The impact of agricultural extension on productivity of smallholder sugarcane farmers in East Java

M Kosim, J M M Aji* and T D Hapsari

Faculty of Agriculture, University of Jember, Jln. Kalimantan No. 37, Jember, East Java, Indonesia

*joni.faperta@unej.ac.id

Abstract. Agricultural extension is one of the most important factors to increase smallholder sugarcane farmer capacity and encourage the acceleration of technology adoption which positively correlates with farm productivity. This study aims to evaluate the impact of agricultural extension on the productivity of smallholder sugarcane farmers in East Java. While few previous studies showing the relationships, very limited involving a relatively large number of samples. This study used data from Indonesian Plantation Farm Household Survey 2014 by the Indonesian Statistical Agency (BPS). The number of samples was 2,893 farmers consisting of 2,463 farmers who did not participate (control group) and 430 farmers who participated in agricultural extension (treatment group). Propensity score matching (PSM) was used to evaluate the impact of agricultural extension on the productivity of sugarcane farming. Typically, the treatment group is better than the control group. The treatment group has an average education of 7.89 years, land area of 2.74 hectares and sugarcane productivity of 72 tons/ha. Meanwhile, the control group has an average education of 5.96 years, land area of 0.88 hectares and sugarcane productivity of 61 tons/ha. Our results show that farmers who participated in agricultural extension have a 9.05 tons higher productivity compared to those who did not participate. Therefore, farmers’ participation in agricultural extension should be encouraged by improving the frequency as well as the quality of agricultural extension. While the number of extension workers for plantation crops is limited, recruitment of more extension workers can be an optional policy for the government.

1. Introduction
Sugarcane is a seasonal plantation commodity that has an important role in the Indonesian economy. About 65% of the sugarcane area is concentrated on Java Island and 34.5% are located on the North Sumatera, Lampung, Gorontalo, South Sulawesi and West Nusa Tenggara. On Java Island, mostly sugarcane (90%) is cultivated by smallholder farmers and the other is cultivated by State Owned or Private Estate [1].

In these two decades, there has been a decrease in the sugarcane area. There are several reasons for the decrease such as inefficient sugar factories which leads some factories to stop their operation; increasing farm labour costs so that, when water is available, more farmers feel that planting rice and corn is more profitable compared to sugarcane [2]; limited understanding of cultivation technology; limited input supports; the yield is not representative, and the sugar prices are not optimal. The other
reasons are caused by obsolete seeds, ratoon cane more than ten times (whereas the maximum was about three times), and sugarcane was harvested when it is not mature enough (less than 12 months) [3,4].

Meanwhile, to support sugarcane factory revitalization, the national target of sugarcane productivity is 93 tons/ha [3]. It is expected to be achieved by adopting certified seed plants also unloading ratoons and land management [5]. With the fact that most farmers still practice ratoon cane many times more than suggested, a breakthrough to improve farmers’ awareness to perform good agricultural practices is necessary. In this regard, the role of agricultural extension to improve the productivity of smallholder sugarcane farmers is of the utmost importance. The Agricultural extension is important to increase the farmers’ capacity. Previous research, the impact of agricultural extension on farmer productivity had different results. Pervaiz et al. [6] found that the farmer extension failed to provide extension services to the farmer communities. The other study has a different result, it showed that the farmers need extension services to improve from traditional agriculture to progressive agriculture [7]. Public extension services have an important role in increasing the effectiveness of the out-grower credit system among smallholder sugar cane farmers in Kisumu county [8].

The efficiency of sugarcane farming is affected by many variables. Thirteen variables are thought to affect the efficiency of sugarcane farming. Ten variables that have a significant effect are farmer's age, farmer education, number of family members, land tenure, land status, farmer group membership, livelihood, seed plant, business ties with input suppliers, and participation in farmer extension [9]. An interesting result of this study that participation in extension has a positive effect on the efficiency of smallholder sugarcane farmers. However, this study did not specifically evaluate the impact of agricultural extension on the productivity of smallholder sugarcane farmers, especially in East Java.

While some studies found to evaluate the role of agricultural extension to the smallholder sugarcane farmers, very few studies are conducted in Indonesia, especially with a relatively large number of samples. This is the reason this research was conducted. This study aims to evaluate the impact of agricultural extension on the productivity of smallholder sugarcane farmers using the Propensity Score Matching (PSM) method. This study focused on East Java province since nearly half of the Indonesian sugarcane production is produced in East Java, so the results of this study are expected to objectively evaluate the impact of agricultural extension on the productivity of smallholder sugarcane farmers in Indonesia.

2. Materials and methods
The impact of participation in agricultural extension to the productivity of smallholder sugarcane farmers in East Java is conducted Propensity Score Matching (PSM).

2.1. Materials
This study used data from the 2014 Indonesian Plantation Farm Household Survey (IPFHS). The data was a part of the Agricultural Census 2013, which is BPS (The Indonesian Statistical Agency) does every 10 years. The survey was conducted from May 27 until July 7, 2014. In total, 5,281 farmers from East Java were interviewed for the IPFHS. The selection of East Java Province, as noted above, due to this area is the largest sugarcane producer in Indonesia with a contribution of 47% of the national sugarcane production, or 72% of sugarcane production in Java [10]. The second consideration is the number of sugarcane farming households in East Java is the largest in Indonesia, reaching 139,760 households or 71.50% of the total sugarcane farming households in Indonesia [1].

However, we removed the data for the farmers who did not have complete data such as land area and sugarcane production were empty. This can happen because a part of farmers sold their sugarcane before harvest (ijon) or sold their sugarcane with an approximation method (tebasan) so that data of their production were unavailable. The final data obtained after screening were 2,893 farmers consisting of 2,463 farmers who did not participate in agricultural extension activities (control group) and 430 farmers who participated in agricultural extension (treatment group).
2.2. Methods
The methods to analyse the data using PSM and the steps are described below[11]:

a. Build a logistic regression model and estimates the propensity score, it is defined as the probability to receive treatment based on the measured covariates:

\[ e(x) = P(Z = 1 | X) \]  

where is denominated \( e(x) \) is the propensity score, \( P \) is the probability, \( Z = 1 \) a treatment indicator with a value of 0 for control and 1 for treatment, and \( X \) is a set of the observed covariates.

b. Algorithm matching with several ways, such as nearest neighbourhood matching, kernel matching and radius matching.

c. Model adequacy check that can be calculated and assessed through the multivariate significance test.

d. See overlap and common support. This method is done to improves the matching algorithm, the balance on the variables, and avoids extrapolation to units within a group that differs greatly on their covariates. So that no comparison unit in other groups was found.

e. Assessing Matching Quality. In this model to measure matching quality using recommended standardized bias (SB) and t-test. If the \( x \) covariates are randomly distributed in the treatment and control groups, the Pseudo R^2 value should be quite low. The first step is to estimate the potential outcome differences between the treatment and control groups as follows:

\[ \Delta i = Y_i - Y_0 \]  

f. Calculate the average treatment effect (ATT). The ATT value used to determine the impact of farmer participation in agricultural extension activities can be estimated as follows:

\[ ATT = E[E(Y_1|D) - E(Y_0|D = 0, p(X))|D = 1] \]  

\( H_0 \) : if the ATT value is negative or zero. Agricultural extension has no impact on increasing sugarcane productivity.

\( H_1 \) : if the ATT value is positive. Agricultural extension has an impact on increasing sugarcane productivity.

3. Results and discussion
Nine variables were identified to influence the farmer’s decisions to participate in agricultural extension[12,13], namely: (a) farmer characteristics (age, education), (b) household characteristics (household size), (c) agricultural characteristics (land tenure, land area (ha), land type, seed plants), and (d) institutional characteristics (farmer groups, contract farming).

3.1. Characteristic of smallholder sugarcane farmers in East Java
PSM is used to estimate the impact of farmer participation in agricultural extension on the productivity of smallholder sugarcane farmers in East Java by comparing the treatment group and the control group. In this study, the treatment group is farmers who participate in agricultural extension (code= 1), while the control group is a group of farmers who don’t participate in agricultural extension (code= 0). Table 1 provides descriptive statistics of the covariate in the analysis. The averages of land area, education, and productivity in the treatment group are higher than in the control group. The average land area in the treatment group was 2.74 ha, which was higher than that of the control group, with an 0.88 ha land area. The average productivity of the treatment group was 72 tons/ha, which was higher than that of the control group whose productivity only 61 tons/ha. The average education of the treatment group was 7.89 years or equal junior high school, meanwhile, the control group was 5.96 years or equal elementary school. It is assumed that farmers who have higher education will be easier to manage and found the information than farmers who have lower education. This result in line with previous research [14,15], that show every additional year of education can improve farmer’s information search and process more rapidly so that farmers with higher education tend to engage more in agricultural extension than those of lower education. The average age of the treatment group is younger than the control group.
Accordingly, for the other variables, land tenure, farmer group participation, seed plant, contract farming and land type, the treatment group are also better than the control group.

**Table 1.** Descriptive statistics of variables influencing farmers’ participation in agricultural extensions.

| Variable                      | Not participate in agricultural extensions (control group) | Participate in agricultural extensions (treatment group) |
|-------------------------------|----------------------------------------------------------|---------------------------------------------------------|
|                              | Mean | S.D. | Freq¹ | Mean | S.D. | Freq¹ |
| Productivity                 | 61   | 72   |       | 72   |      |       |
| X1 Age (years)               | 50.77| 0.232| 49.7  | 0.476|      |       |
| X2 Education (years)         | 5.96 | 0.086| 7.90  | 0.216|      |       |
| X3 Household size²           | 3.85 | 0.028| 3.99  | 0.065|      |       |
| X4 Land tenure               |      |      |       |      |      |       |
| Owner                        | 2117 | 86.0%| 318   | 73.9%|      |       |
| Otherwise                    | 346  | 14.0%| 112   | 26.1%|      |       |
| X5 Land area (ha)            | 0.88 | 0.043| 2.74  | 0.261|      |       |
| X6 Farmer group Participation| 734  | 29.8%| 323   | 75.1%|      |       |
| No participation             | 1729 | 70.2%| 107   | 24.9%|      |       |
| X7 Seed plant                |      |      |       |      |      |       |
| Certified                    | 365  | 14.8%| 109   | 25.3%|      |       |
| No certified                 | 2098 | 85.2%| 321   | 74.7%|      |       |
| X8 Contract farming Participation| 1015| 41.2%| 295   | 68.6%|      |       |
| No participation             | 1448 | 58.8%| 135   | 31.4%|      |       |
| X9 Land type                 |      |      |       |      |      |       |
| Low land                     | 754  | 30.6%| 138   | 32.1%|      |       |
| Otherwise                    | 1709 | 69.4%| 292   | 67.9%|      |       |
| Sample size (n)              | 2463 |      | 430   |      |      |       |

¹The figure in parentheses is the percentage of the farmers in each group
²For the categorical variables, the value represents the number of farmers for each category in each group
³Household size is the number of household members (including farmers) in a particular farm household

3.2 The impact of agricultural extension on the productivity of smallholder sugarcane farmers in East Java

The first step to Analyse PSM was preceded by building a logistic regression model (LRM). PSM is performed using STATA software. Table 2 shows the estimation results of the LRM. Based on Table 2, seven variables significantly influence the decision of farmer participation in agricultural extension (P-value <0.05), namely, education, land area, land tenure, farmer group, certified seed plants, contract farming, and land type. This study in line with another research [14], that an additional year of education increases the likelihood to participate in an extension program. And similarly, the variable of membership in farmer group, land area, certified seed plant and contract farming shows a positive effect on participation in agricultural extension. These are caused by farmers discuss new information and extension programs in the group meetings, and this may motivate farmers to participate in agricultural extension.

**Table 2.** Estimation of logistic regression model (LRM).

| Y                  | Coef.      | Std. Err. | z     | Sig. |
|--------------------|------------|-----------|-------|------|
| Age (years)        | 0.0002042  | 0.0060253 | 0.03  | 0.973|
Furthermore, LRM results were used for the estimation of the propensity score. The common support analysis for matching treatment and control groups through the propensity score. The distribution of the propensity scores must fall in the common support area, ranging between 0 and 1. In the next steps, a balance test was conducted on the mean differences, and we found no covariates that are significantly different between the treatment group and control group. This suggests that the matching algorithm produces a relevant group for comparison.

The value of Average Treatment on The Treated (ATT) is used as an indicator of the impact of the treatment. Furthermore, the impact of farmer participation in agricultural extension activities is shown in Table 3. This study used the nearest neighbourhood matching method to estimate the ATT Scores.

Table 3. shows that agricultural extension has an impact on increasing the productivity of the smallholder sugarcane farmers in East Java. The difference value between the treatment and the control group is 9.0463. This means that participation in agricultural extension has a positive impact to increase productivity. Based on Table 3, smallholder sugarcane farmers who participate in agricultural extension has a productivity of 9.0463 tons/ha which is higher than those who did not participate in agricultural extension.

### Table 3. Estimated impact of participation in agricultural extension on the productivity of sugarcane in East Java.

| Matching | Sample | Treated | Controls | Diff  | t-stat |
|----------|--------|---------|----------|-------|--------|
| NNM      | Unmatched | 256.03  | 1723.04  | -1467.01 | -1.27  |
|          | ATT     | 256.03  | 246.98   | 9.046  | 0.21   |

This study in line with another study [15] in that the role of agricultural extension has a significant effect on farmer participation in the association of farmer group activities. However, the presence of agricultural extension in sugarcane agribusiness is only a supporting institution that can increase the knowledge, skills, and attitudes of farmers. There are several other supporting institutions in the sugarcane agribusiness system such as financial institutions, extension services, processing and marketing institutions, and research and development institutions that could play an important role in helping sugarcane farmers [16].

The results of the analysis demonstrate that although give a positive impact to increase the productivity of smallholder sugarcane farmers in East Java, the farmers’ access to agricultural extension was low. Furthermore, considering the impact of agricultural extension the government should increase both the quantity and quality of farmer extension. As we know the number of agricultural extension workers in Indonesia is currently very low and far from ideal in which an extension worker handles an
average of 20-22 farmer groups from 1-2 villages. Ideally, depending on the area topography, each extension worker should handle 8-16 farmer groups [18]. Finally, efforts to increase access to agricultural extension should focus on strengthening farmer-based organizations, which are important channels for extension delivery and information dissemination. This is since institutional factors such as the provision of agricultural credit, access to irrigation technology, and agricultural extension can enhance farm productivity and thus farmer income, hence efforts are required to make these available to farmers [9,16].

4. Conclusions
The results showed that the treatment group of sugarcane farmers have better characteristics than the control group. Treatment group sugarcane farmers have average education, land area, and productivity of sugarcane bigger than the control group. It showed that agricultural extension has a positive impact on smallholder sugarcane farmers in East Java Province. Therefore, the productivity of smallholder sugarcane farmers in East Java should be promoted by increasing the number and quality of agricultural extensions. The farmers should be welcome to participate in agricultural extension seriously. With the fact that the number of agricultural extension workers especially for plantation crops is limited compared to the crop planted area, recruitment of more extension workers can be an optional policy for the government. The role of sugar factories in improving agricultural extension availability for farmers is also expected so that sugarcane productivity can be boosted.

References
[1] Kementerian Pertanian 2017 Outlook Tebu 2017 Komoditas Pertanian Sub Sektor Perkebunan (Jakarta: Direktorat Jenderal Perkebunan, Kementerian Pertanian)
[2] McDonald G and Meylinah S 2019 Indonesia Sugar Annual Report 2019 GAIN Report Number: ID1908
[3] Lukito A 2017 Analisis usaha tani tebu rakyat dan loyalitas petani berkaitan dengan perilaku petani, peran pemerintah dan pabrik gula Thesis (Semarang, Central Java: Universitas Diponegoro, Semarang)
[4] Subiyono and Wibowo R 2005 Agribisnis Tebu: Membuka Ruang Masa Depan Industri Berbasis Tebu Jawa Timur (Jakarta: PERHEPI)
[5] Zainuddin A and Wibowo R 2019 Farmers Preference on cane breeding attributes in PT Perkebunan Nusantara X Pangan 28 45–56
[6] Pervaiz U, Khan F, Jan D and Zafarullah M 2013 An analysis of sugarcane production with reference to extension services in Union Council Malakandher-Peshawar Sarhad J. Agric. 29 37–42
[7] Dlamini M and Worth S 2016 Agricultural extension in the facilitation of improved sugarcane productivity among small scale growers in Swaziland: a swot analysis Asian J. Agric. Ext. Econ. Sociol. 12 1–13
[8] Gilbert A O, Hillary B K and Asher O C 2012 Effectiveness of extension services in enhancing outgrowers’ credit system: a case of smallholder sugarcane farmers in Kisumu County, Kenya Int. J. Agric. Manag. Dev. 2 199–207
[9] Susilowati S H and Tinaprilla N, 2012 Analisis efisiensi usaha tani tebu di Jawa Timur J. Littri 18 162–172
[10] Direktorat Jenderal Perkebunan 2016 Tebu 2015–2017 (Jakarta: Sekretariat Direktorat Jenderal Perkebunan)
[11] Thoemmes F 2012 Propensity Score Matching in SPSS p 30
[12] Suvedi M, Ghimire R and Kaplowitz M 2017 Farmers’ participation in extension programs and technology adoption in rural Nepal: a logistic regression analysis J. Agric. Educ. Ext. 23 351–371
[13] Mugonola B, Isabirye M, Deckers J, Poesen J, Wanyama J and Mathijs E 2013 Soil and water conservation technologies and technical efficiency in banana production in upper Rwizi micro-catchment, Uganda African J. Agric. Resour. Econ. 8 13–29

[14] Isyaturriyadhah I A and Yudiawati E 2017 Faktor-Faktor yang mempengaruhi partisipasi anggota gabungan kelompok tani tanjung sehati dalam kegiatan kelompok di Kabupaten Merangin Prosiding-Seminar-Nasional-Perencanaan-Pembangunan-Inklusif-Desa-Kota I 683–90

[15] Yuniati S Susilo D and Albayumi F 2017 Penguatan Kelembagaan Dalam Upaya Meningkatkan Kesejahteraan Petani Tebu Pros. Semin. Nas. dan Call Pap. Ekon. dan Bisnis (SNAPER-EBIS 2017) pp 498–505

[16] Anang B T, Bäckman S and Sipiläinen T 2020 Adoption and income effects of agricultural extension in Northern Ghana Sci. African 7 1-11.