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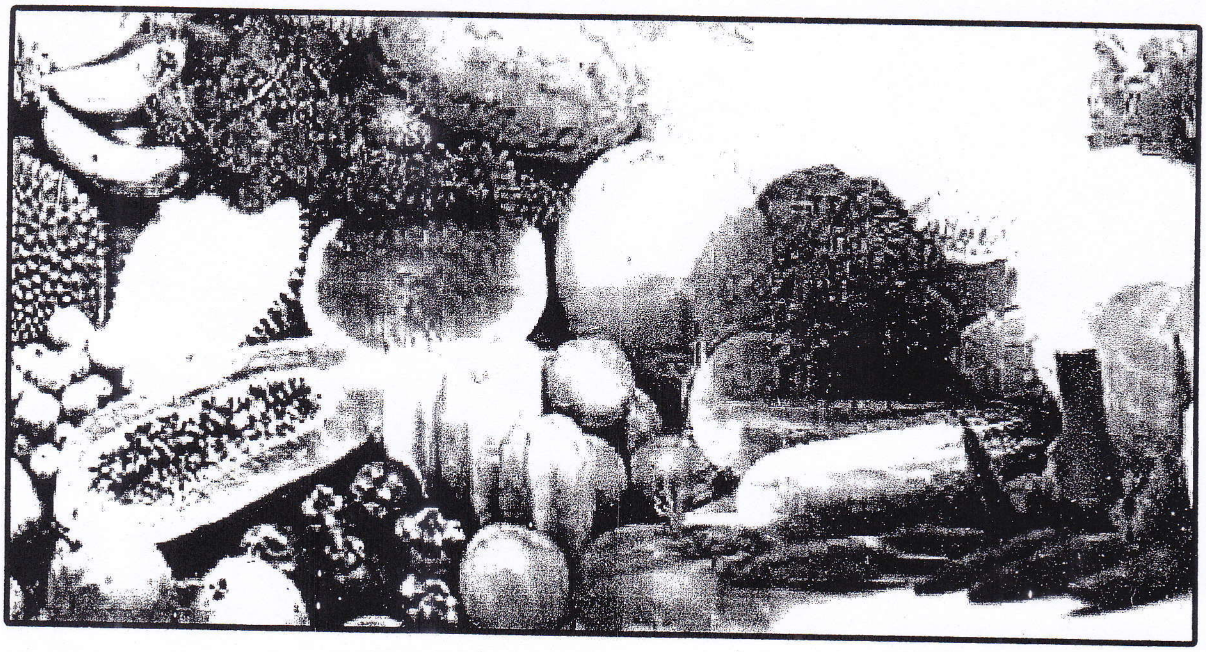

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GENETIC ANALYSIS OF MAIZE QUANTITATIVE TRAITS ON ULTISOL UNDER LOW INPUT

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ABSTRACT

The nature of magnitude genetic parameters for various traits of maize genotypes were important in the development of maize varieties which would be able to adapt on Ultisol. The objective of this experiment was to estimate the amount of genetic variability, broadsense heritability, genetic advance, types of gene actions, inter-relationships among traits and path analysis of maize traits under study. Twenty five maize genotypes consisting of local, lines and hybrid varieties were tested using Randomized Complete Block Design with three replications conducted on Ultisol in Medan Baru Village, Bengkulu Regency. The results of this eperiment revealed that maize genotypes tested showed differeces for ten traits. Vegetative components showed low genetic variation, and high genetic variation was shown by reproductive components. Biomass weight, ear diameter without husk leaves and seed weight/plant showed low to moderate heritability and low genetic advance were controlled by non-additive gene action. Direct selection based on these traits alone would be less effective. Biomass weight and ear diameter with husk leaves showed highly significant positive correlation and maximum direct effects to seed weight/plant. Indirect effects of these two traits also seems to be the cause of correlation, it should be considered simultaneously in selection program for improving maize varieties on Ultisol under low input.

Keywords: genetic parameter, maize, Ultisol, low input

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important foodcrop in Indonesia. However, this crop is less tolerant on acidic soil as Ultisol (Landon, 1984). Maize growth and yield will decrease on pH less than 4.8 (Wade *et al.*, 1988). It was predicted 59% maize cultivation in Indonesia was on Ultisol and most of them were in Sumatera (Subandi, 1988). Up to now, Ultisol is still becoming target for extensification program.

Foy (1988), Munir (1996), Sufardi (1997), Tirtoutomo and Simanungkalit (1988) and Wilkinson (1994) reported that Ultisol had physical and chemical problems such as low pH (4,2-5,0); Al, Mn and Fe saturation; high phosphate fixation by Al, Mn and Fe; low content of N, P, K, Ca, Mg and Mo; limited organic matter and water availability. Moreover, Mohr *et al.* (1972) and Ardjasa (1994) said that Ultisol had low base saturation and cation exchange capacity. Liming the surface soil does not affect subsoil acidity and adequate liming may not be economically feasible. Most of existing maize varieties had low productivity if it was cultivated on Ultisol. Generally, breeding program was designed to create new varieties which would be able to adapt on fertile lands under high input. These varieties will show limited growth and low yield if these were cultivated on marginal land under low input. Development of varieties with greater tolerance to acidic soil would increase maize productivity in Indonesia.

Assesing genetic parameters for important traits is one of the prerequisites for a successful breeding program. Coefficients of variation gives an idea of relative variability present in a population. Heritability estimates provide information on the transmission of traits from the parents to the offspring and thus facilitate evaluation of genetic and environmental effects in phenotypic variation and aid in selection. Heritability estimates with genetic advance enable breeders to predict the real genetic advance under selection (Johnson *et al.*, 1955).

Knowledge of inter-traits relationships is very important in plant breeding for indirect selection for traits that are not easily measured and for those that exhibit low heritability (Ariyo *et al.*, 1987). Correlation studies are necessary to formulate selection criteria to simultaneously improve several traits. As the number of independent traits affecting yield increases, correlation alone become insufficient to explain relationships among traits. It was due to yield being the complex outcome of different traits. Path coefficient analysis was used to determine how various traits affect yield (Fakorede, 1979; Ofori, 1995; Singh dan Singh, 1979).

The experiment aims to estimate the amount of genetic variability, broadsense heritability, genetic advance, types of gene actions, inter-relationships among traits and path analysis of maize traits under study.

MATERIAL AND METHODS

This experiment was conducted on Ultisol in Medan Baru Village, Bengkulu Regency from January till April 2008. Twenty five maize genotypes consistings of local, lines and hybrid varieties were tested using Randomized Complete Block Design with three replications. Plot size was 2 x 5 m with 80 x 20 cm plant spacing. The total dosages of Urea, SP-36 and KCl was applied only 150, 50 dan 25 kg/ha respectively, without liming and organic fertlizer. Estimation of genetic, environmental and phenotyphic variance were determined according to the formula : $\sigma^2_g = (M_2\text{-}M_3)/r$, $\sigma^2_e = M_3$ and $\sigma^2_f = \sigma^2_g + \sigma^2_e$, where M_2 was genotypic mean square, M_3 was error mean square and r was replications.

Estimation of coefficient of genetic variation (CGV) was computed to the formula of Singh and Chaudhari (1979). CGV = $(\sigma_g/X) \times 100$ %, where σ_g was square root of genotypic variance and X was mean of trait value. Criteria of genetic variability was classified based on relative CGV value for all traits studied. Absolute CGV value was determined based on relative CGV value by dividing relative CGV value to be four criteria of absolute CGV : low, rather low, rather high and high.

Broadsense heritability is computed as described by Fehr (1987), $H = \sigma^2_g/\sigma^2_f$ with criteria according to Stansfield (1983) : $0.00 < H < 0.20$ (low), $0.20 < H \leq 0.50$ (moderate) and $0.50 < H < 1.00$ (high). Genetic advance (GA) was determined as described by Singh and Chaudhari (1979) and Falconer (1989). GA = $k. H .\sigma_f$, where k was selection intensity in deviation standar unit (k = 2.06 with selection intensity 5%), H was broadsense heritability and σ_f was square root of phenotypic variance. GA was classified according to Karmana *et al.* (1990) : 0.00 – 3.30% (low), 3.31 – 6.60% (rather low), 6.61 – 10.00% (rather high) and > 10% (high). Simple correlation between traits (r) was computed by the formula as described by Spiegel (1975). Direct and indirect effects of any traits to yield was determined as described by Dewey and Lu (1959). Simultant equation was arranged in matrix form : [Rx] [C] = [Ry], where Rx was correlation matrix between traits, C was vector of path coefficient (direct effect of any traits), and Ry was vector of correlation coefficient between traits (independent variable xi) and yield (dependent variable y). From the matrix equation could be determined vector of path coefficient C. C = Rx^{-1}. Ry, where Rx^{-1} = matrix inverse of Ry.

RESULTS AND DISCUSSION

Analysis variance revealed the presence of significant differences among genotypes for ten traits studied (Table 1). Twenty five genotypes of maize exhibited rather high and high genetic variation for ear height, ear diameter with husk leaves, ear length, number of kernel rows/ear, number of kernels/row, cob diameter, seed weight/plant, harvest index and lodging resistance. Meanwhile, the remaining traits showed rather low and low genetic variation. It looked like that vegetative components showed rather low and low genetic variation. Meanwhile, reproductive components showed rather high and high genetic variation. Sutoro *et al.* (2006) reported total genetic variation for maize seed weight under low level of fertilizer application was less than that under the higher ones.

Table 1. Genetic variation of maize quantitative traits on Ultisol

Traits	F Value for genotypes	Relative CGV value (%)	Criteria of absolute CGV
1. Plant height	4.21 *	20.20	Rather low
2. Number of internodes	4.03 *	10.50	Low
3. Internode length	2.43 *	10.87	Low
4. Number of leaves	3.58 *	9.48	Low
5. Tasseling date	2.34 *	4.07	Low
6. Silking date	0.94	0.00	Low
7. Ear height	2.11 *	34.82	Rather high
8. Biomass weight	1.56	21.15	Rather low
9. Root dry weight	1.15	14.56	Rather low
10. Root length	1.24	4.64	Low
11. Ear diameter with husk leaves	1.66	36.87	High
12. Ear diameter without husk leaves	1.75 *	39.02	Rather low
13. Ear length	1.51	33.08	Rather high
14. Number of kernel rows/ear	1.57	35.31	Rather high
15. Number of kernels/row	1.71 *	45.23	High
16. Cob diameter	1.65	39.97	High
17. Seed weight/plant	1.78 *	47.11	High
18. Harvest index	1.64	40.00	High
19. Number of ears	1.36	5.56	Low
20. Lodging resistance	3.05 *	37.15	High

Estimates of the components of variance, heritability and genetic advance are shown in Table 2. Heritability estimates for plant height and number of internodes was high, 51.71 and 50% respectively. Vargas *et al.* (1994) also found plant height showed high heritability on Ultisol. Heritability was moderate (20.26-46.32%) for internodes length, number of leaves, tasseling date, ear height, ear diameter without husk leaves, seed weight/plant and lodging resistance. Those traits with moderate and high heritability suggests that genetic factors had important role than environment factors in determining phenotypic variation among genotypes. Meanwhile, heritability were low (0.00-19.13%) for silking date, biomass weight, root dry weight, root length, ear diameter with husk leaves, ear length, number of kernel rows/ear, number of kernels/row, cob diameter, harvest index and number of ears, suggests that environmental effects constitute a major portion of the total phenotypic variation for these traits. Sutoro *et al.* (2006) reported that heritability in the environment under low and moderate of fertilizer application was higher than in the environment under optimum level of fertilizer application. Zen dan Bahar (1996) reported their findings on maize was cultivated on Ultisol in Sitiung that plant height, tasseling date, silking date, tasseling date and ear height showed high heritability. Ear length, ear diameter and number of kernel rows/ear showed low heritability. Meanwhile, seed yield showed moderate heritability. These different findings were due to different genotypes used and the evironment where the experiment was conducted.

Tabel 2. Genetic, environment, phenotyphic variance, broadsense heritability and genetic advance of maize quantitative traits on Ultisol.

Traits	Variance (σ^2)			Broadsense Heritability (%)	Genetic Advance (%)
	σg^2	σe^2	σf^2		
1. Plant height	174.96	163.41	338.37	51.71	19.33
2. Number of internodes	0.61	0.61	1.22	50.00	1.14
3. Internodes length	0.88	1.86	2.74	36.50	1.26
4. Number of leaves	0.63	0.73	1.36	46.32	1.11
5. Tasseling date	9.69	21.67	31.36	30.89	3.56
6. Silking date	-2.76	138.29	135.53	0.00	0.00
7. Ear height	28.19	76.11	104.30	27.03	5.68
8. Biomass weight	7.44	39.70	47.14	15.78	2.26
9. Root dry weight	0.05	1.08	1.13	4.42	0.10
10. Root length	0.94	11.78	12.72	7.39	0.51
11. Ear diameter with husk leaves	29.32	133.86	163.18	17.97	4.74
12. Ear diameter without husk leaves	26.90	105.90	132.80	20.26	4.75
13. Ear length	4.89	28.62	33.51	14.59	1.79
14. Number of kernel rows/ ear	2.04	10.81	12.85	15.88	1.18
15. Number of kernels/row	8.98	37.95	46.93	19.13	2.68
16. Cob diameter	9.69	45.13	54.82	17.68	2.75
17. Seed weight/plant	9.61	36.76	46.37	20.72	2.95
18. Harvest index	0.01	0.05	0.06	16.67	0.09
19. Number of ears	0.0033	0.04	0.04	8.25	0.03
20. Lodging resistance	313.78	458.69	772.47	40.62	22.90

High heritability alone does not guarantee large gain from selection unless sufficient genetic advance attributable to additive gene action is present (Srivastava *et al.*, 1994). Plant height and lodging resistance showed high heritability coupled with high genetic advance (19.33-22.90%) suggests that additive type of gene action playing significant role in controlling the expression of these two traits and selection for these traits may be effective. Meanwhile, number of internodes, internode length, number of leaves, tasseling date, ear height, ear diameter without husk leaves, and seed weight/plant showed moderate heritability combined with low genetic advance suggests that these traits under the control of non-additive gene actions. Moreover, biomass weight, root dry weight, root length, ear diameter with husk leaves, ear length, number of kernel rows/ear, number of kernels/row, cob diameter, harvest index and number of ears had low heritability and low genetic advance, suggests that these traits were largely also controlled by non-additive gene actions and greater influencé of environment on the expression of these traits. Therefore, direct selection based on these traits alone would be less effective. Eberhart and Gardner (1966) found the same result that both ear length and ear diameter were controlled by additive and non-additive gene action. Pal and Prodhan (1994) also reported that seed yield, number of kernels/row, number of kernel rows/ear, and ear length were also controlled by non-additive gene actions.

Phenotypic correlation coefficients among the various traits is presented in Table 3, suggested that selection for ear height, more biomass weight, more root dry weight, big ear diameter with and without husk leaves, longer ear, more number of kernel rows/ ear, more number of kernels/row, big cob diameter and high harvest index would result in plant type possessing high seed weight/plant. The absence of correlation between traits studied suggests that selection for these traits could be practised independently.

Path coefficient analysis revealed that maximum direct contribution was made by biomass weight and ear diameter with husk leaves (Table 4). These two traits showed both highly significant positive correlation with seed weight/plant (Table 3). Therefore, these two traits are the prime important traits to select seed weight/plant. It might be related to greater photosynthetic capacity provided by robust leaves. For more efficient approach towards improvement of seed weight/plant, selection should be based on these two traits. The traits showing significantly positive correlation with seed weight/plant were ear height, root dry weight, ear diameter without husk leaves, number of kernel rows/ear, number of kernel/row, cob diameter and harvest index, but they have small direct effect, so neither of them is useful for indirect selection for seed weight/plant. Tasseling date showed significantly negative correlation with seed weight/plant and having small direct effect, so this trait would not be used for indirect selection for seed weight/plant. Kaw and Menon (1972) and Morrison *et al.* (1999) reported the same results on soybean. Plant height, number of internodes, internode length, number of leaves, silking date, root length, number of ears, and lodging resistance showed the lowest direct effects and small correlation coefficient with seed weight/plant, revealed that these traits could not be useful for indirect selection. Significantly positive correlation between ear height, biomass weight, root dry weight, ear diameter with and without husk leaves, ear length, number of kernel rows/ ear, number of kernels/row and cob diameter with seed weight/plant were mostly due to indirect effect of biomass weight and ear diameter with husk leaves. In situation where the indirect effects seem to be the cause of correlation, Singh and Chaudary (1979) suggested that the indirect causal factors should be considered simultaneously in a selection program. Singh and Ram (1983), Sumarno (1985), Mayer *et al.* (1991) and Pinaria *et al.* (1995) reported the same results on soybean. Biomass weight was the most important trait for increasing seed yield/plant on soybean. The use of biomass weight in selection program would reduce energy, cost and time needed, only by weighing dry biomass of maize. Moreover, the use of ear diameter with husk leaves for selection is easier and faster to be applicated. This fenomenon suggests that biomass weight and ear diameter with husk leaves were the best selection criteria for improving superior maize variety on acidic soil under low input.

Table 3. Correlation coefficients among traits of maize on Ultisol under low input

Traits	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	0,87**	0,90**	0,77**	0,18	-0,09	0,77**	0,45**	0,62**	0,14	0,11	0,11	0,06	0,10	0,17	0,11	0,15
2.	-	0.64**	0.99**	0.37**	-0.13	0.55**	0.32**	0.42**	0.11	-0,04	-0,03	-0,06	-0,03	0,11	-0,02	0,06
3.		-	0,63**	0,17	-0,02	0,65**	0,39**	0,59**	0,13	0,13	0,12	0,07	0,11	0,13	0,10	0,12
4.			-	0,38**	-0,12	0,53**	0,30**	0,41**	0,09	-0,05	-0,05	-0,07	-0,04	0,11	-0,02	0,05
5.				-	0,03	-0,03	-0,10	-0,02	-0,03	-0,30**	-0,27*	-0,25*	-0,30*	-0,21	-0,28*	-0,29*
6.					-	0,15	-0,01	0,01	-0,03	-0,06	-0,05	0,01	-0,06	-0,05	-0,04	-0,07
7.						-	0,52**	0,61**	0,09	0,19	0,18	0,19	0,16	0,26*	0,18	0,26*
8.							-	0,75**	0,16	0,61**	0,61**	0,51**	0,62**	0,72**	0,62**	0,72**
9.								-	0,27*	0,39*	0,37**	0,24**	0,36**	0,41**	0,36**	0,40**
10.									-	-0,07	-0,07	-0,13	-0,11	-0,06	0,01	-0,05
11.										-	0,99**	0,91**	0,98**	0,87**	0,93**	0,91**
12.											-	0,91**	0,97**	0,86**	0,93*	0,90**
13.												-	0,89**	0,82**	0,87**	0,85**
14.													-	0,87**	0,91**	0,91**
15.														-	0,86**	0,98**
16.															-	0,89**
17.																-
18.																
19.																

Traits	18	19	20
1.	0,07	-0,04	0,30**
2.	-0,06	-0,11	0,35**
3.	0,08	0,10	0,11
4.	-0,07	-0,11	0,34**
5.	-0,36**	-017	-0,07
6.	-0,06	0,50**	-0,08
7.	0,11	0,18	0,19
8.	0,52**	0,17	0,21
9.	0,31**	0,20	0,09
10.	-0,12	0,09	-0,26*
11.	0,92**	0,20	0,06
12.	0,89**	0,18	0,07
13.	0,85**	0,13	0,07
14.	0,93**	0,17	0,09
15.	0,82**	0,14	0,12
16.	0,86**	0,14	0,05
17.	0,85**	0,14	0,10
18.	-	0,19	0,10
19.		-	-0,13

Table 4. Direct and indirect effects of maize traits to seed weight/plant on Ultisol under low input

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1.	**0,023124**	0,043061	-0,1089	0,058129	-0,00885	0,004781	0,020088	0,176645	-0,10276	-0,00605	0,064089	-0,03089	0,007764
2.	0,020118	**0,049496**	-0,07744	0,074738	-0,01819	0,006906	0,014349	0,125614	-0,06961	-0,00476	-0,02331	0,008426	-0,00776
3.	0,020812	0,031677	**-0,121**	0,04756	-0,00836	0,001062	0,016958	0,153092	-0,09779	-0,00562	0,075741	-0,0337	0,009058
4.	0,017806	0,049001	-0,07623	**0,075493**	-0,01868	0,006375	0,013827	0,117763	-0,06795	-0,00389	-0,02913	0,014043	-0,00906
5.	0,004162	0,018313	-0,02057	0,028687	**-0,04916**	-0,00159	-0,00078	-0,03925	0,003315	0,001297	-0,17479	0,07583	-0,03235
6.	-0,00208	-0,00643	0,00242	-0,00906	-0,00147	**-0,05312**	0,003913	-0,00393	-0,00166	0,001297	-0,03496	0,014043	0,001294
7.	0,017806	0,027223	-0,07865	0,040011	0,001475	-0,00797	**0,026089**	0,204123	-0,1011	-0,00389	0,110699	-0,05055	0,024587
8.	0,010406	0,015839	-0,04719	0,022648	0,004916	0,000531	0,013566	**0,392544**	-0,12431	-0,00692	0,355402	-0,17132	0,065997
9.	0,014337	0,020788	-0,07139	0,030952	0,000983	-0,00053	0,015914	0,294408	**-0,16574**	-0,01167	0,227224	-0,10391	0,031058
10.	0,003237	0,005445	-0,01573	0,006794	0,001475	0,001594	0,002348	0,062807	-0,04475	**-0,04324**	-0,04078	0,01966	-0,01682
11.	0,002544	-0,00198	-0,01573	-0,00377	0,014747	0,003187	0,004957	0,239452	-0,06464	0,003027	**0,582627**	-0,27804	0,11776
12.	0,002544	-0,00148	0,01452	-0,00377	0,013273	0,002656	0,004696	0,239452	-0,06132	0,003027	0,5768	**-0,28085**	0,11776
13.	0,001387	-0,00297	-0,00847	-0,00528	0,012289	-0,00053	0,004957	0,200197	-0,03978	0,005621	0,53019	-0,25557	**0,129407**
14.	0,002312	-0,00148	-0,01331	-0,00302	0,014747	0,003187	0,004174	0,243377	-0,05967	0,004756	0,570974	-0,27242	0,115172
15.	0,003931	0,005445	-0,01573	0,008304	0,108639	0,002656	0,006783	0,282632	-0,06795	0,002594	0,506885	-0,24153	0,106114
16.	0,002544	-0,00099	-0,0121	-0,00151	0,013764	0,002125	0,004696	0,243377	-0,05967	-0,00043	0,541843	-0,26119	0,112584
18.	0,001619	-0,00297	-0,00968	-0,00528	0,017697	0,003187	0,00287	0,204123	-0,05138	0,005188	0,536016	-0,24996	0,109996
19.	-0,00092	-0,00544	-0,0121	-0,0083	0,008357	-0,02656	0,004696	0,066732	-0,03315	-0,00389	0,116525	-0,05055	0,016823
20.	0,006937	0,017324	-0,01331	0,025668	0,003441	0,00425	0,004957	0,082434	-0,01492	0,011242	0,034958	-0,01966	0,009058

	14.	15.	16.	18.	19.	20.	TOTAL	Notes
1.	0,010554	0,00036	0,018513	0,002747	-0,00239	-0,02001	0,15	1 = Plant height
2.	-0,00317	0,000233	-0,00337	-0,00235	-0,00659	-0,02334	0,06	2 = Number of internodes
3.	0,011609	0,000276	0,01683	0,00314	0,005987	-0,00734	0,12	3 = Internodes length
4.	-0,00422	0,000233	-0,00337	-0,00275	-0,00659	-0,02267	0,05	4 = Number of leaves
5.	-0,03166	-0,00468	-0,04712	-0,01413	-0,01018	0,004668	-0,29	5 = Tasseling date
6.	-0,00633	-0,00011	-0,00673	-0,00235	0,029934	0,005335	-0,07	6 = Silking date
7.	0,016886	0,000551	0,030294	0,004317	0,010776	-0,01267	0,26	7 = Ear height
8.	0,065433	0,001526	0,104345	0,020408	0,010177	-0,01401	0,72	8 = Biomass weight
9.	0,037994	0,000869	0,060587	0,012166	0,011973	-0,006	0,40	9 = Root dry weight
10.	-0,01161	-0,00013	0,001683	-0,00471	0,005388	0,01734	-0,05	10= Root length
11.	0,103427	0,001844	0,156517	0,036106	0,011973	-0,004	0,91	11= Ear diameter with husk leaves
12.	0,102371	0,001823	0,156517	0,034928	0,010776	-0,00467	0,90	12=Ear diameter without husk leaves
13.	0,093928	0,001738	0,146419	0,033359	0,007783	-0,00467	0,85	13= Ear length
14.	**0,105538**	0,001844	0,153151	0,036498	0,010177	-0,006	0,91	14= Number of kernel rows/ear
15.	0,091818	**0,00212**	0,144736	0,032181	0,008381	-0,008	0,98	15= Number of kernels/row
16.	0,096039	0,001823	**0,168298**	0,033751	0,008381	-0,00333	0,89	16= Cob diameter
18.	0,09815	0,001738	0,144736	**0,039245**	0,011375	-0,00667	0,85	17= Seed weight/plant
19.	0,017941	0,000297	0,023562	0,007457	**0,059867**	0,00867	0,19	18= Harvest index
20.	0,009498	0,000254	0,008415	0,003925	-0,00778	**-0,06669**	0,10	19=Number of ears
								20= Lodging resistance

CONCLUSION

1. Maize genotypes tested showed differences for ten traits. Vegetative components showed low genetic variation. Meanwhile, high genetic variation was shown by reproductive components
2. Biomass weight, ear diameter without husk leaves and seed weight/plant showed low to moderate heritability and low genetic advance were controlled by non-additive gene action. Direct selection based on these traits alone would be less effective.
3. Biomass weight and ear diameter with husk leaves showed highly significant positive correlation and maximum direct effects to seed weight/plant, the improvement of seed weight/plant should be based on these two traits.
4. Indirect effects of biomass weight and ear diameter with husk leaves seems to be the cause of correlation. These two traits should be considered simultaneously in selection program for improving maize varieties on Ultisol under low input.

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REFERENCES

Ardjasa, W.S. 1994. *Peningkatan produktivitas lahan kering marginal melalui pemupukan fosfat alam dan bahan organik berlanjut pada pola padi gogo- kedelai-kacang tunggak*. Dlm. Utomo, M., Susilo, F.X., Lumbanraja, J., Sudarsono, H. (pnyt.). *Prosiding Seminar Nasional Pengembangan wilayah lahan kering*. Lembaga Penelitian, Universitas Lampung. hlm. 68-81.

Ariyo, O.J., M.E. Akenova and C.A. Fatokun. 1987. Plant character correlations and path analysis of pod yield in okra (*Abelmoschus esculentus*). Euphytica 36 : 677-686.

Chauhan, J.S, F.S.S. Lopez and B.S. Vergara. 1989. Genetic analysis of ratooning ability of rice (*Oryza sativa* L.). Euphytica 40 : 97 : 102

Dewey, D.R. and Lu, K.U. 1959. A correlation and path-coefficient analysis of components of crested wheat grass seed production. Agron. J. 51 : 515-518.

Eberhart , S.A. and C.O. Gardner. 1966. A general model for genetic effects. Biometrics 22 : 864-881.

Fakorede, M.A.B. 1979. Inter-relationships among grain yield and agronomic traits in a synthetic population of maize. Maydica 24 : 181-192

Falconer, D.S. 1989. Introduction to quantitative genetics. New York : John Wiley and Sons, Inc.

Fehr, W. R. 1987. Principles of cultivar development, theory and technique. New York : Macmillan Publishing Company

Foy, C.D. 1988. Plant adaptation to acid, aluminium toxic soils. Commun. Soil Sci.Plant. Anal. 19 : 959-987

Johnson, H.W., H.F. Robinson and R.E. Comstock. 1955. Estimates of genetic and environmental variability in soybean. Agron J. 47 : 314-318.

Karmana, M. H.; A. Baihaki; G. Satari, T. Danakusuma, and A.H. Permadi. 1990. *Variasi genetik sifat-sifat tanaman bawang putih di Indonesia*. Zuriat 1 : 32-36

Kaw, R. N. and P.M. Menon. 1972. Association between yield and its components in soybean. Indian J. Genet. 32 : 276-280

Landon, J. R. 1984. Booker tropical soil manual a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. London : Booker Agriculturare International Limited. 450 pp.

Mayers, J.D.; R.J. Lawn and D.E. Byth. 1991. Adaptation of soybean (*Glycine max* (L) Merr.) to the dry season of the tropics.II. Effects of genotype and environment on biomass and seed yield. Aust. J. Agric.Res. 42:517-530

Mohr, E.C.J., V. A. Van Baren and J.V. Schuylenborg, 1972. Tropical soils : a comprehensive study of their genesis. The Hague-Paris : Van Hoeve.

Morrison, M. J.; H.D. Voldeng and E.R. Cober. 1999. Physiological changes from 58 years of genetic improvement of short-season soybean cultivars in Canada. Agron. J. 91 : 685-689

Munir, M. 1996. *Tanah-tanah utama Indonesia. Karakteristik, klasifikasi dan pemanfaatannya.* Jakarta : Pustaka Jaya.

Ofori, I. 1996. Correlation and path-coefficient analysis of components of seed yield in bambara groundnut (*Vigna subterranea* L.). Euphytica 91 : 103-107

Pal, A.K. and H.S. Prodhan. 1994. Combining ability analysis of grain yield and oil content along with some other attributes in maize (*Zea mays* L.). Indian J. Genet.54 (4) : 376-380.

Singh, R. K. dan B. D. Chaudary. 1979. Biometrical Methods In Quantitative Genetic Analysis. Ludhiana, New Delhi : Kalyani publisher. 296p

Singh, T.P. and H.N. Singh. 1979. Path-coefficient analysis for yield components in okra. Indian J. Agric. Sci. 49 : 244-246.

Spiegel, M.R. 1975. Probability and statistics. New York : Schaum's Outline Series.

Subandi. 1988. *Perbaikan Varietas*. Dlm. Subandi, Mahyudin Syam, dan Adi Widjono (pnyt.) *Jagung*. hlm . 81 – 100. Bogor : *Badan Penelitian dan Pengembangan Pertanian Pusat Penelitian dan Pengembangan Tanaman Pangan.*

Sumarno. 1985. Soybean genotype selection for drying and wet season growth in West Java, Indonesia. Indonesia J. of Crop. Sci.1(1) : 57-64.

Srivastava, A. N. and J.K. Jain. 1994. Variability and coheritability estimates for physiological and economic attributes in soybean. Indian J. Genet. 54 (2) : 179-183

Stansfield, W. D.1983. Theory and problems of genetics. New York : Mc Graw-Hill,Inc

Sufardi. 1997. *Status hara tanaman kedelai* (*Glycine max* L. Merill) *pada berbagai taraf pemupukan di tanah Podsolik Merah Kuning*. Agrista 1(1) : 1-7.

Sutoro, A. Bari, Subandi dan S. Yahya. 2006. *Parameter genetik jagung populasi Bisma pada pemupukan berbeda*. J. Agro Biogen 2 : 1-3

Tirtoutomo, S dan R. D. M. Simanungkalit. 1988. *Pengaruh pemberian kapur dan fosfat terhadap serapan P, pertumbuhan dan hasil kedelai pada tanah Ultisol Sukamandi*. Media. Pen. Sukamandi 6 : 1-8

Vargas, J.D.; S. Pandey; G. Granados; H. Ceballos and E.B. Knapp. 1994. Inheritance to soil acidity in tropical maize. Crop Sci. 34(1) : 50-54.

Wade, M.K., D.W. Gill, H. Subagyo, M. Sudjadi and P.A. Sanchez. 1988. Overcoming fertility constraints in a transmigration area of Indonesia. Neil Caudle (ed.). TropSoils Bulletin No. 88-01. The soil management collaborative research support program, North Carolina State University.

Wilkinson, R.E. 1994. Acid soil stress and plant growth. In. Wilkinson, R.E.(eds). Plant-environment interactions. Pg. 125 – 148. New York : Marcel Dekker, Inc.

Zen, S. dan H. Bahar. 1996. *Penampilan dan pendugaan parameter genetik tanaman jagung. Agrijournal* 3(2) : 1-9.