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Full Length Research Paper

Stability of cassava promising varieties for high tuber and ethanol yield using Ammi model

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An experiment to evaluate the stability of cassava promising varieties for high tuber and ethanol yield using Ammi Model was done during 2007/2008 and 2009 seasons in Lumajang and Banyuwangi (East Java), Lampung Selatan (Lampung), Lampung Timur (Lampung) and Lampung Tengah (Lampung). The experiments were laid down in a RCB Design with three replications. The plot size was a 5 m x 5 m. Plants were spaced 100 cm x 80 cm and fertilizer rates 93 kg N+ 36 kg P_2O_5 + 60kg K_2O/ha were used. The clones tested were CMM 99008-3, OMM 9908-4, OMM 9904-70, CMM 99023-12, OMM 9904-111, CMM 99023-4 and MLG 10311 as promising clones with Adira 4 and UJ5 (released varieties) as checks. Fresh tuber yield (t/ha) of nine months old plants were collected. Based on stability analysis of AMMI model, the study showed that, CMM 99008-3, OMM 9908-4, OMM 9904-70, CMM 99023-4, UJ5, MLG 10311 and Adira 4 were stable clones while CMM 99023-12, OMM 9904-111, were not. The mean of the fresh tuber yield of OMM 9908-4 over locations and years was the highest (42,223 t/ha), 15 % higher than UJ5 /Kasetsart 50), equal to Rp 4.460.800,-/ha or around US $ 496. The yield potential of ethanol of OMM 9908-4 was 14472 liter/ha.

Key words: Cassava, fresh tuber yield, stability, promising clone, high yield, ethanol.

INTRODUCTION

Use of the best high yielding varieties is important in increasing production of cassava. There are eleven released varieties in Indonesia, one of them is **UJ5.** UJ5 was released in 2000. This variety was introduced from Thailand with the name Kasetsart 50. Yield trials of UJ5 were mostly done in Lampung. Adira 4 is the other released variety popular in Java. Adira 4 was released in 1987. There is need to develop new varieties which are better than UJ5 or Adira 4 in order to benefit the farmer.

Prospect of ethanol industry is good. In Indonesia, there is MEDCO Company which produces ethanol from cassava. This company is located in Lampung, Sumatera. Ethanol industry uses the fresh tuber, chips, starch or flour of cassava. Supriyanto (2006) and Broto and Richana (2006) reported that to produced 1liter of ethanol require 6 kg fresh tuber. Ginting *et al.* (2006) reported that 4-6 kg of fresh tuber is required to produce 1litre of ethanol 96 % depending on the type of variety. Supriyanto (2006) reported that cost production of ethanol in Indonesia Rp 2790,- per litre with assumption the price of the fresh root is Rp 300,-, Alfa amylase, Rp 40.000 /kg, and Gluco amylase Rp 50.000/ kg.

In Indonesia, cassavas are planted in various environments. To respond to these conditions, variety trial should be conducted on some environments during planting season. Related to the variety trial, the important information than can be gotten is information about the stability of any genotype. There are a few techniques of analysis; one of them is the technique that is based on additive models. This technique is concentrated in analysis of stability. This technique is based on regression variety performance on environment index like that was proposed and modified by Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Freeman and Perkins (1971) and Shukla (1972). Gauch (1992) proposed the technique that is based on model of AMMI (Additive Main Effects and Multiplicative Interaction). The aim of the trial was to evaluate the stability of varieties, tuber yield and ethanol yield of promising varieties.

MATERIALS AND METHODS

The evaluations were done during 2007/2008 and 2009 seasons in Lumajang and Banyuwangi (East Java), Lampung Selatan (Lampung), Lampung Timur (Lampung) dan Lampung Tengah (Lampung). The experi-

Table 1. Combined ANOVA for 9 cassava clones, 4 locations and two years for tuber yield.

Source	Degree of Freedom	Mean Square
Environnent(E)	7	37.047**
Error (a)	16	47.237
Clones (C)	8	233.371**
C x E	56	91.954**
Error (b)	128	23.807
Coefficient of Variation (%)		13,17

** = 1 % significantly different.

Table 2. Fresh tuber yield (t/ha) of cassava clones/ on eight environment, 2007/2008 and 2009.

No.	Clone/variety	Tuber yield (t/ha) Lumajang 2007/2008	Lampung Selatan 2007/2008	Lampung Tengah 2007/2008	Lampung Timur 2007/2008
1	CMM 99008-3	36.32	31.72 abc	33.33 de	25.23 de
2	OMM 9908-4	42.09	35.66 ab	40.80 bcd	42.55 a
3	OMM 9904-70	41.80	37.74 a	40.33 bcd	42.66 a
4	CMM 99023-12	36.97	27.55 bc	27.08 e	35.36 abc
5	OMM 9904-111	48.41	23.73 c	36.72 cd	19.46 e
6	CMM 99023-4	38.41	32.52 abc	50.17 a	29.72 cd
7	MLG 10311	33.51	39.81 a	49.31 ab	41.63 a
8	UJ5	40.68	37.74 a	43.06 abc	38.42 ab
9	ADIRA 4	39.55	27.62 bc	37.50 cd	32.14 bcd
Mean		39.75	32.68	39.81	34.13
LSDs 5 %		-	8.01	8.64	6.65
C.V. (%)		14.03	14.15	12.54	11.25

Note: The numbers in same colms with same letters are not significantly different at 5% level.

Table 2. Continued.

No.	Clone/variety	Tuber yield (t/ha) Lumajang 2009	Banyuwangi 2009	Lampung Selatan 2009	Lampung Tengah 2009	Mean
1	CMM 99008-3	46.87	29.81 b	30.31	23.63 e	32.15 e
2	OMM 9908-4	60.37	47.34 a	34.13	34.84 a	42.22 a
3	OMM 9904-70	52.81	43.76 a	29.65	25.41 cd	39.27 bc
4	CMM 99023-12	55.18	52.19 a	35.52	24.49 de	36.79 cd
5	OMM 9904-111	48.80	46.74 a	24.27	26.00 c	34.27 de
6	CMM 99023-4	54.43	30.96 b	30.76	17.85 h	35.60 d
7	MLG 10311	52.95	47.52 a	36.79	21.56 f	40.38 ab
8	UJ5	45.73	30.76 b	34.55	19.14 g	36.26 cd
9	ADIRA 4	48.32	43.68 a	32.52	29.57 b	36.36 cd
Mean		51.72	41.42	32.06	24.72	37.04
LSDs 5 %			10.74	-	0.96	2.79
C.V. (%)		11.48	14.99	13.53	9.63	13.17

Note: The numbers in same colms with same letters are not significantly different at 5% level.

Table 3. Analysis of variance base AMMI model for tuber yield.

Source of variance	Degree of freedom	Mean squares
Location (L)	7	37.047**
Error	16	47.237
Clone (C)	8	233.371**
C x L	56	91.954**
IPCA1	14	63.213**
IPCA2	12	39.707*
IPCA3	10	19.202
IPCA4	8	10.351
Combined error	128	23.807

**, *: significantly different at 1 % and 5 %, respectively.

experiments were laid down in a Randomized Complete Block Design (RCBD) with three replications. The plot size was 5 m x 5 m. Planting distance was 100 cm x 80 cm. Fertilizers were applied at the rate of 93 kg N+ 36 kg P_2O_5 + 60kg K_2O/ha. The cassava varieties (Treatments) used were CMM 99008-3, OMM 9908-4, OMM 9904-70, CMM 99023-12, OMM 9904-111, CMM 99023-4 and MLG 10311 with Adira 4 and UJ5 (released varieties) as checks. Fresh tuber yield (t/ha) of nine month old plants was collected. Fresh tuber yield was analysed using MSTAT (Michigan Statistic), version C software (released by Michigen State University) to obtain the combined analysis of variance. MSTATC program to obtain the combined analysis of variance. IRRISTAT (International Rice Research Institute Statistic) software, version 5.0 (released by International Rice Research Institute) was used to analyze of variance based on AMMI model, to find IPCA scores, and figure of IPCA biplot.

RESULTS AND DISCUSSIONS

The analysis of variance of 9 clones, four locations, and two years for fresh tuber yield are given in Table 1. The result can be seen that Interaction of clones and locations was significantly different for the fresh tuber yield in 9 months. Genotype interacts with environment to produce phenotype is natural low. This phenomenon was also reported by sholihin (2009) and (2011), and Kalkani and Sharma (2010).

Based on `Table 2, it can be seen that the fresh tuber yield of OMM 9908-4 was the highest in two environment i.e Lumajang (2009) and Lampung Tengah (2009), the second grade in Lumajang (2007/2008) and Lampung Timur (2007/2008). The fresh tuber of OMM 9908-4 was higher significantly than UJ5 in Lampung 2009, while the other environments, the fresh tuber yield of OMM 9908-4 was equal to UJ5. The mean of the fresh tuber yield of OMM 9908-4 over locations and years was the highest (42.223 t/ha, 15 % higher than UJ5 /Kasetsart 50), equal to Rp 4.460.800,-/ha or around US $ 496, - if US $ 1, = Rp 9000,-. The yield of OMM 9908-4 will be higher than 42.223 t/ha, if this clone is planted in better environment with high input. Sholihin *et al.* (2010) reported Malang 6 produced more than 100 t/ha when this variety was planted with plant distance 1,25 x 1,25 m and fertilized 500 kg Phonska, 300 kg Urea, and manure ferlilizer 5 t/ha. Doses of fertilizers used in this experiment was 93 kg N+ 36 kg P_2O_5 + 60kg K_2O/ha.

Red mites are an important insect pest in Cassava specially in Java. Farmers in Java do not like UJ3 because Uj3 is susceptible to red mite and tuber disease cause by *Fusarium Sp.* In order to make new variety acceptable by farmer, new variety should not be susceptible to red mite and tuber disease It was reported that OMM 9908-4 was moderately resistant to mite and to tuber disease caused by *Fusarium Sp*. (Sholihin, 2011).

Many industrial products are made from cassava, such as starch, sorbitol, fructose, glucose, crackers, and ethanol. Prospect of ethanol industry is good. The important thing in ethanol industry is supply of raw material. A good raw material is important in determining a good ethanol industry. It was reported that the yield potential of ethanol of OMM 9908-4 was 14472 liter/ha, 20 % and 33 % higher than Adira 4 dan UJ5 (Sholihin, 2011).

It can be seen from the Table 3 that the effect of clones x locations interaction was significantly different at 1 %, with AMMI models, source of variance of clones x locations interaction can be divided to some components, i.e. IPCA1, IPCA2, IPCA3, and IPCA4. IPCA 1 and IPCA 2 were significantly different, while IPCA 3 and IPCA 4 was not significantly different. Forty eight percent of interaction sum square was contributed by IPCA1, 26 % by IPCA 2, the residual was by IPCA 3 and IPCA 4.

The tuber yield of OMM9908-4 was the highest, while CMM99008-3 was lowest. Based on figure 1, it can be determined that clone which was not on one point on the vertical axis means those clones had a different main effect. The tuber yield of clone 8 (UJ5) and 9 (Adira 4) were similar, but the interaction effect with location was

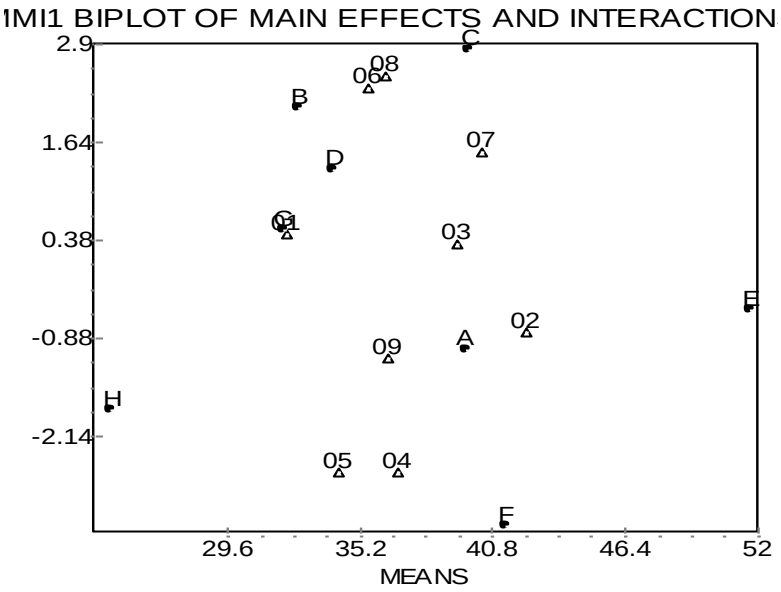

Figure 1. Biplot of IPCA 1 and fresh tuber yield in nine months
Note: 1. CMM99008-3 , 2. OMM9908-4 3. OMM9904-70 4. CMM99023-12
5. OMM9904-111 , 6. CMM99023-4 , 7. MLG 10.311, 8. UJ5 9. ADIRA 4
A: Lumajang, 07/08 B: Lampung S., 07/08 C: Lampung T., 07/08 D: Lampung T, 07/08
E: Lumajang, 09 F: Banyuwangi, 09 G: Lampung S., 09 H: Lampung T., 09

Table 4. IPCA score for locations and mean of fresh tuber yield in nine months.

Locations	Fresh tuber yield t/ha	IPCA1	IPCA2
A. Lumajang,Inceptisol, 110 m sea level, 2007/2008	39.75	-1.034	2.765
B. Lampung Selatan, Ultisol,135 m sea level, 2007/2008	32.68	2.068	-0.447
C. Lampung Timur, Ultisol, 2007/2008	39.81	2.831	1.782
D. Lampung Tengah, Ultisol, 58 m sea level, 2007/2008	34.13	1.280	-2.889
E. Lumajang,Inceptisol, 110 m sea level, 2009	51.72	-0.532	-0.027
F. Banyuwangi,Entisol, 168 m sea leavel, 2009	41.42	-3.302	-1.229
G. Lampung Selatan, Ultisol, 135 m sea level, 2009	32.06	0.507	-0.669
H. Lampung Tengah, Ultisol, 58 m sea level, 2009	24.72	-1.818	0.713

different. Clone 8 (UJ5) had positive interaction with D location while clone 9 (Adira 4) had negative interaction with D location.

IPCA score for four locations during two years and mean of tuber yield is given in Table 4. Biplot IPCA 1 and IPCA 2 for environment based on tuber yield were given in Figure 2. Based on this figure, it can be seen that locations used was a good enough. These mean that locations used was varied. Position of A (Lumajang, 07/08) was far from C (Lampung T., 07/08), H (Lampung T., 09),

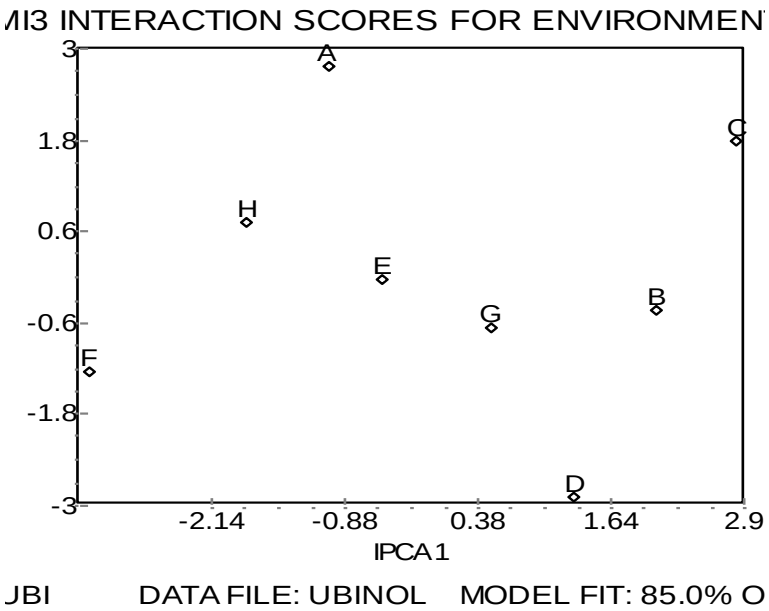

Figure 2. Biplot of IPCA 1 and 2 for environment based on fresh tuber yield in nine months.
Note: A: Lumajang, 07/08 B: Lampung S., 07/08 C: Lampung T., 07/08 D: Lampung T, 07/08 E: Lumajang, 09 F: Banyuwangi, 09 G: Lampung S., 09 H: Lampung T., 09

Table 5. IPCA score for clones and fresh tuber yield in nine months.

No.	Clones	Tuber yield (t/ha)	IPCA1	IPCA2
1	CMM 99008-3	32.15	0.465	0.911
2	OMM 9908-4	42.22	-0.813	-0.875
3	OMM 9904-70	39.27	0.335	-0.967
4	CMM 99023-12	36.79	-2.603	-2.173
5	OMM 9904-111	34.27	-2.598	2.953
6	CMM 99023-4	35.60	2.342	1.663
7	MLG 10311	40.39	1.513	-1.747
8	UJ5	36.26	2.487	0.060
9	Adira 4	36.36	-1.129	0.174

E (Lumajang, 09) G(Lampung S. 09), B (Lampung S., 07/08), and D (Lampung T, 07/08). This could attribute to variations in environment.

The average for tuber yield of OMM 9908-4 was the highest, followed by MLG 10311, OMM 9904-70, CMM 9904-100, Adira 4, and UJ5. UJ5 recorded high score on IPCA 1 (2.487) and CMM 99023-12 had low score (-2.603) (Table 5). Biplot of IPCA1 and IPCA2 for clones based on tuber yield was given in figure 3. Based on this figure, it can be identified the stability of clone. Stable clone was the clone which was close to point (0, 0) and clones OMM 9904-70, CMM 99008-3, OMM 9908-4 and Adira 4 were more stable than CMM 99023-4, MLG 10311 and UJ5. There are two possibilities in which cassava can buffer to varying environment conditions. One is that a clone is a hybrid, and second that it has a genetic potential to perform well irrespective of the environment where they are grown. There was correlation between tuber yield and starch yield because starch yield is multiplication between fresh tuber yield and starch content. Sholihin (2009) reported that environmental factors which are important in determining stability of cassava clone/variety based on the starch yield in nine months were bulk density (weight per volume of soil, g/cm^3) of soil on subsoil, rain days in fifth month, the minimum air temperature in fourth months, and

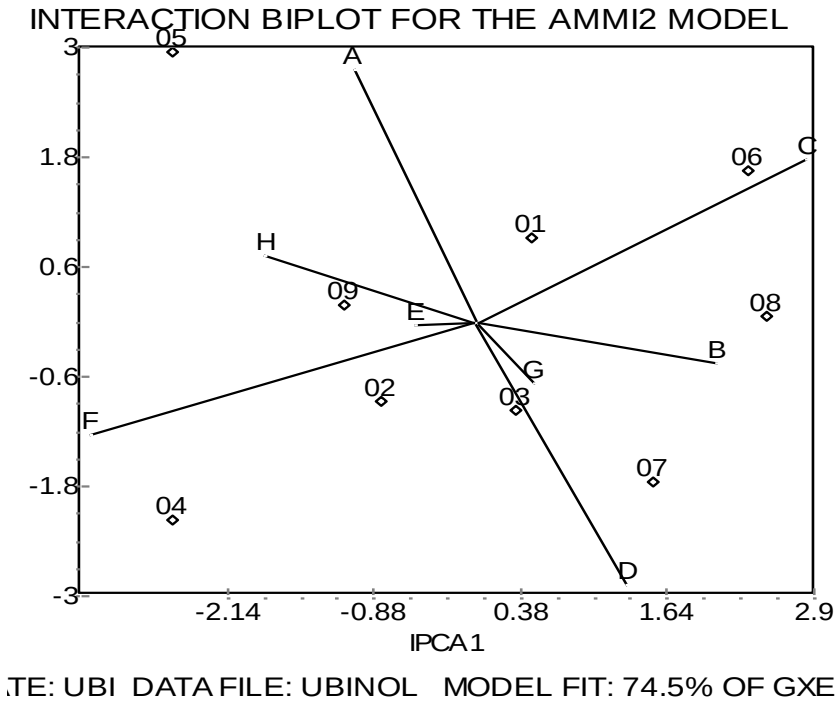

Figure 3. Biplot of IPCA 1 and IPCA 2 for clones based on fresh tuber yield in nine months

Note: 1. CMM99008-3 6. CMM99023-4
2. OMM9908-4 7. MLG 10.311
3. OMM9904-70 8. UJ5
4. CMM99023-12 9. ADIRA 4
5. OMM9904-111

A: Lumajang, 07/08 B: Lampung S., 07/08 C: Lampung T., 07/08 D: Lampung T, 07/08
E: Lumajang, 09 F: Banyuwangi, 09 G: Lampung S., 09 H: Lampung T., 09

the minimum air humidity in seventh month.

CONCLUSION

Clone OMM 9904-70, CMM 99008-3, OMM 9908-4, and Adira 4 were more stable than CMM 99023-4, MLG 10311, and UJ5.

The mean of the fresh tuber yield of OMM 9908-4 over locations and years was the highest.

The yield potential of ethanol of OMM 9908-4 was 14472 liter/ha.

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