Analysis of Agronomic Actions of Rubber Plant on Smallholder Rubber Productivity in Banjar Regency

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Analysis of Agronomic Actions of Rubber Plant on Smallholder Rubber Productivity in Banjar Regency

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Abstract:
Background*: Banjar Regency is the 4th largest rubber producer in South Kalimantan. The agronomic action of rubber plant is one of the determinants of rubber productivity. The purpose of the study was to analyze the effect of agronomic actions of rubber plant on smalholder rubber productivity in the Banjar Regency.*
Materials and Methods*: The research method was a survey method by purposive sampling and interviewed 100 rubber farmers randomly. This research was conducted in the Districts of Karang Intan, Mataraman, Simpang Empat and Cintapuri Darussalam.*
Results*: The result of this research was that the agronomic actions of rubber crop have a significant effect on the productivity of smallholder rubber in the Banjar Regency.*
Conclusion: *The multiple regression equation of rubber agronomic action on smallholder rubber productivity in Banjar Regency is* $Y = 2524{,}842 + 62{,}100X_1 + 0{,}349X_2 - 6{,}652X_3 + 0{,}514X_4 - 0{,}210X_5 + 0{,}972X_6 + 0{,}785X_7 + 0{,}007X_8 + 47{,}711X_9 + 188{,}140X_{10} - 181{,}695X_{11} + 4{,}328X_{12} - 728{,}075X_{13} + 27{,}923X_{14} - 28{,}945X_{15} - 61{,}375X_{16} + 1005{,}271X_{17} + 162{,}576X_{18} - 31{,}910X_{19}$*. The tapping length and stimulant variables significantly affect smallholder rubber productivity in Banjar Regency.*

Key Word*: fertilization, tapping, pest management*

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I. Introduction

The plantation is one of the agricultural sub-sectors that supply raw materials for large industries, absorb labor, and generate foreign exchange for the country. The plantation products which have been the national export commodities consist of oil palm, rubber, tea, coffee and tobacco. Indonesia was once the number one natural rubber producer in the world. The area of rubber land in Indonesia is the largest, but productivity is ranked 4th after Thailand, Malaysia, and Vietnam.

Rubber plantations in Indonesia, according to their operations, has divided into National Plantations (NP), Private Plantations (PP), and Smallholder Plantations (SP). The area of rubber in Indonesia in 2019 was 3,653,084 ha, with details of NP 165,467 ha, PP 241,491 ha, and SP 3,246,127 ha. The productivity reached 1,096 kg ha-1. The largest dry rubber-producing provinces are South Sumatra, North Sumatra, Riau, Jambi, West Kalimantan, and South Kalimantan[1].

South Kalimantan ranks the 6th dry rubber producer in Indonesia. In 2020, the area of smallholder rubber plantations in South Kalimantan was 245,616 ha, with a total production of 186,574 tons and productivity of 1,034 kg ha-1 (sheet)[2]. Banjar Regency is the 4th largest rubber producer in South Kalimantan after Tabalong, Balangan, and Hulu Sungai Tengah regencies. The planted area of smallholder rubber in Banjar Regency is 25,525 ha, with a production of 18,187.19 tons and productivity of 903 kg ha^{-1} (sheet)[3].

One of the steps needed in increasing the productivity of rubber plants is to apply agronomic measures of rubber plants in smallholder plantations, by recommendations from the Indonesian Rubber Research Institute including the use of planting material, according to the agro-climate of the location[4], balanced fertilization[5], according to the leaf change pattern [6], preventive management of rubber pests through soil cultivation[7] and planting antagonistic plants such as sensevieria plants [8] and curatively with chemicals, botanicals, and biological agents such as *Trichoderma* sp[9] as well as tapping concerning the physiology of latex [10].

Due to that, the agronomic actions of rubber plants by smallholder farmers on the rubber productivity in Banjar Regency need to be analyzed.

II. Materials and Methods

The research method was a survey method by purposive sampling and interviewing randomly selected rubber farmers. This research had conducted in 4 sub-districts in Banjar Regency, South Kalimantan Province.
Research sites: Karang Intan, Mataraman, Simpang Empat, and Cintapuri Darussalam districts.
Research duration: August to September 2021.
Sample siza: 100 respondents.
Sample calculation:
The total sample was obtained by the Slovin formula from the total population of rubber farmers 11,619 people.

$$n = \frac{N}{1+Ne^2}$$

$$n = \frac{11.619}{1+(11.619\ x\ 10^{\%2})}$$

$$n = \frac{11.619}{117,19}$$

$$n = 99$$

Annotation :
n = sample size; N = population size; e = margin of error 10%
Procedure methodology
The data collected were primary data (interviews using questionnaires) and secondary data (supporting data sourced from government agencies, references, and supporting publications).
Statistic analysis
Data were analyzed using SPSS version 22. The data obtained were tested for classical assumptions, which were the normality test (Kolmogorov Smirnov), heteroscedasticity test (Spearman Rho), and multicollinearity test. Data were analyzed by the F test through analysis of variance at a 95% confidence level to determine the simultaneous effect of the independent variable (X) on the dependent variable (Y). The independent variables (X) that affected the dependent variable (Y) had determined by using the t-test at the 95% confidence level (α= 0.05). Correlation analysis (r) had used to understand the level of relationship closeness between the variables of the agronomic actions of rubber plants.

Multiple regression equation with dummy variables the effect of agronomic actions of rubber plants on smallholder rubber productivity in Banjar Regency had shown below :

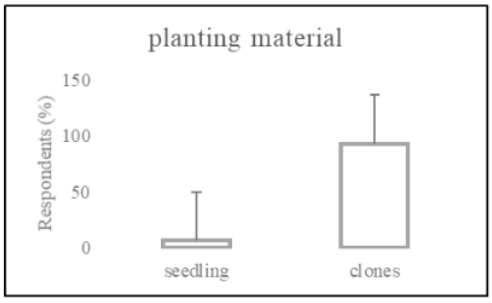
$$\mathbf{Y = b0 + b1X1 + b2X2 + b3X3 + b4X\neg4 + b5X5 + \ldots\ldots + b16X16}$$

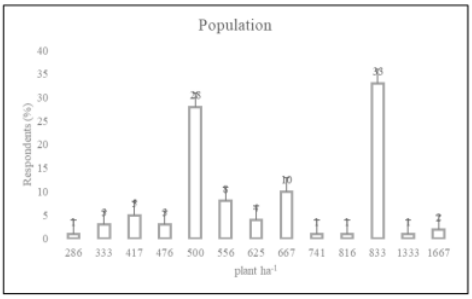
Annotation :

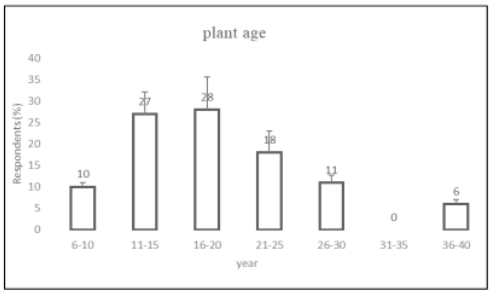
Y	=	Rubber productivity in Banjar Regency (kg ha^{-1} year^{-1})
b_0	=	Intercept
$b_{1\,2dst}$	=	Variable coefficient
X_1	=	Variable of planting material
X_2	=	Variable of population (plant ha^{-1})
X_3	=	Variable of plant age (year)
X_4	=	Variable of Phonska dosage (kg ha^{-1} year^{-1})
X_5	=	Variable of Urea dosage (kg ha^{-1} year^{-1})
X_6	=	Variable of SP36 dosage (kg ha^{-1} year^{-1})
X_7	=	Variable of KCl dosage (kg ha^{-1} year^{-1})
X_8	=	Variable of organic fertilizer dosage (kg ha^{-1} year^{-1})
X_9	=	Variable of fertilizer frequency (times year^{-1})
X_{10}	=	Variable of fertilizing method (dummy variable, incorporated to the soil = 1, not incorporated to the soil = 0)
X_{11}	=	Variable of pest and disease management (dummy variable, conducted = 1, not conducted = 0)
X_{12}	=	Variable of tapping panel to-
X_{13}	=	Variable of tapping length (S per-)
X_{14}	=	Variable of tapping thickness (mm)
X_{15}	=	Variable of tapping depth (mm)
X_{16}	=	Variable of tapping frequency (d)
X_{17}	=	Variable of stimulant used (dummy variable, used = 1, not used = 0)
X_{18}	=	Coagulant (dummy variable, recommended coagulant = 1, not recommended coagulant = 0)
X_{19}	=	Cup lump collection (days)

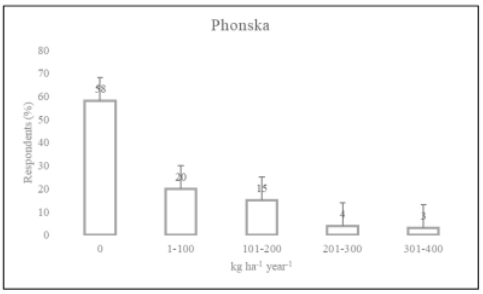
III. Results

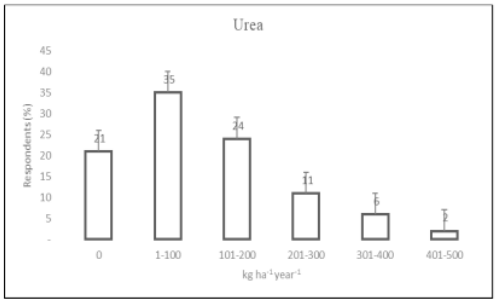
The following is the percentage of respondents for each rubber plant agronomic action variable (X) in Banjar Regency.

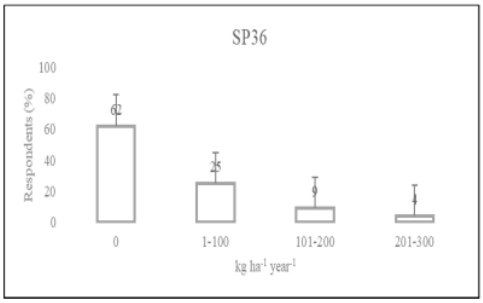


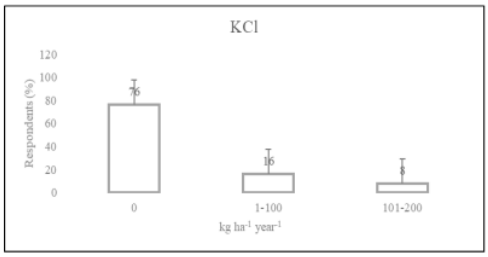


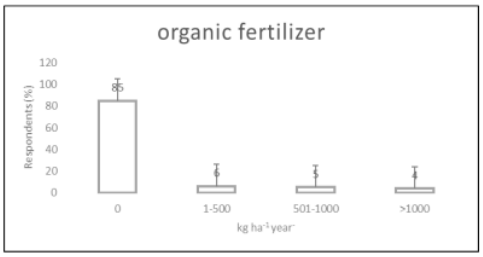


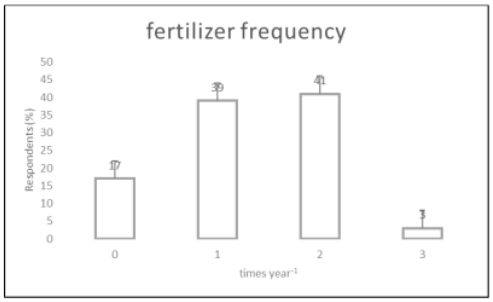


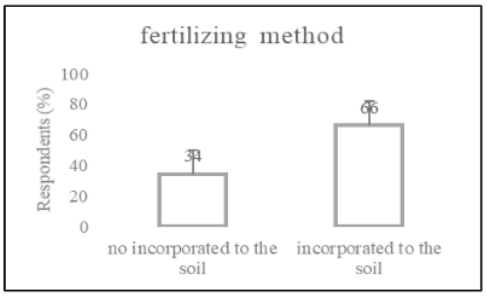


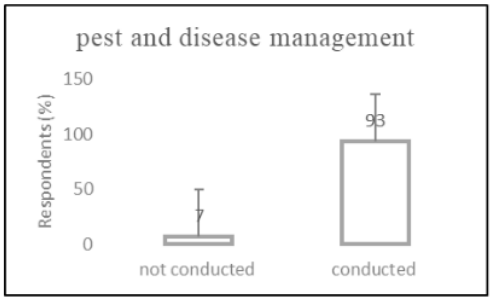


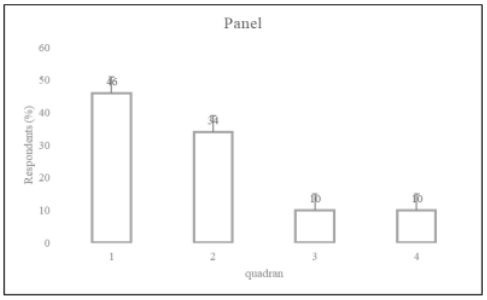


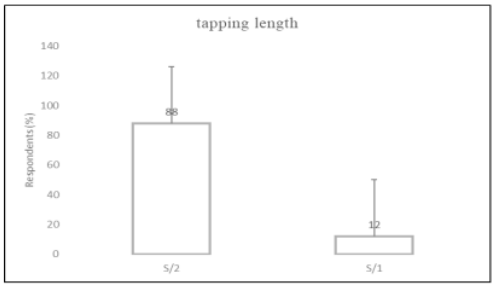


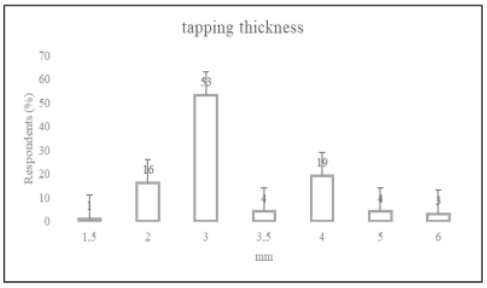

fertilizer frequency
Respondents (%)
50
45
40
35
30
25
20
15
10
5
0
17
39
41
3
0
1
2
3
times year-1

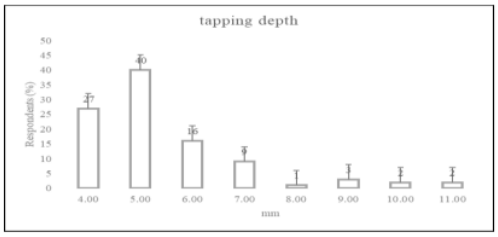

fertilizing method
Respondents (%)
100
80
60
40
20
0
34
66
no incorporated to the soil
incorporated to the soil

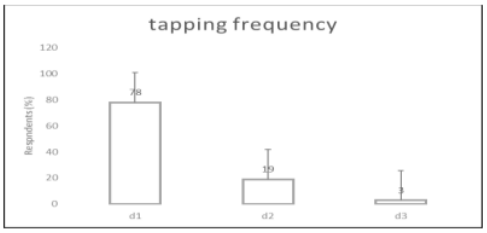

pest and disease management
Respondents (%)
150
100
50
0
7
93
not conducted
conducted

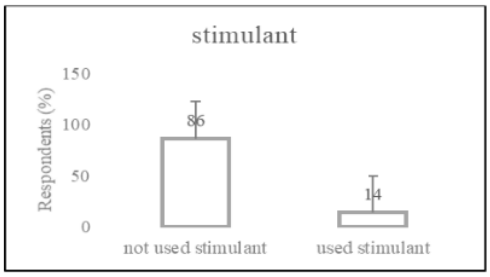

Panel
Respondents (%)
60
50
40
30
20
10
0
46
34
16
16
1
2
3
4
quadran

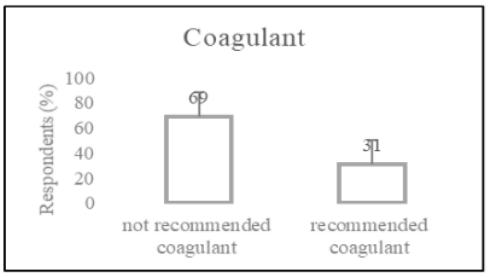

tapping length
Respondents (%)
140
120
100
80
60
40
20
0
88
12
S/2
S/1

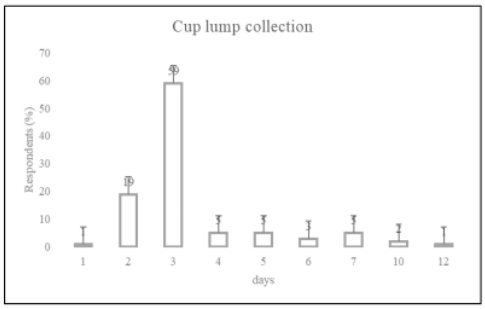

tapping thickness
Respondents (%)
70
60
50
40
30
20
10
0
7
16
53
7
19
7
7
1,5
2
3
3,5
4
5
6
mm

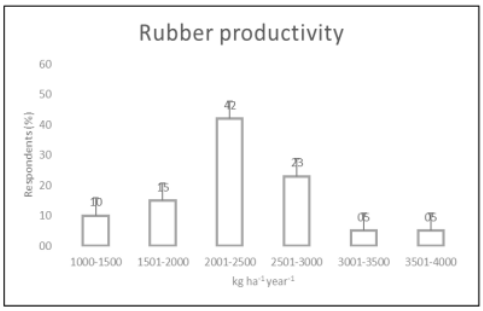

tapping depth
Respondents (%)
50
45
40
35
30
25
20
15
10
5
0
27
40
16
8
1
3
2
3
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
mm


tapping frequency
Respondents (%)
120
100
80
60
40
20
0
78
19
3
d1
d2
d3


stimulant
Respondents (%)
150
100
50
0
86
14
not used stimulant
used stimulant


Coagulant
Respondents (%)
100
80
60
40
20
0
69
31
not recommended coagulant
recommended coagulant





Analysis of Rubber Crops Agronomy Actions on Community Rubber Productivity in Banjar Regency

Table 1 showed the results of the analysis of the variance of the agronomic actions of rubber plants on the productivity of smallholder plantations in the Banjar Regency. The variable of agronomic action of rubber plantations (X) simultaneously showed very significant effect (P<α=0.01) on the productivity of smallholder rubber (Y) in the Banjar Regency.

Table 1: Analysis of variance of agronomic action of rubber plants on smallholder rubber productivity in the Banjar Regency

Model	df	Sum of Squares	Mean Square	F	Sig
Regresi	19	20258754,33	1066250,23	6,298	0,000**
Sisa	80	13543208,42	169290,105		
Total	99	33801962,75			

Annotation : ns = not significant (P>α=0.05); * = significant (P<α=0.05>0.01); ** = very significant (P<α=0.01)

Table 2 showed that the variables of planting material, spacing, plant age, Phonska, Urea, SP36, KCl, organic fertilizer, fertilizer frequency, fertilizer method, pest management, panels, tapping thickness, tapping depth, tapping frequency, coagulant, and lump collection were partially not significantly different (P>α=0.05) on smallholder rubber productivity in Banjar Regency, while the variable length of tapping and stimulants did.

Table 2 : Partial effect of agronomic actions of rubber plants on smallholder rubber productivity in the Banjar Regency

Variables	Coefficient Regression	Error Standart	t	Sig.
(Constant)	2524,842	486,688	5,188	0,000
Planting material (X_1)	62,100	201,611	0,308	0,759^{ns}
Population (X_2)	0,349	0,219	1,597	0,114^{ns}
Plant age (X_3)	-6,652	7,279	-0,914	0,364^{ns}
Phonska (X_4)	0,514	0,588	0,874	0,385^{ns}
Urea (X_5)	-0,210	0,549	-0,383	0,703^{ns}
SP36 (X_6)	0,972	0,733	1,327	0,188^{ns}
KCl (X_7)	0,785	1,256	0,625	0,534^{ns}
Organic fertilizer (X_8)	0,007	0,010	0,680	0,498^{ns}
Fertilizer frequency (X_9)	47,711	85,128	0,560	0,577^{ns}
Fertilizing method (X_{10})	188,140	118,191	1,592	0,115^{ns}
Pest & disease management (X_{11})	-181,695	196,939	-0,923	0,359^{ns}
Panel (X_{12})	4,328	51,801	0,084	0,934^{ns}
Tapping length (X_{13})	-728,075	335,297	-2,171	0,033*
Tapping thickness (X_{14})	27,923	54,787	0,510	0,612^{ns}
Tapping depth (X_{15})	-28,945	29,681	-0,975	0,332^{ns}
Tapping frequency (X_{16})	-61,375	179,021	-0,343	0,733^{ns}
Stimulant (X_{17})	1005,271	133,367	7,538	0,000**
Coagulant (X_{18})	162,576	105,367	1,543	0,127^{ns}
Cup lump collection (X_{19})	-31,910	28,067	-1,137	0,259^{ns}

Annotation : ns = not significant (P>α=0.05); * = significant (P<α=0.05>0.01); ** = very significant (P<α=0.01)

The equation for the effect of agronomic action on rubber plantations on smallholder rubber productivity in Banjar Regency is Y = 2524,842 + 62,100X1 + 0,349X2 - 6,652X3 + 0,514X4- 0,210X5 + 0,972X6 + 0,785X7 + 0,007X8 + 47,711X9 + 188,140X10 - 181,695X11 + 4,328X12 - 728,075X13 + 27,923X14 - 28,945X15 - 61,375X16 + 1005,271X17 + 162,576X18 - 31,910X19 (R^2 = 0,599).

IV Discussion

The planting material variable had no significant effect on the productivity of smallholder rubber in Banjar Regency. In line with the previous research that stated the intensity of tapping treatment on rubber seedlings did not significantly affect the increase in latex volume and dry rubber content. However, stimulant treatment significantly affected latex volume compared to do not[11].

Quick starter (QC) clones were characterized by adequate high production since the beginning of tapping and peak production in the 7-10 tapping years until reaching the lowest point in the 15 tapping years. Slow starter (SS) clones had characterized by slight initial tap production, then increased by inch until they reached peak production in the 12-15 tapping years and then stabilized until nearing rejuvenation[12].

The plant population variable had no significant effect on the productivity of smallholder rubber in Banjar Regency. In line with the results of research, which stated that differences in rubber planting spaces (4 x 6 m, 4 x 5 m, 3 x 5 m, and 3 x 4 m) did not show significantly different results on dry rubber content, ash content, and residue level[13].

The rubber plant age variable did not significantly affect the productivity of smallholder rubber in the Banjar Regency. A prior study stated that the highest weight of latex after grinding and after smoking was found at 37 years of age compared to 10, 11, and 23 years of age[14]. However, another study stated that the treatment of 10-year-old rubber had a higher dry rubber content, about 68-71%, than 30-year-old rubber[15].

The dose variables of Phonska, Urea, SP36, and KCl had no significant effect on the productivity of smallholder rubber in Banjar Regency. A study stated that rubber fertilized with compound fertilizers produced a higher latex than the single one, 263.35 and 259.48 liters, respectively, even though it was not significantly different [16]. The treatment of NPK tablets, equivalent to 75% of single fertilizer, showed the highest renewable bark thickness compared to the NPK treatment of 15%, 20%, and 50% of a single fertilizer dose but not significantly different[17].

The efficiency of N fertilization is generally below 50% even with good management because it is susceptible to evaporation, leaching, and denitrification. Rubber fertilization with a single fertilizer treatment (Urea, SP36, and KCl of 300, 400, and 300 g plant^{-1}) showed no significantly different dry rubber yield from the Mutiara fertilizer treatment 16-16-16 350 g plant^{-1}. Rubber plants that received the compound fertilizer treatment produced 68,755 kg of dry rubber, while those that received single fertilizer treatment only 67,614 kg[16]. Fertilizer application on the rubber-producing plant with KCl doses of 250, 300, 350, and 400 g plant^{-1} showed that rubber productivity was not significantly different[19].

Variables of organic fertilizer application did not show a significant reaction to the productivity of smallholder rubber in the Banjar Regency. Research on the different types of organic fertilizers in subsoil soil in rubber nurseries showed no significant effect on the variable dry weight of seeds and crown-to-root ratio[20].

The productivity of smallholder rubber in the Banjar Regency did not significantly affect by the fertilizer frequency variable. The frequency of fertilization in rubber plantations with macro-nutrient deficiencies is conducted twice a year, i.e., in April and October (early dry and rainy seasons, respectively)[21].

The proper time of fertilization follows the leaf turnover of leaf stadia in phase 3 (all leaves falling and brown leaf buds appear) and phase 4 (leaves starting to turn light green). Especially the application of nitrogen fertilizer which can accelerate leaf recovery to form perfect leaves [22].

Partially, the fertilizer method did not significantly influence the productivity of smallholder rubber in the Banjar Regency. Loss of nutrients by broadcasting is about 30%, while incorporation is nearly 2%. Loss of N due to evaporation is higher than leaching by rainwater[23].

Pest and weed management variables partially have no significant effect on smallholder rubber productivity in Banjar Regency. The weed management frequency is between 1 - 4 times per year. The main pests that often attacked farmers' rubber plants were termites. The active ingredients for controlling pests on rubber plants such as termites, ants, grasshoppers, caterpillars, and others were Delmaterin, Chlorphyritos, Betasulfetrin, Karbaryl, and Karbofuron[24]. Diseases that attack rubber were white root fungus, upas fungus, dry tapping groove, moldy rot, and leaf fall disease.

Management of white root disease by[24] 1) removing and eradicating of roots remain; 2) cultivation of legume plants; 3) planting healthy seedlings, do not plant host plants such as tubers or gum plants, sowing sulfur 100-200 g plant^{-1} at 1 m away from the stem during immature rubber plantation; 4) prevention by planting antagonistic plants such as Curcuma, galangal, arrowroot, zigzag plant, the miracle leaf, pandanus, and green chiretta[25], sansevieria[8] etc; 4) technical culture by fertilization and weeding; 5) curative efforts by treating diseased plants every six months and eradicating dead plants or using biological agents *Trichoderma* sp[9].

Tapping panel dryness (TPD)[l] were susceptible to QS clones such as PB 260, BPM 1, PB 330. PB 235, PR 261 and RRIC 100[23]. Dry control of tapping grooves by: 1) giving extra KCl at 160 g plant^{-1} year^{-1} fertilizer on plants with symptoms of TPD[12] ; 2) preventive efforts include tapping management according to the typology of rubber clones, tapping and application of stimulants according to recommendations, technical culture including plant maintenance and fertilization, low tapping frequency during the dry season and 3) the curative

control by bark scraping technique, application of NoBB formula, antico F-96, and vegetable allelochemicals for 3 months[26].

Upas fungal disease (*Corticium salmonicolor*) attacked the main rubber branches causing brownish-black latex to melt on the surface of the stem, then rot and dry, peeling off, causing the crown to break and die. Curative by applying functional with the active ingredient tridemorph on the peeled rotten stem skin [24].

Moldy rot disease (*Ceratocystis fimbriata*) attacked the tapping area by forming gray hyphae parallel to the tapping groove extending to the cambium and wood. Preventive by not planting susceptible clones such as GT 1, narrow spacing, and deep tapping depth. Curative by applying a fungicide with the active ingredients of carbendazim, benomyl, methyl thiofanate, penta chloro nitro benzene and dipping the tapping knife into the fungicide solution[24].

The symptoms of Fusicoccum leaf fall disease (fungus *Neofusicocum* sp.) were a brownish symmetrical zone on the leaf surface. The leaves would dry, fall off, or hang abnormally on the branches. Preventive by planting more than one clone and fertilizing according to recommendations. Curative by misting fungicides with active ingredients triadimefon or hexaconazole[24].

The panel variable had no significant effect on the productivity of smallholder rubber in the Banjar Regency. The height of the tapping field determines the wooden lath, the size of metal ribbon, and the number of latex vessels. However, the clone determines the thickness of the bark and the number of laticifer rings[27]. Tapping downwards causes the tapping panel separate from the crown so that the flow of photosynthate and the latex regeneration process had inhibited[28].

The tapping length variable had a significant effect on the productivity of smallholder rubber in the Banjar Regency. Short tapping cut in GT1 clones increased sucrose concentration (assimilate material) and inorganic phosphate (energy to convert sucrose into rubber particles). Moreover, it stabilized turgor pressure and latex cell gradient, then the flow pressure rate increased, and assimilated products had transported smoothly[28]. The appropriate system for clone PB260 were tapping cut at S/2 U d3 ETG /27d production 19,27 g p^{-1} s^{-1} and S/4 U d3 ET /30d production 18,90 g p^{-1} s^{-1} with the tiol concentration 0,4 mM[29].

The variables of tapping thickness and depth did not significantly affect the productivity of smallholder rubber in the Banjar Regency. The older the plant, the more scattered the latex vessels. The distribution of laticifers until the age of 5 was 66.8-68.8% of 1-2 mm away from the cambium. Meanwhile, at the age of 15-20 years, 44.8% and more than 20 years tend to be evenly distributed with a further distance to the cambium[27]. The characteristics of the GT1 clone were a thick renewable bark, potential, and resistance to exploitation pressures, while the QS clone had a low potential renewable bark[30].

The tapping frequency had no significant effect on the productivity of smallholder rubber in the Banjar Regency. The decrease in tapping frequency caused the number of tapping days to diminish, which affected the cumulative rubber production. The decrease in the number of tapping days per year greatly affected the cumulative production of rubber[31]. The tapping frequency d2 S/2 showed the balancing between latex production and formation[32].

The stimulant variable had a very significant effect on the productivity of smallholder rubber. Giving ethylene stimulant affected the surrounding tissue area of 80-120 cm[10]. Ethylene absorbs water from the cells around the laticifer, which causes the turgor pressure to rise so that the latex flow rate increases[33]. The faster and extensive the flow of latex, the more volume of latex produced[34]. The impact of ethylene application on rubber plants occurred for nine days[10]. Ethylene slowed the blockage of latex vessels so that latex flows longer [24].

Pemberian stimulan meningkatkan aktivitas metabolisme ditandai oleh peningkatan Phosfat Inorganik sebagai indikator sedang berlangsung konversi sukrosa menjadi partikel karet dan peningkatan Thiol sebagai antioksidan terhadap ROS akibat penekanan metabolisme dan eksploitasi berlebihan[28].

The stimulant application was recommended only for SS clones, while QS clones do not[12]. The tapping on clones RRIM 600 and PB 217 was not enough to explore their production potential, so alternative stimulants are needed[32]. Latex production per tapping after ethylene application for clone PB 260, PB 217, and GT1 increased by 24.1%, 73.6%, and 52%, respectively. SS clones (GT1 and PB 217) performed better to ethylene than QC clones such as PB 260[3].

The coagulant variable had no significant effect on the productivity of smallholder rubber in Banjar Regency. SP36 fertilizer and alum absorbed water when used as a coagulant[35]. The highest weight loss had shown by slab with TSP coagulant[36].

The cup lump collection variable has no significant effect on the productivity of smallholder rubber in the Banjar Regency. A long slab stored caused weight loss because the moisture content of slab evaporated and then decreased in wet weight. The longer it had stored, the content of dry rubber slab clumped with the recommended coagulant increased up to 84%, and the weight decreased to 70%. On days 1-2 days of storage, the weight of the slab and cup lump shrank intensively, and it continued until constant weight[37].

V. Conclution

The agronomic action of rubber plantations simultaneously had a significant effect on the productivity of smallholder rubber in the Banjar Regency. The tapping length and stimulant variable had a significant and very significant effect on the productivity of smallholder rubber in Banjar Regency, respectively. The multiple regression equation of agronomic action of rubber plant on smallholder rubber productivity in Banjar Regency was Y = 2524,842 + 62,100X1 + 0,349X2 - 6,652X3 + 0,514X4- 0,210X5 + 0,972X6 + 0,785X7 + 0,007X8 + 47,711X9 + 188,140X10 - 181,695X11 + 4,328X12 - 728,075X13 + 27,923X14 - 28,945X15 - 61,375X16 + 1005,271X17 + 162,576X18 - 31,910X19.

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