10
Number of irrigation	1	100	100
	2	90	96
	3	23	23
	4	6	13
1st irrigation		43	20
2nd irrigation		83	86
3rd irrigation		80	100
4th irrigation	6	13	