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Genotype Interaction High Production and Early Aged Promising Lines Soybean With Environment In East Java

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Abstract

Genotype interaction with environment is general phenomenon in many countries with high biogeophysic variability as Indonesia. Different responses two or more genotypes a certain environment to the other environment will be followed by modification sequence genotype. Stability analysis and adaptability could be used to identify genotype in multilocation test. An experiment had been held in April until July 2013 at 8 locations, are experiment garden Inlitkabi Genteng Banyuwangi, Muneng Probolinggo, Kendal Payak Malang, Lumajang, Nganjuk, Ngale-Ngawi, and State Polytechnic of Jember. The choice of locations are based on centers production and altitude (≤ 500 m asl). Seven promising lines of soybean Jember multi location tested were: (1) GHJ-1, (2) GHJ-2, (3) GHJ-3, (4) GHJ-4, (5) GHJ-5, (6) UNEJ-1, (7) UNEJ-2. As well as three varieties, namely : Malabar as donor parent early maturity, (9) Ringgit as standard of comparation Malabar as donor parent early maturity, (9) Ringgit as standard of comparation standard of comparation is susceptible to leaf rust, and (10) Wilis. GHJ-1 line was result of crossing between Unej-1 x Malabar, while GHJ-2 was a reciprocal hybrid. GHJ-3 was the result of crossing between Unej-2 x Malabar, where as line GHJ, GHJ-4 and GHJ-5 was a standard of hybrid (Malabar x Unej-2). Crosses with Malabar varieties intended to shorten the lifespan of the results of its cross. Results of the experiment were as follows: Genotype GHJ which were stable and could adapt on eight research environments with high yield and early maturing age were (a) GHJ-3 genotype where the average yield is 3.02 t/ha was almost equal to the average population 3.04 t/ha, was the highest results in locations Malang 3.62 t/ha and was the highest genotype ranking Ngawi location. The mean age genotype ripe pods were shorter than the average population that is 77 days, for Probolinggo, Jember and Jombang were 73-75 after planting. (b) GHJ-5 the average of the results of genotype 3.12 t/ha was higher than the average population. The results per hectare GHJ-5 genotype in Jember, Malang and Lumajang was the highest one spot compared to the other Genotypes. The highest result in the location of Jember was 3.92 t/ha. The mean age Genotype ripe pods were shorter than the average population that was 79 days, for Probolinggo and Jombang were 75 days after planting.

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1. Introduction

Indonesia has a vast macro-geophysic environment that gives a growth environment to a very large variety of plants. However, the variety of the growth environments do not guarantee a genotype or variety will grow optimally and have high production rates in all areas. The national soybean production of Indonesia in 2014 was 892.60 thousand tons, with the island of Java producing 566.30 thousand tons. East Java accounted for 329.461 tons a year or 42.43% with productivity between 1.3-1.5 ton/ha (BPS, 2014). Until now, the national soybean productivity has only reached 1.2 tons per hectare (Jaya Mejana, 2015). According to Heriawan (2013), the national demand of soybeans has reached 2.4 million tons each year, whilst the production by farmers is estimated to be 850 thousand tons or 35% of the total demand, causing an import of 1.55 million tons from America.

The governor of East Java, Soekarwo, claims that the province has the largest soybean production rate amongst all the other provinces. As much as 350 thousand tons are produced in East Java from the total of 700-800 thousand tons of national soybean production each year. The low national soybean production rate is caused by several factors: (a). The unwillingness of farmers to cultivate soybeans due to the low selling price, thus being less attractive than other agricultural commodities such as corn and rice (b) The low productivity of only 1.2-1.3 t/ha. (c). The variation of conditions of soybean production centers causing certain plant varieties unable to adapt well.

To overcome the low production rate, a high quality variety with a high production rate of 2.5-3 ton/ha needs to be created which will then attract farmers to cultivate it. The high quality variety is an innovation in technology that is easily adoptable for farmers and can significantly contribute to increase production. The production of soybeans is in accordance with the genetically potential of its variety in which they have a high production rate, short production age, and is tolerant towards biotic and abiotic threats. The production techniques are a synthesis of high quality varieties and the LWPP (land, water, plant and pests) management technique. The innovation of technology was seen in the usage of seeds with excellent quality, the creation of drainage canals, sufficient watering and control towards certain environments.

The endeavor to reach the national demand of soybeans needs new high quality varieties which have the following characteristics: (a) Has a short production age which allow farmers to plant twice a year. (b)Has a high productivity rate (($\geq$ 2.5 ton/ha) to increase the farmer's income. (c) Can resist the main disease of soybean plants (rusting leaves) to reduce production cost. A variety with such characteristics will encourage farmers to cultivate soybeans which will be in accordance with the commitment to reduce soybean imports to increase domestic prices, along with the development of soybean plants with varieties that are suitable to each of their locations. Such a condition has caused soybean cultivators to try to find a high quality variety with a short production age and a high production rate of more than 2 tons per hectare, which is more productive than previous short-aged soybeans. The potentially high quality varieties of GHJ-1,GHJ-2, GHJ-3. GHJ-4 and GHJ-5 that were found by the research of Sjamsijah and Setyoko (2009) had a potential production rate of more than 2.5 ton/ha and had a short production age, and was ready to harvest after 73-76 days. It also had the ability to resist the rusting leaves disease.

The land and soil conditions and the growth environments in Indonesia are very varied. As a natural ecosystem, the agricultural lands have biotic and abiotic components that interact with each other. The relationship between land conditions and the plants' response towards land management will determine the productivity of the land. One of the efforts to increase soybean productivity is the endeavor to find high quality varieties which are suitable to certain environments and locations. This is caused by the fact that soybean plants have varying genetically abilities to adapt towards its surrounding environment, thus the correct selection of varieties is crucial in optimizing production. Therefore, new varieties that will be developed in production center areas need to be researched on how far the location affects the characteristics of the plants and how the productions can be used as a guideline to determine the correct varieties at the correct locations. The interaction between the plant genotype and the environment will affect the morphology of the plant (the components of the seed) during growth. The quantitative characteristics are not only caused by the genetic-environmental relationship, because genetic characteristics are not shown if they are not supported by the environment that is favorable for the plant's growth.

Information about the stability of a genotype and its interaction with the environment is crucial to be known by the farmer in deciding which variety is suitable for a certain location. These two parameters gain unprecedented importance if the evaluated varieties are those that are new and are produced from plant breeding. Some research results have shown an interaction between genotypes and the environment (GE) at various agricultural sites in several vast locations (Subhan and Edward, 2001; Paul et al. 2003). This shows that the correct selection of varieties for certain locations is much more beneficial than finding a variety that can adapt to many situations. However, varieties that have more stable results and a high capability to adapt is still very much sought for by farmers because they will give a relatively stable production rate even if they are cultivated in several different locations.

These stable varieties differ very slightly when planted in dissimilar environmental conditions. Hence, a stable variety will produce the relatively same results when they are cultivated in different environments. On the other hand, unstable varieties will react differently to each varying environment. The stability of a variety is not only shown by its production results but also by the stability of its agronomic characteristics such as the production components.

As we know, a phenotype that is seen on a plant is an effect of the interaction between the genotype and the environment, which will then affect the production of the plant. Inconsistent production caused by altering environmental conditions indicates that there is an interaction between the genotype and the environment. Simply put, the genotype x environment interaction can be distinguished into: (1) the differing response by two or more different or changing genotypes from one environment to another, in which this phenomenon does not change the ranking of the genotypes from one environment to another, and (2) the differing response of two or more genotypes from one environment to another which is followed by the change of the ranking of the genotypes. In the first condition, it does not affect the breeding program, unlike the second condition where it greatly eliminates the chance to gain a genotype that can adapat to all environments (Arsyad and Nur, 2006). According to Baihaki and Wicaksana (2009), information of the genotype x environment interaction is extremely important for countries with a vast biogeophysical variability such as Indonesia. Plant breeders can harness the potential of specific environments in deciding the area of distribution of a new high quality variety. In this case, there are two alternatives. (a) To release the variety in a vast spatial range and (b) To release the variety in a smaller and more specific range

The genotype x environment interaction in soybean plants has frequently been researched on (Arsyad and Nur, 2006). The usage of the average production value from various locations as a criteria of variety selection is inappropriate. Using a regression analysis, Finley and Wilkinson (1963) defined adaptable varieties as those that have a high production average in several environments, those that have an above-average stability to adapt to sub-optimal environments, and those that have a lower-average stability to adapt to optimal environments. The interaction between the genotype and the environment is a component that affects the result and the phenotypic expression (Karasu et al. 2009), where differing environmental conditions will result in differing responses towards the phenotypic characteristics of each genotype.

According to the concept of stability, a genotype can be said to be stable if: (1) the difference between environments is small, (2) the response towards environments is parallel with the average response of all genotypes in the same experiment, and (3) the mean squares of errors of the regression model in the environmental index is small. The stability concept states that the purpose of plant breeding caused by the genotype x environment interaction is: (1) to gain a genotype with high yield and stability in a vast variation of environments (vast adaptation), and (2) to gain a genotype with high yield in a certain environment (local adaptation).

The stability and adaptability of a genotype is important to gain, because varieties from plant breeding will be cultivated by farmers in varying environments and thus requires an adaptable variety to reduce the risks caused by changes in the environment. Stability is time-based while adaptability is spatial-based. A stability analysis is needed to distinguish characteristics of varying genotypes in several environments and to help plant breeders to select high quality genotypes. The concept used in assessing high quality varieties of soybeans is by observing the consistency of their agronomic characteristics during a series of experiments.

The capability of plant varieties to adapt in a large variation of environments has attracted the attention of many agronomic experts and plant breeders. For the cereal plant in the southern part of Australia, adaptation is imperative as the variation of environments between location and season is extremely common.

Finley and Wilkinson (1963) stated that there are two important clues in the stability analysis, which are the regression coefficient and the mean in all environments. A regression coefficient between 1.0 shows average stability. If associated to a low mean, the variety will not be able to adapt in all environments. A regression value above 1.0 shows an increase in sensitivity towards changes in the environment, below-average stability, and a larger specificity. Adaptability is inversely proportional with the mean results of a variety. Varieties that have same regression coefficient or close to 1 shows average stability, which shows bad adaptation in all environments if it is followed with a low results mean. Coefficients larger than 1 show below-average stability, and such a variety adapts in environments with low productivity.

Even though plant breeders know the importance of genetic variation in adaptability, none has been able to harness it until the breeding has been completed. This is caused by the issue in defining and measuring adaptability itself or the complexity of the environment. The interaction between the variety and environment or variety and season is the basis of adaptability measurement. Though such measurements show good results, they are not enough to overcome the dynamic responses of varieties in different environments. Such a technique also becomes inaccurate and difficult to use if the number of genotypes being tested is very large. There will be a change in the ranking of varieties from one location to another and from season to season which will cause confusion in data interpretation.

2. Research Methods

The research was conducted on MK I in soybean production centers in East Java in April to November in 2013 at eight locations, namely: Inlitkabi Banyuwangi, Experimental Garden State of Polytechnic of Jember, Inlitkabi Muneng (Probolinggo), Kendalpayak Malang, Ngale (Ngawi), Farming land in Randu Agung Lumajang, Ngudikan Nganjuk and Perak Jombang. The choice of location based on production soybean centers with the altitudes were ≤ 500 asl.

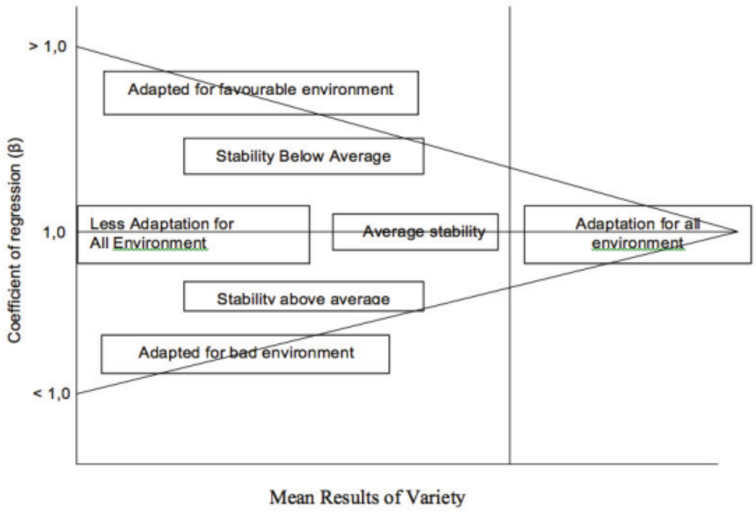

Figure 1. The general Interpretation of the pattern of population varieties If the regression coefficient varieties in plots at the mid point of varieties

Seven promising lines soybean of Jember multilocation are tested as (1) GHJ-1, (2) GHJ-2, (3) GHJ-3, (4) GHJ-4, (5) GHJ-5, (6) UNEJ-1, (7) UNEJ-2. As standard of comparation varieties are (8) Malabar as donor parent early maturity, (9) Ringgit as standard of comparison was susceptible to leaf rust, (10) Wilis as standard of comparison was medium seed and often planted in East of Java. GHJ-1 line was result of a crossing UNEJ-1 x Malabar, GHJ-2 was product reciprocal crossing. GHJ-3 was result of a crossing UNEJ-2 x Malabar, while GHJ-4 and GHJ-5 were reciprocal crossing product (Malabar x UNEJ-2). Crossing with parental variety of Malabar are mean to shorter ages their products of crossing.

The experimental design used for each location was Randomized Block Design with ten treatment (genotypes) and three repetitions. Size each plots was 2.8 x 4.5 m, or about 12.6 m^2. The distance between rows was 40 cm and 15 cm. Every hole planting filled by three seeds, after its grew left two healthy plants.

Dosage fertilizer are used are (75 kg ZA + 100 kg SP-36 + 75 kg KCl)/ha + 5 ton/ha stable manure. Half of dosage fertilizer was given at time planting, and the remnant was given at time flowering plant (30 days ages).

2.1. Setting the boundaries of the model selection and interpretation of adaptability.

Determination of variety adaptability response are used the selection boundary analysis based on regression coefficient and the average varieties yield (Finlay and Wilkinson, 1963 *cit* Blum, 1982) as are explained in Figure 1.

Table 1. Experimental Location Soil Type Characteristics, altitudes, rainfall and Numbers of Rainy Days

No.	Location of experiment farm	Soil type	Levitation (mdpl)	Rainfall (mm) 2013				Number of rainy (days)
				April	May	June	July	
1.	KP Genteng Banyuwangi	Entisol	168	---	459	294	527	35
2.	KP Politeknik Negeri Jember	Inceptisol	89	21	262	128	26	32
3.	KP Muneng Probolinggo	Alvisol	10	4	56	274	---	30
4.	KP Ngale Ngawi	Vertisol	100	275	269	103	---	38
5.	Kabupaten Lumajang	Entisol	100	4	100	241	155	36
6.	Kabupaten Jombang	Inceptisol	55	221	229	272	74	28
7.	Kabupaten Nganjuk	Inceptisol	93	---	54	192	91	15
8.	KP Kendal Payak Malang	Inceptisol	445	19	132	266	---	27

Table 2. Summary F Calculate Variety Combined

No.	Agronomic Character	Location	Rep. X Location	Genotype	Genotype x Location
1	Full seed (R2)	761.9738**	1.2778 tn	63.5981**	6.3071**
2	Beginning Maturity (R7)	619.4978**	0.3846tn	158.5205**	17.1491**
3	Full Maturity (R8)	23.5289**	2.2024tn	66.1935**	17.0603*
4	100 Seed Weight	23.4631**	2.2217**	126.0374**	4.1176**
5	Number of Pods	49.5416**	8.6748*	2.1114**	6.7865**
6	Plant height	251.2783**	3.0589**	46.1070**	6.7897**
7	Number of branch	22.0341**	1.8459*	1.5872**	1.6250*
8	Seed weight per ha	24.3611**	1.2937tn	1.2041tn	2.4382*

Result of stability test for seed weight per ha showed that GHJ-1, GHJ-2, GHJ-3, GHJ-5, UNEJ-1 and Wilis were stable genotypes, that meaning that those were have potential production a certain line same at same with the environment quality. Allard and Bradshaw (1964), explained that a line had variance change phenotype relatively same and high production consistently at different environment namely stable lines, while unstable genotypes are GHJ-4, UNEJ-2, Malabar and Ringgit with regression coefficient bigger than 1, is 1,73, its mean those lines over production at than normal level production with suitable environment that is 3,8 ton/ha at Jember, 3,34 ton/ha at

Jombang. Coefficient regression value >1 indicated improvement sensitivity forward environment change, below average stability and had bigger specificity.

Table 3. Stability Test for Seed Yield production (t/ha)

Genotype	bi	t-calc	t-table		Sd²	F-calc	F-table		Criteria
GHJ-1	0.59	-1.09	2.00	ns	-0.06	0.34	2.16	ns	Stable
GHJ-2	1.60	1.61	2.00	ns	0.02	1.18	2.16	ns	Stable
GHJ-3	0.96	-0.10	2.00	ns	0.02	1.20	2.16	ns	Stable
GHJ-4	0.98	-0.05	2.00	ns	0.12	2.23	2.16	*	Not Stable
GHJ-5	1.04	0.11	2.00	ns	0.07	1.70	2.16	ns	Stable
Unej-1	0.88	-0.33	2.00	ns	0.05	1.48	2.16	ns	Stable
Unej-2	1.05	0.12	2.00	ns	0.12	2.28	2.16	*	Not Stable
Malabar	0.64	-0.97	2.00	ns	0.61	7.43	2.16	*	Not Stable
Wilis	1.26	0.69	2.00	ns	-0.02	0.81	2.16	ns	Stable
Ringgit	1.00	0.00	2.00	ns	0.37	4.86	2.16	*	Not Stable

The number in column F followed * significantly different table to the value of 5%

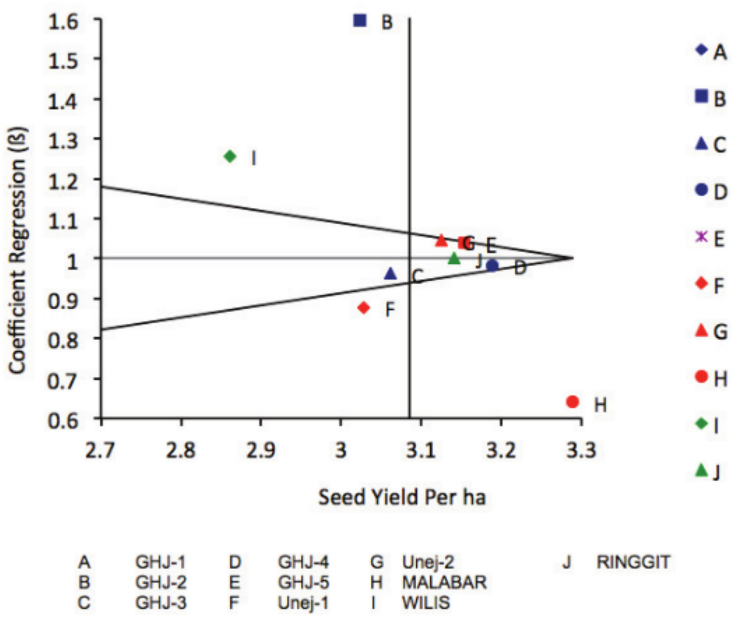

Figure 2. Stability and Adaptability Yield of Soybean

The result of multilocation of expectation soybean lines that high product and early ripening at 8 locations in Jawa Timur that were Banyuwangi, Jember, Lumajang, Probolinggo, Jombang, Nganjuk, Malang, and Ngawi showed there were un-optimal growth soybean because in the experiment location had a climate anomalies in rainfall since April to July with high intensity rainfall. At the time should be begin dry season. The influence of rainfall along vegetative growth to generative and ripening caused maturity pod become longer with ranges 77-79 and seed production per ha become un-optimal. Based on BPS data showed that soybean production per ha in 2013 at Java decreased with ranges 1.1 ton/ha.

The combined variance for yield and yield component of 10 soybean genotypes at 8 locations showed that had high significantly different between genotype interaction with flowering time, pod ripe age, harvest ripe age, weight of 100 seed. Number of filled pod and height plant character while for number of branches and weight of seed per ha showed significantly different. Those are proved that performance genotype influenced by location experiment and superior of each genotype for every location. According to Kuswanto (2007), genotype interaction x environment gave different performance phenotype interlocation, so that line that showed the superior performance in certain location had not it at the other location.

Based on Figure 3, could be explained that GHJ-4, GHJ-5, UNEJ-2 and Ringgit were categorized in able to adapted for all environment multilocation test, three genotype were crossing product UNEJ-2 with Malabar. Finley & Wilkinson (1963) stated that there are two importance guidelines for stability analysis, are regression coefficient (b) and average value for all environment, range coefficient regression 1 showed average stability.

Table 4. Stability Test Pods Maturity, R7 (days)

Genotype	Code	Average	bi	SE.b	t-calc	t-table		Sd²	F-Calc	F-table		Kriterion
GHJ-1	A	77.33	1.10	0.25	0.39	2.00	ns	3.59	20.86	2.16	*	Tdk stabil
GHJ-2	B	76.58	1.07	0.25	0.28	2.00	ns	3.62	21.08	2.16	*	Tdk stabil
GHJ-3	C	77.63	1.05	0.25	0.19	2.00	ns	2.64	15.60	2.16	*	Tdk stabil
GHJ-4	D	77.71	1.11	0.25	0.43	2.00	ns	1.80	10.94	2.16	*	Tdk stabil
GHJ-5	E	78.96	0.89	0.25	-0.44	2.00	ns	1.70	10.42	2.16	*	Tdk stabil
Unej-1	F	78.46	0.87	0.25	-0.50	2.00	ns	0.11	1.63	2.16	ns	Stabil
Unej-2	G	81.29	0.93	0.25	-0.30	2.00	ns	4.43	25.56	2.16	*	Tdk stabil
Malabar	H	78.96	0.66	0.25	-1.37	2.00	ns	20.16	112.65	2.16	*	Tdk stabil
Wilis	I	79.42	1.36	0.25	1.41	2.00	ns	1.68	10.32	2.16	*	Tdk stabil
Ringgit	J	82.79	0.98	0.25	-0.09	2.00	ns	8.12	45.95	2.16	*	Tdk stabil
Average		78.91										

The number in column F followed * significantly different table to the value 5%

Results of stability analysis of ten genotypes showed that almost all unstable except the Unej-1, This results indicated that that environmental factors were very influential on the growth of ripe pods. Rain factor that may affect plant growth is the amount or volume of rain, dissemination or distribution of rainfall and effective rainfall. Rainfall level, distribution, rainy day were different at eight location would cause the differences on ripening pods ages or unstable condition. Locations where there was rain in the phase of ripening pods, ripening pods weould retreated or became more longer. Ripening age of Unej-1 was due to the ability to adapt and avoid the un-favorable enviromental effect, genetically.

3. Conclusion and Suggestions

There are high significantly different genotype environment interaction on flowering age (R2), pod ripe age (R7), harvest age (R8), weight of 100 seeds, number of pods, plant height, number of primary branches characters, and had significantly different for seed production per/ha character. GHJ genotype is stable and able to adapt for 8 environments experiment namely GHJ-3, GHJ-4, and GHJ-5 will produced more than 3 ton/ha with early maturity.

There are two specially adapted to genotypes environment, namely: GHJ-1 is stable, specially adapted to less favorable environment experiment Banyuwangi (2,39 ton/ha) and Probolinggo (2,79 t/ha) is the first range, GHJ-2 has unstable yield and specially adapted to favorable environment, in Malang (3,72 t/ha), Jember (3,8 t/ha) and is the lowest yield when will be comparation with other genotypes. Stabilities and adaptabilities test necessary held in broader location experiment and several MK in order to more know about genotype interaction with environment at other centers soybean production.

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