Financial analysis of direct application of reactive phosphate rock fertilizer on corn farming on upland acid soils

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Abstract. Indonesia has extensive upland acid soils, which is around 99.6 million hectares spread across Sumatera, Kalimantan and Papua Islands. The use of upland acid soils for food crops is an urgent need because of the government's self-sufficiency target, including corn. The level of nutrient in upland acid soils is relatively low so it requires adequate input of ameliorant, inorganic and organic fertilizers to produce high corn yield. A demonstration farm of corn based on the direct application of reactive phosphate rock (RPR) fertilizer was carried out in rainy season 2018/2019 by involving three farmer groups as cooperative farmers, with an area of 50 ha in Margosari village, Metrokibang subdistrict, Lampung Timur Regency. This paper presents the results of financial analysis of corn farming at the demonstration farm area. Data was gathered from 52 farmers (43.7% of the cooperative farmers) which randomly selected as survey respondents. The results of the analysis showed that balanced fertilization using RPR as much as 1 t ha⁻¹ as a source of P fertilizer was financially benefited to farmers. The average corn productivity of hybrid varieties reached 14.357 t ha⁻¹ and it gave an R/C ratio of 1.8.

1. Introduction

The upland acid soils (UAS) is generally located in areas with high rainfall intensity, more than 2,000 mm/year which the level of soil nutrient leaching is generally high and soil fertility is low [1]. Farming constraints on UAS include low pH (<5.5), low organic C-content and exchangeable bases, and low cation exchange capacity. In addition, the UAS soils is sensitive to erosion and the level of decomposition of organic matter is high [2].

The opportunity to increase UAS productivity is very possible since the technology for overcoming constraints has been widely available as a result of research and development of various parties, including the Agricultural Research and Development Agency, Ministry of Agriculture. However, the available technology is still largely in partial, so that it cannot be completely resolved the biophysical constraints of UAS and socio-economic constraints of dryland farmers which are generally characterized by low ownership and access to sources of capital.

Assembling agricultural technology of UAS farming must pay attention to the physical, chemical and biological properties of the soils. Management of UAS requires integrate the use of inorganic, organic, and biological fertilizers, as well as soil enhancers. Then the land preparation and soils tillage must be adapted to the soil physical conditions, as well as the management of pests and plant diseases.
that should be aligned with the results of climatic conditions. Another important technological component is the type of plant that is developed must be high yielding varieties and easily to market it.

Various research results indicate that soil enhancers, both in the form of biochar, manure, and dolomite can have a positive effect on soil properties and plant productivity, especially on UAS farming [3-4]. The results of Mulyono's study [5] showed that giving 10 t ha⁻¹ of Flemingia congesta fresh biomass with recommended fertilizer dosages on UAS farming could increase corn yield by 128%.

Research on demonstration scale area of 50 hectares (Demfarm scale study) with one of its objectives was to increase corn productivity and income of corn farmers on UAS farming was carried out in Margosari village, Metrokibang sub-district, East Lampung District, Lampung Province in RS 2018/2019. The technological component studied in Demfarm scale study was Reactive Phosphate Rock fertilizer (RRP), dolomite, inorganic fertilizers, organic fertilizers, and hybrid corn seeds, as well as how to grow corn with the Zigzag system. The Demfarm scale study activities was carried out on farmers’ land, and farmers their selves were as implementing research activities under the guidance of researchers and field technicians. The farmers also obtained technical explanations about the application of the technology under the Demfarm scale study in the form of technical guidance sessions.

This paper presents the results of the Demfarm scale study, especially related to financial analysis of the application of UAS management technology based on the use of RPR fertilizer and soil enhancers on hybrid corn farming.

2. Material and Method
The specific site of the Demfarm scale study was at the UmbulKating land block, Margosari village. The distance of this site from the surrounding residential areas was about 1 to 7 km with an average of 3.1 km. The number of cooperative farmers involved in Demfarm scale study was 119 persons from 3 farmer’s group in the same village.

Farmers’ socio-economic data and corn farming activities in the Demfarm scale study area were collected through survey approach. The survey was conducted in the third week of December 2018. Respondents of the survey were 52 cooperative farmers who were selected by simple random sampling technique. The opportunity of cooperative farmers to be selected as survey respondents was 43.7%.

The survey instrument was structural questionnaires which were filled in by enumerators who interviewed respondents personally. The scope of the contents of the questionnaire included: (a) farmer characteristics, (b) the area and land tenure status, (c) livestock ownership, (d) use of corn farming inputs, including labour in the Rainy Season (RS) 2017/2018 and RS 2018/2019, (e) corn productivity in RS 2017/2018 and RS 2018/2019, and (f) farming constraints faced by farmers. In addition to the primary data, secondary data were also collected from various sources, such as book of “Metrokibang in Figure” which was issued by the local Bureau of Statistics [6] and literatures. The primary and secondary data were processed and analysed descriptively, presented in the form of narratives, tables and graphs. This paper presents and discuses only data on farmers’ characteristics, corn farming input, corn yield and the farming profit.

3. Result and Discussion
3.1. Site conditions and characteristics of farmers
Administratively, the Demfarm scale study area was in Margosari village, one of the seven villages in Metrokibang Sub-district. Accessibility to the village was relatively good. The distance of this village to the centercity sub-district and district was about 6 km and 40 km, respectively.

The population of Margosari village was around 2,073 people with the growth rate reaching 1.77%/year. The population density was about 319 people/km². The main source of the people's livelihood was agriculture. In the village there were 776.97 ha of upland farming, and generally planted with corn, cassava, and chilli. The potential of livestock in Margosari village was quite high. There were 267 cattle, 948 goats, and 2,086 chickens. The existence of those animals was very important as a source of animal manure for making compost or organic fertilizer. Based on that information, the location of
Demfarm scale study to increase corn yield based on integrated fertilizer application and soil enhancers was right on target area. Besides, the village was a corn production centre supported by farmers’ who responsive to use fertilizers, including manure.

The age of farmers was classified as productive, which was an average of 40 years old with a range between 20-63 years old. Farmer education was also relatively high, that is, most of them have graduated from junior and senior high school (64%) and the rest was graduated from elementary school. The experience of corn farming generally has been above 10 years (44.2%), some between 5-10 years (32.7%) and only a small percentage of farmers who have only cultivated corn for less than 5 years (23.1%). It was hoped that the cooperative farmers would implement and adopt corn farming technology developed in the Demfarm scale study area.

The main source of income of respondents was food crops, vegetables and estate crops farming (64%), livestock business (17%), farm labourers (8%), trade and others (11%). The level of farmer’s income was about IDR 33,800,000/family/year or equivalent to IDR 10.2 million/capita/year or equal to US $ 767/capita/year. This amount of income per capita was lower compared to the national income per capita which was about US $ 5,360/year. However, the farmer’s income was higher than the national poverty line which was US $ 360/capita/year. It means, although farmer’s income was lower than the national average income but it was 113% higher than the national poverty line. Hopefully, Demfarm scale study would increase farmer’s income to get closer to the level of national per capita income.

3.2. Farming inputs on farmer’s practice and Demfarm scale study

The use of production inputs on corn farming was distinguished by two planting seasons, namely the rainy season (RS) before the Demfarm scale study and the rainy season when the Demfarm scale study was being carried out. The first season (RS 2017/2018) was represented as farmer’s practices and the second one (RS 2018/2019) was demonstration technology practices on upland acid soils farming.

The types of production inputs on corn farming include seeds, inorganic fertilizers, manure, and soil enhancers, as presented in Table 1. The corn varieties used by cooperative farmers include NK22 (80.8%), Bisi 18 (17.3%) and DK (1.9%). The use of corn varieties was generally based on the experience of the previous planting season, in terms of yield and selling price. The existence of buyers and high yields of corn is equally important to farmers in determining the varieties of corn to plant.

Table 1. The use of corn farming inputs on farmer’s practice in Margosari village, Metrokiban sub-district, Lampung Timur Regency, RS 2017/2018

| No | Inputs          | Quantity (kg ha⁻¹) | % of farmers use |
|----|----------------|--------------------|-----------------|
| 1  | Seed of corn   | 20                 | 100             |
| 2  | Manure         | 6269               | 94.2            |
| 3  | Dolomite       | 254                | 34.6            |
| 4  | Urea           | 456                | 86.5            |
| 5  | NPK Phonska    | 216                | 84.6            |
| 6  | KCl            | 47                 | 44.2            |
| 7  | SP36           | 33                 | 25.0            |

Source: primary data (processed)

The types of fertilizers and soil enhancers used by cooperative farmers on corn farming include manure, dolomite, urea, NPK Phonska, KCl and SP36. Manure, urea and NPK Phonska were used by most farmers. Manure was mostly in the form of chicken manure purchased, and a small portion in the form of self-owned cattle or goat manure. A few farmers applied dolomite (34.6%), KCl (44.2%), and SP36 (25.0%), respectively.

Without taking into account the macro nutrient content on manure and dolomite, the dosage of inorganic fertilizer used by farmers on corn farming contained nutrients of N (242 kg ha⁻¹), P₂O₅ (44 kg ha⁻¹), and K₂O (62 kg ha⁻¹). These data shows that fertilizer used by farmers on corn farming was still not balanced where the nutrients content of N, P, and K were very high. Fertilizer dosage
recommendation for corn farming consists of urea 200 kg ha\(^{-1}\), SP 36 100 kg ha\(^{-1}\) and KCl 75 kg ha\(^{-1}\), which contain nutrient of N (92 kg ha\(^{-1}\)), P\(_2\)O\(_5\) (36 kg ha\(^{-1}\)), and K\(_2\)O (46 kg ha\(^{-1}\)). For optimal yield of corn (9.4 t ha\(^{-1}\)) Patola\(^7\) applied 247.5 kg N ha\(^{-1}\), 45 kg P\(_2\)O\(_5\) ha\(^{-1}\) and 45 kg K\(_2\)O ha\(^{-1}\).

In addition to inorganic fertilizers and soil enhancers, farmers also applied chemical herbicides and pesticides. Herbicides applied to control weeds, while pesticides were to control crop pests and diseases. The average expenditure for weeds, pests and diseases control were about IDR 648,695 ha\(^{-1}\). The overall cost of corn farming for agricultural inputs on farmer’s practice in RS 2017/2018 was IDR 7.7 million ha\(^{-1}\).

In RS2018/2019 during implementation of the Demfarm scale study all cooperative farmers obtained subsidy on agricultural inputs, namely seeds of corn (variety of NK22 Jumbo), manure, dolomite, reactive phosphate rock, urea, and KCl fertilizer, as presented in Table 2. According to farmers the subsidized farming inputs somehow were still lacking so farmers still bought several inputs independently. Agricultural inputs purchased by farmers independently were corn seeds (7.6% of farmers), manure (36.5%), dolomite (8.9%), urea (46.7%), KCl (17.8%), NPK Phonska (100%), and SP36 (100). In addition, farmers also used pesticides and herbicides for pests and weeds control worth at IDR 545,686 ha\(^{-1}\).

Table 2. The use of corn farming inputs on Demfarm scale study area in Margosari village, Metrokibang sub-district, Lampung Timur Regency, RS 2018/2019 (kg ha\(^{-1}\))

| No | Inputs              | Subsidy | Self-help of farmer | Total    |
|----|---------------------|---------|---------------------|----------|
| 1  | Seeds of corn       | 20      | 1.6                 | 21.6     |
| 2  | Manure              | 4,000   | 2,296               | 6,296    |
| 3  | Dolomite            | 1,000   | 98                  | 1,098    |
| 4  | Reactive PR         | 1,000   | 0                   | 1,000    |
| 5  | Urea                | 350     | 307                 | 657      |
| 6  | NPK Phonska         | 0       | 124                 | 124      |
| 7  | KCl                 | 100     | 22                  | 122      |
| 8  | SP36                | 0       | 14                  | 14       |

Source: primary data (processed) and Demfarm research document

During socialization of Demfarm scale study activities the farmers were actually given an explanation by the research team that they did not need to add phosphate source fertilizers, such as NPK Phonska or SP36 because there was 1,000 kg ha\(^{-1}\) of RPR subsidy containing 28-30% of P\(_2\)O\(_5\). In fact, the farmers still applied NPK Phonska (124 kg ha\(^{-1}\)) and SP36 (14 kg ha\(^{-1}\)). Some farmers argued that the fertilizers had already been purchased before knowing the Demfarm scale study activity. Further, they were hoping the yield of corn would be even higher than before.

The dosage of inorganic fertilizers in RS 2018/2019 was equivalent to the nutrient content of N (321 kg ha\(^{-1}\)), P\(_2\)O\(_5\) (324 kg ha\(^{-1}\)) and K\(_2\)O (94 kg ha\(^{-1}\)). If it was assumed that the benefits of RPR residues could be effective for 4 planting seasons, then the nutrient content of P\(_2\)O\(_5\) became around 99 kg ha\(^{-1}\). Overall, the use of inorganic fertilizer in RS 2018/2019 was much higher than farmer’s practice in RS 2017/2018, especially for P and K nutrients. Moreover, in RS 2018/2019 farmers applied herbicides and pesticides worth at IDR 448,529 ha\(^{-1}\).

Based on the current prices, the value of the use of agricultural inputs on corn farming in RS 2018/2019 was IDR 11,536,144 ha\(^{-1}\). In case the cost of RPR application was distributed evenly into 4 planting seasons, then the cost of corn farming was become IDR 9,286,144 ha\(^{-1}\). Based on the use of these high input, then farmers expected that corn productivity in RS 2018/2019 would be increased by around 50-100% from the average of corn productivity in RS 2017/2018.
3.3. The use of labour and total cost of farming

The use of labour in corn farming includes the need for land preparation and soil tillage, application of manure, dolomite, fertilizers, planting and maintenance of crop, as well as pest and diseases control, harvest and post-harvest activities. Land preparation and soil tillage activities generally use tractor and a small portion of man power. Manure and dolomite applications were mostly carried out during land preparation and soil tillage activities. Regarding farmer using RPR, the application was then carried out by spreading it on the surface of the land, flattened and mixed in to the ground with tools or manually. Farmer stated that RPR application need extra labour about 4 to 6 days per hectare. The application of manure and dolomite were usually done by family labour, except farmers who manage upland more than or equal to 1.0 ha. Rich farmers generally use hired labour. Likewise, for the application of inorganic fertilizers and pest or diseases control activities.

Corn planting and weeding activities can be done in mutual cooperation or paid for. Meanwhile, the costs of harvesting and post-harvest of corn was paid based on the amount of yields obtained the hired labour. However, in general, more than 50% of farmers sold corn at a certain price level, for example IDR 2,000 kg\(^{-1}\) where the buyer was responsible for doing post-harvest activity. The selling systems was detrimental to farmers, because if farmers did it themselves it would only cost about IDR 80 - 85 kg\(^{-1}\), while the selling price of corn was about IDR 2,200 - 2,300 kg\(^{-1}\). The fact in the field showed the importance of the existence of corn thresher for farmers.

Based on wage rate of IDR 50,000-60,000/working day and assumed the farming activities were fully paid, the labour cost of corn farming of farmer’s practice in RS 2017/2018 was IDR 3.4 million ha\(^{-1}\) for cultivation and IDR 2.1 million ha\(^{-1}\) for harvest and post-harvest activity, respectively. It means the total labour cost was IDR 6.50 million ha\(^{-1}\). The same figure of total labour cost for RS 2018/2019 was IDR 7.16 million ha\(^{-1}\) consisted of IDR 4.7 million ha\(^{-1}\) for cultivation and IDR 2.4 million ha\(^{-1}\) for harvest and post-harvest activities, respectively. It shows that the labour cost of Demfarm scale study was 10.2% higher than farmer’s practice labour cost.

Based on the data above, it can be calculated that the cost of corn farming on farmer’s practice (RS 2017/2018) was IDR 13.2 million ha\(^{-1}\) which consisted of the cost of agricultural inputs (58%) and labour wages (42%). While, the total cost of corn farming on Demfarm scale study (RS 2018/2019) was IDR 18.7 ha\(^{-1}\) which consisted of the cost of agricultural inputs (61.7%) and labour costs (38.3%). The high cost of corn farming in RS 2018/2019 was due to farmer applying agricultural inputs other than sourced from the subsidy, such as urea, NPK Phonska, and manure.

3.4. Corn productivity and farming profits

The productivity of corn obtained by farmers in RS 2017/2018 was quite varied. It ranged between 3.8 - 13.5 t ha\(^{-1}\) and the average was 7.9 t ha\(^{-1}\). The variation occurred due to different on corn variety, fertilizers dosage, and cultivation techniques among farmers. Meanwhile, the yield of corn in the Demfarm scale study (RS 2018/2019) are presented in Figure 1. These yield data came from 122 cooperative farmers’ land, including survey respondents.

The range of corn yield was relatively high, i.e. between 7.320– 22.000 ha\(^{-1}\) or 14.357±2.82 ha\(^{-1}\). It was clear that Demfarm scale study increased corn productivity as much as 81.7% compared to farmer’s practice. Reactive PR was the only production input that has never been applied by farmers before. This result was in line with previous studied [8-9].

The source of yield variation was to come from the biophysical conditions of the land and the number of production inputs, especially fertilizers. The amount of fertilizers applied by farmers, although subsidized, but quite different, because some farmers provided fertilizers by themselves, as explained earlier.

Based on the average of corn selling price (IDR 2,370 kg\(^{-1}\)), the revenue of corn farming on farmer’s practice was about IDR 18.7 million/ha. Therefore, the income of farmer’s practice corn farming was about IDR 5.6 million/ha with R/C equal to 1.42. It means farmer’s practice of corn farming was financially feasible.
Then, the selling price of corn of RS 2018/2019 (Demfarm scale study) was about IDR 2,400 kg\(^{-1}\). Hence, the farm income and its R/C ratio can be calculated as follows:

a) Average yield of corn: 14,357 kg ha\(^{-1}\)
b) Selling price of corn: 2,400 IDR kg\(^{-1}\)
c) Farm revenues: 34,456,800 IDR ha\(^{-1}\)
d) Farm costs: 19,142,667 IDR ha\(^{-1}\)
e) Farm income: 15,314,133 IDR ha\(^{-1}\)
f) R/C ratio: 1.799

![Figure 1. Statistics on the yield of corn in the Demfarm scale study area, Margosari village, Metrokibang sub-district, Lampung Timur regency, RS 2018/2019](image)

If it was assumed that the effect of the use of RPR was spread evenly over the 4 planting seasons, by reducing 75% the cost of dosage and application labour of RPR, then the cost of corn farming will decrease and the value of R/C ratio became 2.1. At the yield level and selling price of corn, the cooperative farmers declared that corn farming was financially viable and benefited. However, the farmers realized that they had used too much fertilizer since they applied additional fertilizers which they purchased by themselves. This Demfarm scale research needs to be continuing with a focus on observing corn yield in the next few seasons with the same dose of fertilizers without the source of P fertilizer [10].

4. Conclusion
Cooperative farmers were classified as productive age with relatively high level of education. Location of the Demfarm scale study was properly selected to increase corn yield and farmer’s income as the local farmers were very responsive to apply new technology in upland acid soils farming systems.

The corn farming technology applied on Demfarm scale study area could increase corn yield as well as farmer’s income. The application of balanced fertilization based on using reactive phosphate rock as source of P nutrient on high yielding corn variety was financially viable, either calculated in one or four cropping seasons.
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