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Improving coffee taste beverage by planning ecologically through enrichment the associate plant species under people's forest cropping system

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Abstract. Robusta coffee beans is one of Indonesian's major export commodity. Unfotunately, its beverage is left behand from those Arabica's of other competitor countries. Improving beverage taste quality of Robusta, therefore, is in needing to leverage its export compitiveness. One important thing in the coffee beverage quality improving is its strong, the uniqueness and distinctiveness of its taste that should be manipulated ecologically. This research aimed at planning in improving taste beverage by enriching the associate plant species surrounding coffee crops growing under people's forest mangement. This research was conducted on the community forest area of Batutegi, Tanggamus Disrict of Lampung_Indonesia. The terestrial survey conducted on in between June to July 2018. We employed 17 sites of plot sample to identify the associate plant species exist surround the coffee crops. We started taking sample from 400 m moved up accross the landscape to reach the highest elevation of plot at arround 1,200 m ASL. Samples of raped coffee fruits taken compositely from 3-5 trees for each plot, then dried in 60^{0}C chamber room for 6 days at the Laboratory of Agronomy, Lampung University. Cupping test was conducted by 10 certiffied panelists of the Indonesian Coffee and Cacao Research Center, in Jember, East Java_Indonesia. The relationship between cofffee taste beverage with their associate plant species were determined by OLS. The result showed that there were significant relations between the quality of coffee (fragrance and flavor) with the associate plants phase of tree, shrub and undergrowth (seedling). By planning to enrich the associate species plants surround the coffee crops, we would gain the improvement taste of coffee beverage.

1. Introduction

Coffee bean is the biggest comodity in the world trading behand the petroleum. Its beverage is the biggest consume in the world. The taste of coffee beverage indeed can be created through fabrication process accompanied by adding some ingridient of chemical compounds. But this process is not a natural processess that susceptible to the comsummer health care issue and environmental impcat of the fabrication in relation to the waste dispossal process (Mussatto, 2011). The final taste even so will remain much depend on the biochemical containts in the coffee bean that only can be synthezised in nature (Gimass *et al*., 2014). Researchs on developing its quality through cultivating in natural farming, therefore, are the area of highly interest for some schollars. Bakri *et al.,* (2018) reported that the phenomenon of farmer in moving up planting on the higher elevation of the forest area was not only the behavior of the climate change adaptation to look for the most suitable elevation for the sake of improviong best production but also according to Towaha *et al*., (2014) could be consioder coffee taste quality.

One of the superior coffee beans from Indonesia, also the most cultivated on the people forest, especially in Lampung Province region with the robusta was the majority species. It meant that the robusta species has strategical value for farmers economic empowerment. According to Dirjen Perkebunan (2018), Lampung Province is the second most producing region accompanied by South Sumatera. Unfortunately, this achievement does not affect the welfare of coffee farmers. According to Incamila *et al.* (2015), the coffee produced by the farmer in Lampung Province generally categorized as non-grade coffee caused by its weak quality. In order to enhance the export competitiveness, Aranawa *et al*. (2010) argued that improve the coffee beans quality. Furthermore the final coffee consumption would be determined by the quality of taste especially that composed in the natural way on farm cultivation and to avoid adding some ingridients in fabrication process. For this reason hence the final aim of coffee cultivation is to improve the high quality of taste itself whic is determined through cupping test (Purwanto *et al*., 2005).

According (Dani *et al*., 2013) all of the ecological attributes such as elevation, climate, soil fertility, associate plant phase, and silviculture contributes immensly to the quality coffee beverage. Quality and taste of coffee beverage is also influenced by non-genetic including some ecological factors. The important factors in the determination of coffee quality highly affects the price of coffee (Nugroho *et al*., 2012). As mentioned before, the study of relationship between coffee taste and ecological factors is limited. Coffee taste quality is a determining factor of the success of export, hence the study of this relationship is necessary. This research aims to reveal the relationship coffee taste as the function of ecological factors and then the relationship wolu be applied to develop coffee taste by planning the enrichment coffe beverage taste ecollgically i.e. through rearrange the associate plant specieses growing surrond the coffee crops.

2. Material and Method

2.1. *Place and material used*

This study was conducted on the area of social forestry (HKm Hutan Kemasyarakatan) of Batutegi, Lampung Province, Indonesia, that geographical coordinate lies in between the meredian $104^0 30'34''$ *E* – $104^0 49'14''$ *E* and the longitude between $05^0 05'50''$*S* – $05^0 16'33''$*S*. The terestrial survey was conducted on during June to July 2018. The materials and equipments used were includes stationeries, compass, clinometer, camera, water-filled bucket, mass scale, oven chamber, thermometer, and statistcal analysis software.

2.2. *Observation technique*

We started surveying from 400 m moved up accross the landscape to reach the highest elevation upon of plot at arround 1,200 m ASL. We employed 17 sites of plot sample to idenfy the associate plant species existed surround the coffe crops. We made in triplicate plots for every site observation which consisted of 4 sub plots with dimension of 20 x 20 m^2, 10 X 10 m^2, 5 X 5 m^2 and 2 X 2 m^2 plots for identifying the tree, pole, shrub, and undergrowth (seedling) phases associated plants species respectively. Furthermore, sampling coffee fruits was carried out compositely taken from 3-5 tree crops for each site observation point in order to obtained around 3 kg.

2.3. *Laboratory analysis*

Laboratory analysis was to determined the taste quality test. Cupping test was conducted in Indonesian Coffee and Cacao Research Centre (Puslitkoka) in Jember_Esat Java, Indonesia. Taste quality test performed by 10 professional panels. In the process, coffee beans were grinded on a cup, and during the grinding process some cuppers smelt the fragrance that yawned. Through this fragrance, the taste of a coffee colud be well-predicted, whether it wolud be sweet, sour or stinky. Moreover, flavor precepted by tongue and nose will determine the value of quality and complexity (see SCAA, 2009a). Taste test in form of cupping test is in guidance to Specialty Coffee Associate of America/SCAA, which must include a minimum of 3 professional panelists (SCAA, 2009a). The taste factor comprises of fragrance (at the time of brewing), flavor, body (viscosity), acidity, aftertaste, sweetness, balance, clean up, uniformity and overall. Taste scores categorized into four groups 6.00–6.75 = good; 7.00–7.75 = very good; 8.00–8.75 = excellent; 9.00–9.75 = outstanding. If the total score ≥ 80 (on the scale of 100), then the coffee is categorized as a specialty coffee (SCAA, 2009b).

2.4 *Data processing and analysis method*

Taste of coffee analyzed in accordance with the taste test of SCAA (Specialty Coffee Associate of America, 2009a) in terms of fragrance and aroma, flavor, body, ratio of bitterness-sweetness, ration of acidity/salty, aftertaste, balance, cleanness, and uniformity. We only interested in investigated on the two first of taste of the coffee berverages.

2.5 *Coffee taste model*

Linear relationship (OLS: Odinary Least Square) model of coffee growing location ecological factors and the improvementment of coffee taste can be formulated (Law *et al*., 1991). We would analysis the fragrance and flavor base on the 4-phases associate plant of the coffee tree crop as the following.

The beverage fragrance as the function of associate plants of the coffee crop

Phase tree : $[Y_{1,1}]_i = \alpha_{1,0} + \alpha_{1,1}[SPEC_1]_i + \alpha_{1,2}[SPEC_2]_i + \ldots \alpha_{1,n}[SPEC_n]_i + \mu_{1,i}$

Phase pole : $[Y_{1,2}]_i = \alpha_{2,0} + \alpha_{2,1}[SPEC_1]_i + \alpha_{2,2}[SPEC_2]_i + \ldots \alpha_{2,n}[SPEC_n]_i + \mu_{2,i}$

Phase shrub : $[Y_{1,3}]_i = \alpha_{3,0} + \alpha_{3,1}[SPEC_1]_i + \alpha_{3,2}[SPEC_2]_i + \ldots \alpha_{3,n}[SPEC_n]_i + \mu_{3,i}$

Phase ground: $[Y_{1,4}]_i = \alpha_{4,0} + \alpha_{4,1}[SPEC_1]_i + \alpha_{4,2}[SPEC_2]_i + \ldots \alpha_{4,n}[SPEC_n]_i + \mu_{4,i}$

The beverage flavor as the function of associate plants of the coffee crop

Phase tree : $[Y_{2,1}]_i = \beta_{1,0} + \beta_{1,1}[SPEC_1]_i + \beta_{1,2}[SPEC_2]_i + \ldots \beta_{1,n}[SPEC_n]_i + \mathfrak{Z}_{1,i}$

Phase pole : $[Y_{2,2}]_i = \beta_{2,0} + \beta_{2,1}[SPEC_1]_i + \beta_{2,2}[SPEC_2]_i + \ldots \beta_{2,n}[SPEC_n]_i + \mathfrak{Z}_{2,i}$

Phase shrub : $[Y_{2,3}]_i = \beta_{3,0} + \beta_{3,1}[SPEC_1]_i + \beta_{3,2}[SPEC_2]_i + \ldots \beta_{3,n}[SPEC_n]_i + \mathfrak{Z}_{3,i}$

Phase ground: $[Y_{2,4}]_i = \beta_{4,0} + \beta_{4,1}[SPEC_1]_i + \beta_{4,2}[SPEC_2]_i + \ldots \beta_{4,n}[SPEC_n]_i + \mathfrak{Z}_{4,i}$

$SPEC_{1...n}$	=	The associate species plants of coffee crop founded in the field survey
$\alpha_{1,0}$ to $\alpha_{1,n}$	=	The parameter of model of the beverage fragrance
$\beta_{1,0}$ to $\beta_{1,n}$	=	The parameter of model of the beverage flavor
$\mu_{i,n}$ and $\mathfrak{Z}_{i,n}$	=	The residual error

3. Result and discussion

3.1. Associate plant species founded

In principle, this technique of improving coffee taste beverage has to be based on the arrangement of associate plant species growing surrounding the coffee crop for every growth phase: undergrowth, shrub, pole and tree. In this study, a survey and analysis of plants species of the four growth phases has been performed. From the survey, we found 35 associate species plant from all observation sites of 17 plots, as provide in Table 1. Furthermor they could be classified in 22 botanical families. It is also can be noted that *fabaceae* family is the dominant one in the study area. This family is one of the most diverse families in the world, even in Brazillia ecosystem, the geographic distribution of fabaceae as the largest one (Gomes, et al., 2018). As could be examined in the table, all the specieses of the fabaceae found were legumes that well known as their capability in nitrogen fixation from air. This character could be expected to stimulate the coffee crop growth and then enhance some biochemical composition process during bean filling. Carvalho et al. (2011) poved that the organic coffee bean showed higher content of chlorogenic acid, caffeine and trigonelline than conventional one.

Table 1. The associate plant species of coffee crops found study area for four growth phases of every species

Family	Indonesian Name	Latin Name	Growth phase of			
			Tree	Pole	Shrub	Undergrowth
Acanthaceae	Rambatan	*Mikania micrantha*				*
Aracea	Tekelan	*Eupatorium riparium*				*
	Talas	*Colocasia esculenta*				*
Anacardiaceae	Mangga	*Mangifera indica*	*			
Asteraceae	Krinyuh	*Eupatoriun perfoliatum*				*
	Sintrong	*Crassocephalum crepidoides*				*
Auracariaceae	Damar	*Shorea javanica*	*			
Bombocaceae	Durian	*Durio zibetinus*	*	*	*	*
Convolulaceae	Rayitan	*Ipomoea tribola*				*
Dilleniaceae	Kasapan	*Tetracera scandens*				*
Euphorbiaceae	Karet	*Ficus elastica*	*	*	*	*
	Kemiri	*Aleurites moluccana*	*			
Fabaceae	Petai	*Parkia speciosa*	*	*		
	Dadap	*Erythrina variegata*		*		
	Lamtoro	*Leucana leucocephala*		*		
	Gamal	*Gliricidea sipeum*			*	
	Sono Keling	*Dalbergia latifolia*	*	*	*	*
	Kaliandra	*Calliandra callothesus*				*
	Mimosa	*Mimosa pudica*				*
	Jengkol	*Pitecolobium lobatum*	*	*	*	
Iophatherium	Rumput Bambu	*Pogonatherum crinitum*				*
Lamiaceae	Jati	*Tectona grandis*		*		
Lauraceae	Alpukat	*Parsea americana*	*	*		
	Medang	*Schima wallichii*	*	*		
Malvaceae	Waru	*Hisbiscus tiliaceus*	*	*		
	Kakao	*Thebroma cacao*			*	*
Meliaceae	Mahoni	*Swietenia macrophylla*	*	*		*
Mimosaceae	Sengon Laut	*Paraserianthes falcataria*	*			
Myristiaceae	Jambu Biji	*Psidium guajava*			*	*
Verbenaceae	Wareng	*Gemelina arborea*	*			
	Laban	*Vitex pinnata*	*			
Polipodiaceae	Paku leyat	*Phymatodes longissima*				*
Rubiaceae	Kentangan	*Borreira latifolia*				*
Rhamnaceae	Kayu Afrika	*Maesopsis eminii*	*			

Zingberaceae	Temu Lawak	*Curcuma xantorhiza*	*

Source: research result (2017); Note: *available

3.2. The effect of undergrowth phase of the associate plant species on the fragrance

The role of associate plants species of undergrowth phase on the fragrance of coffee beverage was summarized in Table 2.

Tabel 1. ANOVA of the effect of undergrowth phase of associate plant species on the fragrance value

Source	DF	SS	MS	F	P
Regression	18	2.54684	0.14149	2.89	0.097*
Residual Error	6	0.29430	0.04901		
Total	24	2.84088			

S = 0.221371 R-Sq = 89.6% R-Sq(adj) = 58.6%

As depicted in Table 2, eventhough was only 58.6% [as expressed by the R-sq (adj)], the undergrowth phase of the associate plant species were significantly affected to the fragrance. This claim was proven by it P=0.097. According to Azwar (2005), significant level (p) or α is described as proportion or percentage, meanwhile (1- α)100% is known as confidence level. As an example, if we decided α on 0.05 or 5% means that we decided confidence level of (1-0.05) = 0.95 or 95%. We further needed to explore what the specieses that have played a significant role to the fragrance values were. We could examine it in the Tabel 3.

Table 2. The T test of the effect the undergrowth phase associate plants species on the fragrance value

Predictor (Associate plants)		**Coef.**	**SE Coef.**	**T**	**P**	**Signif.**
Indonesian Name	English (Latin) Name					
Constant	-	5.9586	0.4551	13.09	0.000	
Bandotan	----(*Geratum conyzoides*)	1.0000	0.2711	3.69	0.010	**
Cabai	Chili (*Capsicum annum*)	-0.0018	0.3270	-0.01	0.996	
Cempaka	----(*Magnolia champaca*)	1.7123	0.5819	2.94	0.094	*
Cengkeh	Clove (*Eugenia aromatica*)	1.1241	0.5664	1.98	0.094	*
Kakao	Cocoa (*Theobroma cacao*)	1.9623	0.5819	3.37	0.015	**
Kaliandra	---(*Calliandra collethesus*)	0.1664	0.1888	0.88	0.412	
Karet	Rubber (*Ficus elastica*)	0.0009	0.3166	0.00	0.998	
Kentangan	-----(*Borreira latifolia*)	0.6250	0.2711	2.31	0.061	*
Kerinnyuh	-----(*Eupatorium riparium*)	1.3750	0.3131	4.39	0.005	***
Mimosa	-----(*Mimosa pudica*)	0.0018	0.1828	0.01	0.992	
Rambatan	-----(*Mikania micrantha*)	0.1241	0.1635	0.76	0.477	
Randu	Kapook (*Ceiba pentandra*)	-0.2473	0.4087	-0.60	0.567	
Rumput Bambu	-----(*Pogonatherum crinitum*)	-0.3336	0.3977	-0.84	0.434	
Sengon	-----(*Paraserianthes falcataria*)	-0.6645	0.5017	-1.32	0.234	
Sintrong	---(*Crassocephalum crepidoides*)	-0.8355	0.2832	-2.95	0.026	**
Sonokeling	Rosewood (*Dalbergia latifolia*)	-0.9586	0.3977	-2.41	0.053	*
Paku leyat	-----(*Phymatodes longissimi*)	0.7114	0.3656	1.95	0.100	
Tekelan	-----(*Eupatorium riparium*)	0.7500	0.3131	2.40	0.054	*

Note: *p* = *<10%, **<5%, ***<1%

As could be examined in Table 3, that was from 18 associate plant species only did the *Sintrong* and *Sonokeling* (Rosewood) could reduce the fragrance value whereas the 8 other specieses could improve significantly and the 8 specieses remain were neutral. There was currently no research reported to understand the mechanism of fragrance improvement by seedling phase of associate plant. Despite coffee bean physical and beverage quality attributes being inherent factors, the environment, which includes crop management factors, can play a major role in determining their expression (Odeny *et al.,* 2015). The roles believed that the ecological mechanism is still performed such as relations among biotic, abiotic, and silviculture factors surrounding the coffee plants. Further research is in needing to reveals the ecological mechanisme of affecting the fragrance by some associate species plants. Base on this finding, however, we recommend that plant with both the *Sintrong* and *Sonokeling* (Rosewood) species should be avoiding in reforestration planning. In contrast, we prefer to retain the 16 others as the associate plants specieses in order to impove the fragrance taste of Robusta coffee beverage.

3.3. The Effect of shrub phase associate plant species on the fragrance value

Table 4 showed the shrub phase associate plant specieses were signicantly affected fragrance value. It was was connoted by its R-Sq of 68.3% with P=0.003. To examine which species that had the positively or negatively effect on the fragrance we depicted the T test result in Table 4.

Table 4. ANOVA the effect of shrub phase of associate plant species on the fragrance value

Source	DF	SS	MS	F	P
Regression	8	1.19746	0.14968	5.63	0.003
Residual Error	13	0.34577	0.02660		
Total	21	1.54323			

S = 0.163087 R-Sq = 77.6% R-Sq(adj) = 63.8%

There were 8 species founded in the field obseration. For which species of the associate plant species have the effect on the fragrance we need to examine Table 5. Of the 8 species only did Cengkeh (clove) and *sonokeling* (rosewood) expressed the negative effect on the fragrance value. In contrast only did the Jambu (guava) species had psotivley impact and the 6 others were neutral.

Table 5. The T test of the effect the growth phase associate plants species on the fragrance value

Predictor (Associate Plants)		Coef.	SE Coef.	T	P	Signif.
Indonesia Name	English (*Latin*) Name					
Constant		7.65909	0.0492	155.76	0.000	
Cengkeh	Clove (*Eugenia aromathica*)	-0.3725	0.1823	-2.04	0.062	**
Gamal	Cuickstick (*Gliricidea sipeum*)	0.1334	0.0952	1.40	0.185	
Jambu	Guava (*Psidium guajava*)	0.3409	0.1703	2.00	0.067	**
Jengkol	--------(*Pitecolobium lobatum*)	-0.1675	0.1823	-0.92	0.375	
Kakao	Cocoa (*Theobroma cacao*)	-0.0425	0.1823	-0.23	0.819	
Pala	Nutmeg (*Myristica fragrans*)	0.2075	0.1823	1.14	0.276	
Randu	Kapook (*Ceiba pentandra*)	-0.1675	0.1823	-0.92	0.375	
Sonokeling	Rosewood (*Dalbergia latifolia*)	-1.0425	0.1823	-5.72	0.000	****

Note *p* : **<10%, ***<5%, ****<1%

Untill nowadys there is also no study on ilucidating the mechanism of affecting the fragrance of the associate plants species especially of the shrub phase. We, anyhow, based upon this research finding it is strongly also recommed that avoid using *sonokeling* (rosewood) and clove in reforestation planning on coffee agroforestry in the area concern. In contrast we recommend that use the 6 other remain specieses on the planning. Furthermore, guava special should have strongly recommeded due to its highly economic value in people forest as well as the reason of the diversity improvement effort in the study area. By doing so, the reforestation program not only merely to meet the reclamation of forest ecosystem area but also to develope farmer income through the improvement effort of their coffee bean quality of fragrance.

3.4. The effect of pole phase of associate species plant on the fragrance value

Base on the F test we concluded that there is no significant impact of the pole phase associate plant to fragrance component. This phase could not be considered as the tool for planning encologically in developing the taste of coffee baverage. We have no idea upon consideration in applying the all associate plant species on planning reforestation as the way improving the coffee taste quality especially for the fragrance.

3.5. The effect of tree phase of associate plant specieses on the fragrance value

We have 20 associate plants species of tree phase of growth. The *F* statistic test of effect of tree phase on the fragrance value was depicted in Table 6. As could be examined in Table 6, there was significant effect of this phase on the fragrance as connoted by P=0.077. This strong effect also indicated by its R-Sq(adjt)=74,5%. For the sake of sellecting the positive, neutral, or negative impact of the tree phase, we need to examine the T test as available in Table 7.

Table 6. ANOVA of the of effect of tree phase of associate species plants on the fragrance value

Source	DF	SS	MS	F	P
Regression	20	2.72018	0.13601	4.51	0.077
Residual Error	4	0.12070	0.03017		
Total	24	2.84088			

S = 0.173710 R-Sq = 95.8% R-Sq(adj) = 74.5%

Among the 20 of this phase, there were 3 species that have significant effect in reducing the fragrance value, *e.i. afrikawood* (*Maesopsis eminii*), cempaka (*Magnolia champaca*), and *wareng* (*Gmelina arbore*). Only did the *durian* (duiro) species could improve the fragrance value whereas the other 17 remain specieses were neutral. It is also still remain poor explanation upon the mechanism on how these facts happen. Perhaps the most rational one is to examine the of the associate plants specieses in ecological role. Durio was a species have strong, extended, and deep root penetration into the soil that could reach rizhospheric zone of subsoil so that the root of the durio could uptake much more and much vary kinds of nutrients and brings them to leafe and other parts of the plant. Whenever leaf aging and falls on the land surface then decomposing process lasts, there would be released some varies and abundance of nutrient. So that there was an abundant nutrients suplay on the land surface and infiltrates by rain water into top soil and available and easly uptaken by sallow root cofee crop. Some nutrients have essential roles in physiological process during synthezing some biochemical compouds of coffee beans that affect to the fragrance and flavor of its berverage.

Table 7. The T test of tree phase associate plants species that affect to the fragrance value

Predictor (Associate Plants) Indoensian	English (Latin)	Coef.	SE Coef.	T	P	Signif.
Constant		7,8550	0,1642	47,84	0,000	
Kayu Afrika	-------(*Maesopsis eminii*)	-0,7200	0,3920	-1,84	0,140	*
Alpukat	Advocado (*Parsea americana*)	-0,0450	0,1702	-0,26	0,805	
Cempaka	------ (*Magnolia champaca*)	-0,5400	0,1800	-3,00	0,040	***
Cengkeh	Clove (*Eugenia aromatica*)	-0,3650	0,6100	-0,60	0,582	
Damar	Damar (*Shorea javanica*)	0,1350	0,4288	0,31	0,769	
Durian	Durio (*Durio zibetinus*)	0,9400	0,4210	2,23	0,089	**
Jengkol	--------(*Pitecolobium lobatum*)	-0,1400	0,3250	-0,43	0,689	
Randu	Kapook (*Ceiba pentandra*)	0,7800	0,6833	1,14	0,317	
Karet	Rubber (*Ficus elastica*)	-0,0400	0,1800	-0,22	0,835	
Kemiri	Nutmug (*Myristica fragrans*)	0,2050	0,1178	1,74	0,157	
Mangga	Jack fruit (*Arthocarpus integra*)	0,2350	0,2619	0,90	0,420	
Medang	---------------(*Schima wallichii*)	-0,2700	0,2493	-1,08	0,340	
Nangka	Jack fruit (*Arthocarpus integra*)	-0,5100	0,7490	-0,68	0,533	
Pala	Nutmeg (*Myristica fragrans*)	0,4650	0,6305	0,74	0,502	
Petai	---------- (*Parkia speciosa*)	-0,2250	0,2457	-0,92	0,412	
Songon laut	--------- (*Paraserianthes falcataria*)	-0,4500	0,6223	-0,72	0,510	
Sonokeling	Rosewood (*Dalbergia latifolia*)	0,3600	0,4145	0,87	0,434	
Wareng	---------- (*Gmelina arbore*)	-1,8000	0,8326	-2,16	0,097	**
Waru	---------- (*Hisbiscus tilaicus*)	-0,5050	0,4071	-1,24	0,283	
Mindi	Chinaberry (*Melia azedarach*)	-0,4450	0,3723	-1,20	0,298	

Note *p* : **<10%, ***<5%, ****<1%

This explanation, however, is still in needing further research, and so does the other mechanism. Base on this finding we also recommed that avoid using *afrikawood* (*Maesopsis eminii*), cempaka (*Magnolia champaca*), and *wareng* (*Gmelina arbore*)species in reforestration program in the area. In contrast using 17 other species especially for durio wherener the program also intended to retain or improving the fragrance of coffee beverage.

3.6. The effect of undergrowth associate plants species to flavor value

There was found 18 associate plants specieses in the area of the study. As depcted in Tabel 8, the *F* statistic test resulted P=0.004 that connoted that this growth phase gave significant effect on the flavor value accompanied by R-Sq (adj) = 88.1%. The *T* statistic test provide in Table 9

Table 8. The of effect of undergrowth phase of associate plants species on the flavor value of coffee beverage

Source	DF	SS	MS	F	P
Regression	18	2.36913	0.13162	10.83	0.004
Residual Error	6	0.07290	0.01215		
Total	24	2.44203			
	S = 0.110224	R-Sq = 97.0%	R-Sq(adj) = 88.1%		

As could be examined in Tabel 9, all species of this phase gave significant effect in developing coffee beverage's flavor. There were 8 species that gave the negative effect *i.e.* rubber, *mimosa, rambatan,* kapook, *rumput bambu, senggani,* and rosewood. Whereas 10 others were affected the beverage flavor value positivelly significant.

Table 9. The T test of undergrowth phase associate plants species that affect to the flavor of coffee beverage value

Predictor (Associate Plants) **Indonesian**	**English (*Latin*)**	**Coef.**	**SE Coef.**	**T**	**P**	**Signif.**
Constant		6.0382	0.2266	26.64	0.000	
Bandotan	---(*Ageratum conyzoides*)	1.2500	0.1350	9.26	0.000	***
Cabai	Chili (*Capsicum annum*)	0.2709	0.1628	1.66	0.147	
Cempaka	------ (*Magnolia champaca*)	1.3714	0.2897	4.73	0.003	***
Cengkeh	Clove (*Eugenia aromatica*)	1.0105	0.2820	3.58	0.012	**
Kakao	Cacao (*Theobroma cacao*)	1.3714	0.2897	4.73	0.003	***
Kaliandra	------- (*Calliandra callothesus*)	0.2118	0.0940	2.25	0.065	*
Karet	Rubber (*Ficus elastica*)	-0.2605	0.1576	-1.65	0.150	
Kentangan	-------- (*Borreira latifolia*)	0.2500	0.1350	1.85	0.113	
Kerinyuh	-------- (*Eupatorium odoratum*)	1.3750	0.1559	8.82	0.000	***
Mimosa	------- (*Mimosa pudica*)	-0.2709	0.0910	-2.98	0.025	**
Rambatan	------- (*Mikania micrantha*)	0.2605	0.0814	3.20	0.019	**
Randu	Kapook (*Ceiba pentandra*)	-0.6564	0.2035	-3.23	0.018	**
Rumput bambu	-------- (*Pogonatherum crinitum*)	-0.6632	0.1980	-3.35	0.015	**
Sengon	-------- (*Paraserianthes falcataria*)	-1.3577	0.2498	-5.44	0.002	***
Sintrong	---(*Crassocephalum crepidoides*)	-0.3923	0.1410	-2.78	0.032	**
Sonokeling	Roosewood (*Dalbergia latifolia*)	-1.0382	0.1980	-5.24	0.002	***
Paku Leyat	----------- (*Phymatodes longissimi*)	0.3818	0.1820	2.10	0.081	*
Tekelan	------------(*Eupatorium riparium*)	1.0000	0.1559	6.42	0.001	***

Note *p* : *<10%, **<5%, ***<1%

Based on this phenomenon, we argue that some ecological mechanisms play an important role in forming some biochemical compounds that determined the flavor in coffee crop physiology processes. We, therefore, recommend that enrich with these 10 assosciate plants species. Whereas the 7 others need to be weeded and incorporated in soil surface as the source of soil organic matter and nutrients

3.7. The effect of shrub phase of associate plant species to flavor value

Table 10 showed that of shrub phase of associate plants species affected significantly to the flavor value that implied by P=0.000. It was supporyted by the R-Sq(adj) = 79.2%.

Table 10. ANOVA of the effect of shrub phase of associate plants species on flavor value

Source	DF	SS	MS	F	P
Regression	8	1.67736	0.20967	11.93	0.000***
Residual Error	15	0.26354	0.01757		
Total	23	1.94090			

S = 0.132549 R-Sq = 86.4% R-Sq(adj) = 79.2%

As could bee examined in Table 11, there were 8 species of shrub phase growth associate plants in the research area. Among them there were 6 species that affected flavor negatively significant. The guava and *pala* species (*Myristicha fragrance*) gave postive effect signicfancantly. Only did cocoa have neutrally effect. So far, there was no published research results explaning the ecological mechanism upon this phenomenon as well. We, anyhow, base upon this recommend that plan to retain the guava and *pala* species due to their positive role in forming flavor in coffee beverage.

Table 11. The T test of shurb phase associate plants species that affect to the flavor value

Predictor (Associate Plants)		Coef.	SE Coef.	T	P	Signif.
Indonesian	English (*Latin*)					
Constan		7.6635	0.0368	208.46	0.000	
Cengkeh	Clove (*Eugenia aromatica*)	-0.4663	0.1482	-3.15	0.007	****
Gamal	Cuickstick (*Gliricidea sipeum*)	-0.0272	0.0758	-0.36	0.725	
Jambu	Guava (*Eugenia guajava*)	0.2115	0.1376	1.54	0.145	*
Jengkol	--------(*Pitecolobium lobatum*)	-0.2612	0.1482	-1.76	0.098	**
Kakao	Cocoa (*Theobroma cacao*)	0.1138	0.1482	0.77	0.455	
Pala	Nutmeg (*Myristicha fragrance*)	0.2388	0.1482	1.61	0.128	*
Randu	Kapook (*Ceiba pentandra*)	-0.0113	0.1482	-0.08	0.940	
Sonokeling	Roosewood (*Dalbergia latifolia*)	-1.1362	0.1482	-7.67	0.000	****

Note: *p* : **<10%, ***<5%, ****<1%

3.8. The effect of pole phase associate plants species to flavor value

Similar to the effect of pole phase of associate plant species to the fragrance, we also no the effect to the flavor too. So that we no recommend that do anything in planning on the flavor improving with this phase growth of the associate plant species surround the coffee crops.

There were 20 asociate plant species founded in the study area. They together affected signifanctly to the flavor value, as indicated by P=0,005 and supported by the R-Sq(adj) = 78,8% in Table 12. As depicted in Tabel 13, among the 20 species, only did *afrikawood* gave the negative effect. In contrast only did the *kemiri* species gave the positive effect, while the other 18 remains were neutral.

Table 12. ANOVA of tree phase of associate plants affecting flavor value

Source	DF	SS	MS	F	P
Regression	20	2,35591	0,11780	5,47	0,055
Residual Error	4	0,08612	0,02153		
Total	24	2,44203			

S = 0,146728 R-Sq = 96,5% R-Sq(adj) = 78,8%

Table 13. The T test of tree phase associate plants species that affect to the flavor value

Predictor (Assosiate Plants)		Coef.	SE Coef.	T	P	Signif.
Indonesian	English (*Latin*)					
Constant		7,5767	0,1387	54,63	0,000	
Kayu Afrika	------ (*Magnolia champaca*)	-0,8233	0,3311	-2,49	0,068	**
Alpukat	Advocado (*Persea amaricana*)	-0,0150	0,1438	-0,10	0,922	
Cempaka	-------(*Magnolia champaca*)	-0,0967	0,1520	-0,64	0,559	
Cengkih	Clove (*Eugenia aromatica*)	0,0183	0,5153	0,04	0,973	
Damar	Damar (*Shorea javanica*)	0,0717	0,3622	0,20	0,853	
Durian	Durio (*Durio zibentinus*)	0,1883	0,3556	0,53	0,624	
Jengkol	---------- (*Pitecolobium lobatun*)	0,2600	0,2745	0,95	0,397	
Randu	Kapook (*Ceiba pentandra*)	0,0783	0,5772	0,14	0,899	
Karet	Rubber (*Ficus elastica*)	0,0283	0,1520	0,19	0,861	
Kemiri	---------- (*Aleuritesmolluccanna*)	0,2350	0,0995	2,36	0,078	**
Mangga	Manggo (*Mangifera indica*)	0,0367	0,2212	0,17	0,876	
Medang	----------(*Schima wallichii*)	0,0350	0,2106	0,17	0,876	
Nangka	Jack fruit (*Mangifera indicai*)	0,0533	0,6327	0,08	0,937	
Pala	Nutmeg (*Myristica fragrance*)	-0,1367	0,5326	-0,26	0,810	
Petai	---------- (*Parkia speciosa*)	-0,0750	0,2075	-0,36	0,736	
Songon laut	--------- (*Paraserianthes falcataria*)	-0,7333	0,5256	-1,40	0,235	
Sonokeling	Rosewood (*Dalbergia latifolia*)	0,2717	0,3501	0,78	0,481	
Wareng	---------- (*Gmelina arbore*)	-1,1683	0,7033	-1,66	0,172	
Waru	---------- (*Hisbiscus tilaicus*)	-0,1267	0,3439	-0,37	0,731	
Mindi	Chinaberry (*Melia azedarach*)	-0,2583	0,3145	-0,82	0,458	

Untill now there was not find authors who published their research results about the ecological mechanisme to explain this phenomenon. We argued that types and the quantity of biochemical compounds in the coffee fruits would determine the flavor, while the kinds and quantity of nutrients would determine the internal cell physiologic during the compound synthesis process. And so did the some externally environmental variables of the coffee crop took important role in cell physiologic in the compound syntehsis including air temperture, soil water content, material excudate from associate plant roots etc. We, however, are in needing some comprehensive researches in order to reveal upon all of these addressed argumentation.

To increase these values, an engineering of cultivation based on agroforestry system planning has to be done in order to win the competition in coffee market, which is a key to increase the income of farmers and the recovery of biodiversity of the forest area.

4. Conclusion and recommendation

4.1. Conclusion

Based on the discussion of this study, the conclusions that can be drawn are as follows:

1. *Fragrance* of coffee can be improved significantly by these following plants: a. Seedling (Bandotan (Willy-goat weed), Cempaka (Magnolia), Cacao, Kentangan (Borerria), Kerinyuh (Champor grass), Sonokeling (Rosewood) and Takelan (Siam weed)). b. Shrub (Cengkeh (Clove), Jambu (Guava) and Sonokeling (Rosewood)). c. Tree (Cempaka (Magnolia) and Wareng (Gmelina)).
2. *Flavor* of coffee can be improved significantly by these follow plants: a. Seedling (Bandontan (Willy-goat weed), Cempaka (Magnolia), Cengkeh (Clove), Cacao, Kerinyuh (Champor grass), Mimosa, Rambatan, Randu (Java Kapok), Grass, Sengon (Albizia), Sonokeling (Rosewood), and Takelan (Siam Weed)). b. Shrub (Cengkeh (Clove), Sonokeling (Rosewood), and Jengkol)), and c. Tree (Afrika (Umbrella Tree) and Kemiri (Candlenut)).
3. The planning of quality improvement is by implementing the coffee agroforestry plan in production forest area, and enrichment and thinning of growth phase type. Agroforestry plan in the protected forest can be done by the enrichment and thinning of growth phase type based on the demand of export-target countries.

4.2. Recommendation

Based on the discussion in this study it is recommended to perform a further study about the coffee taste with the species of shade tree in the hope that the taste can attract national and internation coffee consumers.

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