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Full Length Research Paper

Grain yield and associated traits of maize (*Zea mays* L.) genotypes in Malaysian tropical environment

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Twenty two tropical composite maize *(Zea mays* L.) genotypes from International maize and Wheat Improvement centre (CIMMYT) were grown in randomized complete block design with two replicates to assess the correlation between yield and other traits such as 50% silking (female flowering date), 50% tasseling date (male flowering date, Ear/plant, thousand grain weight, plant height and ear height in the tropical environment of Malaysia. Grain yield correlated highest between field weight (rA = 0.59), followed by ear height (rA = 0.50) and plant height (rA = 0.49). Positive correlations was not found between grain yield and days to 50% silking (rA = 0.17), days to 50% tasseling (rA = 0.19), ear/plant (rA = 0.26) and thousand grain weight (rA = 0.10). Negative correlation was observed between maturation date (rA = -0.025) and grain filling period (rA = -0.198). Higher values of two traits, such as plant height (R^2 = 0.24) and ear height (R^2 = 0.25) showed appreciably higher tend to grain yield. From linear models, days to 50% tasseling (R^2 = 0.04) and days to 50% silking (R^2 = 0.04) accounted for only 4% of the total variation in grain yield (R^2 = 0.04) while the other traits accounted for as much as 96%. No linear regression found between grain yield and maturation date (R^2 = 0.00). But there were linear regressions between grain yield and ear / plant (R^2 = 0.056), field weight (R^2 = 0.361) and 1000 grain weight (R^2 = 0.02) in proportion of 5.6, 36.1 and 2% of grain yield, respectively. Negative linear regression was observed between grain yield and grain filling period ((R^2=0.036). Field weight, ear height, and plant height and shell percentage have the highest correlation with grain yield that were determine by the yield of twenty two tropical composite maize (*Z. mays* L.). The present findings might be useful to the breeders to select the potential parental materials for maize improvement program in tropical Malaysia.

Key words: Maize, grain yield, tropical environment.

INTRODUCTION

Maize (*Zea mays* L.) is the most widely grown cereal in the world. It is the third most important and highest industrial valued cereal in the world after wheat and rice (Anon, 2000). Maize is versatile over a range of agro climatic zones and its suitability to diverse environments is unmatched by any other crop. It is grown from 58° N to 40° S, from below sea level to altitudes higher than 300 meters and in areas with 250 mm to more than 5000 mm of rainfall per year, with growing cycles ranging from 3 to 13 months (Shaw, 1988). The most important agronomic traits in maize include grain yield, days to tasseling, days to silking, tassel branches, plant height, ear height, leaf length, leaf width, leaf area, ear weight, grain moisture, kernel rows and 1000 kernel weight (Haq et al., 2005). Genotypes with desirable traits are major contributing factor in grain yield. Grain yield of maize is highly correlated with kernel set (Cirilo and Andrade, 1994a; Otegui et al., 1995) which is sensitive to environmental conditions during tasseling and silking (Tollenaar et al., 2002; Hall et al., 1981; Kiniry and Ritchie, 1985; Westgate and Boyer, 1986; Cirilo and Andrade, 1994b) stages. A trait like kernel number is related to light interception (Andrade et al., 1993; Kiniry and Knievel,

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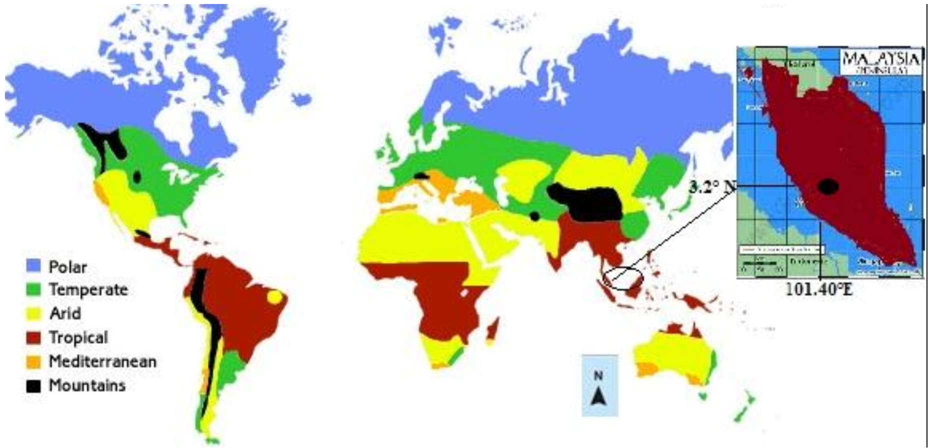

Figure 1. Location of study field of Malaysia in tropical regions of the world.

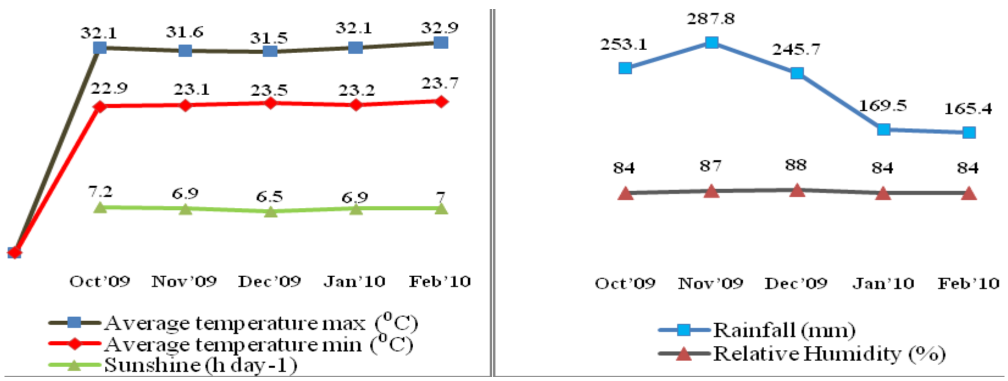

Figure 2. Climatic condition was at site during study period.

1995) and differ in low, intermediate and high latitude environments (Edmeades et al., 1993., Kiniry and Knievel, 1995; Andrade et al., 1993; Tollenaar et al., 1992). In temperate regions, direct selection for duration of grain filling may increase grain yield, environments where the length of the growing season is not entirely utilized (Egli, 2004). Muchena and Iglesias (1995), Iglesias and Minguez (1995), Dele´cale et al. (1995), Jones and Thornton (2003), Abraha and Savage (2006) assessed the impacts of different climates on grain yield in maize at different locations of the world and observed that grain yield severely varied from each locations because of the changes of different yield influencing traits. In the present study it was tried to find out the yield influencing traits in 22 genotypes and identify their yield potentiality in Malaysian tropical environment.

MATERIALS AND METHODS

Experiment site

Twenty two tropical maize genotypes received from International October, 10, 2009 in the experimental field of Genetics and Molecular Biology, situated at 3.20° N 101.40°E with elevation of 22 m from sea level (Figure 1), and climatic condition was hot and humid with frequent rain (Figure 2), Institute of Biological Science, Faculty of Science, of the University of Malaya.

Experimental design and management practice

The experiment was laid out in a randomized complete block design (RCBD) with two replications. Each experimental plot was 2.0 m long and 2.0 m wide, with 5 rows 50 cm apart, giving a gross plot area of 4.0 m^2. Plot to plot distance were 1m and plant to plant distance was 50 cm. The land was ploughed 4 times and leveled by laddering. To drain the excess rain water field there were drainage channel around the plots. The plots were fertilized with the N_2, P_2O_5, and K_2O at the rate of 120, 80, and 40 Kg ha^{-1} respectively. Nitrogen is to be applied in 3 equal splits. The first application of nitrogen is applied at sowing along with phosphorus. The second dose of nitrogen is applied after 30 days of sowing and the third dose at tasseling stage of crop. Two seeds were planted in each hill (planting hole) and plots were weeded three times on 15, 30 and 45 days after sowing. After sowing no irrigation was required for the crops. To adjust the population density in different plots thinning of maize plant was done to maintain a plant to plant distance approximately 50 cm. According to the level of infestation and infection insect-pests and disease control measures were adopted.

Table 1. Mean variation of quantitative traits in 22 maize genotypes conducted at experiment Field Genetic and Molecular Biology, Faculty of Science, University Malaya, Malaysia.

Source of variation	GY	PH	EH	DT	DS	MD	EP	FW	TGW	GFP	SP
Mean	1073.13	205.87	79.57	63.13	65.13	91.11	13.159	1709.023	284.136	26.022	36.159
CV%	23.15	8.25	15.69	4.66	4.66	5.29	10.656	20.163	6.654	13.950	32.636
F Value	0.94	2.51*	3.28	2.08**	2.08*	0.96	0.78	0.76	2.42**	1.11*	0.85

*Significant different at 5%, ** significance different at 1% . (PH= plant height, EH= ear height, DT= days to 50% tasseling, DS= days to 50% silking, MD= maturating date, EP= ear corn/plant, FW= field weight, TGW= thousand grain weight, GFP= grain filling period, SP= shell percentage GY= grain yield).

Data collection on quantitative traits

Agronomic parameters such as the date, when half of the genotypes appeared silk and half of the genotypes appeared Tassel, flowering date for both male (tassel) and female (silk) inflorescences were measured. Plant height was measured from soil surface to the base of leaf flag. Ear height was also measured from the soil surface to the base of lowest cob. Number of ear/plant and days to maturity were recorded after physiological maturity stage (ripening stage). Thousand grain weights was measured by counting five hundred seeds picked at random and then their weight multiplied by two. After the attainment of physiological maturity, the plants in the plots were harvested manually. Husk covers that cover and protect the corn grain were removed and the corn kernel were dried for a few days in the sun, and later weighed twice for accuracy. Husk covers were counted and air root, which is root that emerge from the stem from first or second nodes that are hanging on the air were recorded from each genotypes for both replication. Grain filling period were calculated by deducting maturation time to flowering date. Field weight is measured by weighing the whole ear corn for each genotype. Grain weight in other hand is only the weight of grain alone without the husk cover and shell. Thousand grain weights was measured by counting five hundred seeds picked at random and then the weight multiplied by two. Shell percentage was gain by calculating the difference between field weight and grain weight. The ears and stover were considered to be dry when their weight became constant.

Statistical analysis

Analysis of variance was done to know the differences among genotypes considering all characteristics. Before doing ANOVA in normality test (Kolomogorove-Smirnove) all data showed a normal distribution, so SAS 9.2 was used for ANOVA. Means were compared by DMRT (Duncan multiple range test). Excel stat software was used to estimate correlation and regressions among grain yield and yield contributing characters.

RESULTS AND DISCUSSION

Genotypic performance

The observed results demonstrated that the twenty-two identified genotypes did not differ significantly from one another However, Entry 16 and Entry 17 were the highest yielding genotypes performed with 1.41 and 1.45 kg yield /plot. These two entries were not significantly different in grain yield potentiality but their flowering dates differed significantly (Tables 1 and 2). Entry 8 was identified as the lowest yielding genotype followed by Entry 2, Entry 19, Entry 22 and entry 15. In addition, Entry 22, Entry 2, Entry 15 and Entry 19 also showed the poorest grain yield respectively and associated with less production number of ear/plant, late maturation date and lodging. Reduction of ear/plant might be the effect of lowest tolerance of drought, low nitrogen, and density stress although the genotypes were grown in the same environment (Betra´n et al., 2003). Moriri et al. (2010) suggested that late maturity may be due to variation of density stress response as plants at lower planting density tended to flower and matured earlier than those planted at higher density. Takatlidis and Koutroubas (2004) also observed faster maturity in higher density.

Variation of quantitative traits

From Table 1, the 22 maize genotypes did not differ significantly (at 5% level of significance) in all traits except plant height and grain filling. Plant height is controlled by dominant alleles (Dudley et al., 1996) and diversity in the level of adaptation among various genotypes are also high (Greaves, 1996). Days to 50% of tasseling, days to 50% of silking and thousand grain weight did not differ significantly among genotypes. This may have been so because tassel initiation, morphogenesis and anthesis are sensitive to temperature (Warrington and Kanemasu, 1983). Field weight, ear/plant and ear height did not differ significantly among genotypes. With a mean average of 91 days and coefficient of variations of 5.29 maturation did not differ significantly among genotypes. Highly significant differences in grain yield were found among the genotypes. Entry 16 and entry 17 performed highest grain yield among the genotypes. Significantly differences in grain yield means are the effects of dominant gene and are considered as a favorable source of alleles for improvement of elite maize population (Trifunovi et al., 1998).

Correlation of quantitative traits

Genetic correlation analysis is technique, which elaborates the degree of association among quantitative factors. In our experiments, grain yield was positively

Table 2. Means of the different parameters for quantitative traits evaluated at experiment field Genetic and Molecular Biology, Faculty of Science, University Malaya, Malaysia.

Varieties	GY	PH	EH	DT	DS	MD	EP	FW	TGW	GFP
16	1465.5^{a}	234.55^{ab}	102.00^{a}	70.50^{ab}	69.00^{ab}	91.50^{a}	13.00^{a}	1975.5^{a}	296.00^{bcd}	22.50^{b}
17	1410.5^{a}	247.60^{a}	94.90^{ab}	71.50^{a}	71.50^{a}	96.50^{a}	14.00^{a}	2009.0^{a}	296.00^{bcd}	25.00^{b}
12	1356.5^{ab}	204.30^{bcdef}	102.1^{5a}	66.00^{abcd}	66.50^{abcde}	92.00^{a}	14.00^{a}	2081.0^{a}	252.00c^{d}	25.50^{ab}
5	1193.5^{ab}	192.35^{cdef}	85.75^{abcde}	59.00^{cd}	61.00^{de}	87.50^{a}	12.50^{a}	1655.5^{a}	298.00^{bc}	26.50^{ab}
1	1166.5^{ab}	179.70^{ef}	63.90^{cdef}	60.00^{bcd}	65.00^{abcde}	90.50^{a}	14.50^{a}	1688.5^{a}	295.00^{bcd}	26.50^{ab}
14	1160.0^{ab}	208.00^{abcdef}	77.90^{abcde}	67.00^{abc}	67.00^{abcde}	88.50^{a}	13.50^{a}	1506.0^{a}	250.00^{d}	21.50^{b}
7	1114.0^{ab}	192.20^{cdef}	75.25^{abcde}	61.50^{abcd}	62.00^{bcde}	87.50^{a}	13.00^{a}	1732.5^{a}	263.00^{bcd}	25.50^{ab}
13	1085.5^{ab}	200.65^{ebdcf}	86.90^{abcde}	68.50^{abc}	66.50^{abcde}	90.00^{a}	13.00^{a}	1450.5^{a}	283.00^{bcd}	23.50^{b}
18	1074.0^{ab}	221.00^{abcde}	83.25^{abcde}	68.50^{abc}	68.50^{abc}	96.00^{a}	14.50^{a}	1726.0^{a}	279.00^{bcd}	27.50^{ab}
20	1066.0^{ab}	230.70^{abc}	100.80^{a}	66.00^{abcd}	67.00^{abcde}	96.50^{a}	13.50^{a}	1836.0^{a}	268.00^{bcd}	29.50^{ab}
10	1062.0^{ab}	194.95^{bcdef}	62.65^{def}	61.00^{abcd}	63.00^{bcde}	97.00^{a}	12.00^{a}	1782.5^{a}	296.00^{bcd}	34.00^{a}
3	1023.0^{ab}	188.55^{def}	59.85^{ef}	59.00^{cd}	63.00^{bcde}	91.50^{a}	13.50^{a}	1578.0^{a}	289.00^{bcd}	28.50^{ab}
9	1000.5^{ab}	194.15^{bcdef}	63.90^{cdef}	63.00^{abcd}	61.50^{cde}	90.50^{a}	12.00^{a}	1511.5^{a}	342.00^{a}	29.00^{ab}
4	990.0^{ab}	204.95^{bcdef}	83.25^{abcde}	59.00^{cd}	60.00^{e}	86.50^{a}	14.00^{a}	1799.5^{a}	301.00^{ab}	26.50^{ab}
6	974.5^{ab}	190.20^{cdef}	44.00^{f}	60.00^{bcd}	61.00^{de}	87.50^{a}	13.00^{a}	1468.0^{a}	285.00^{bcd}	26.50^{ab}
21	969.0^{ab}	220.20^{abcde}	91.50^{abcd}	63.50^{abcd}	65.00^{abcde}	89.00^{a}	14.50^{a}	1834.5^{a}	285.00^{bcd}	24.00^{b}
15	957.5^{ab}	212.75^{abcdef}	93.20^{abc}	66.50^{abcd}	64.50^{abcde}	89.00^{a}	12.00^{a}	1358.0^{a}	264.00^{bcd}	24.50^{b}
19	897.5^{ab}	229.90^{abcd}	98.15^{a}	62.50^{abcd}	64.00^{bcde}	89.50^{a}	13.00^{a}	1954.5^{a}	254.00^{cd}	25.50^{ab}
22	869.5^{ab}	210.55^{abcdef}	75.40^{abcde}	68.00^{abc}	68.00^{abcd}	95.00^{a}	13.50^{a}	1813.9^{a}	279.00^{bcd}	27.00^{ab}
2	861.0^{ab}	175.90^{f}	64.50^{cdef}	60.00^{bcd}	63.00^{bcde}	87.50^{a}	12.00^{a}	1561.5^{a}	304.00^{ab}	24.50^{b}
8	818.0^{b}	182.95^{ef}	67.00^{abcde}	56.00^{d}	68.00^{abcd}	91.00^{a}	12.50^{a}	1368.5^{a}	282.00^{bcd}	23.00^{b}
Average	1073.136	205.875	79.57727	63.86364	65.13636	91.11	13.15	1709.02	284.13	26.02

GY = Grain yield (gm), PH = plant height (cm), EH = ear height (cm), DT = days to 50% Tasseling (days),DS = days to 50% silking (days). Means with the same letter within the same column are not significantly different.

correlated with plant height; ear height and field weight (Table 3). According to Martin and Russell, (1984); Burak and Magoja, (1991) plant and ear heights are strongly associated with grain yield. Grain yield have also positive correlations with ear height, ear length and ear diameter (Burak and Magoja, 1991; Malvar et al., 1994; Singha and Prodhan, 2000), but not with kernel weight (Martin and Russell, 1984). Correlations did not find between grain yield and days to 50% tasseling, days to 50% silking, ear/plant and thousand grain weights. This is supported by the findings made by Afzal et al. (1997). Grain yield was found to be negatively correlated with shell percentage. There was no correlation between maturating date and grain filling period. Similar observations also founded by Rehman et al. (1995).

Tropical maize genotypes sometimes show undesirable traits such as: lateness (where earliness is needed), excessive plant or ear height, poor husk cover, low grain yield potential and low harvest index. Plant height was positively correlated with ear height, days to 50% tasseling, days to 50% silking, number of ear/plant, field weight and grain yield. Negatively no correlation was observed between plant height and shell percentage (Table 3). This finding was in agreement with what have been reported by Sigha and Prodhan (2000) that grain yield is positively associated with plant height. Burak and Magoja (1991) found maximum correlation between plant height and grain yield. A strong positive genetic correlation was observed among ear height and plant height. Positive and weak correlation found on days to maturity and shell percentage, but a negative and weak correlation was exhibited in

Table 3. Correlation among various quantitative traits of 22 genotypes of maize.

Variable	PH	EH	DT	DS	MD	EP	FW	TGW	GFP	SP	GY
PH	1										
EH	0.74**										
DT	0.43**	0.36									
DS	0.33	0.24	0.69**								
MD	0.17	0.06	0.59**	0.60**							
EP	0.44*	0.25	0.04	0.17	0.15						
FW	0.56**	0.43*	0.05	-0.19	0.11	0.52**					
TGW	-0.11	-0.25	-0.16	-0.02	-0.03	-0.17	0.02				
GFP	-0.15	-0.19	-0.18	-0.30	0.58**	0.02	-0.06	0.00			
SP	0.05	-0.09	-0.22	-0.01	0.04	0.10	0.26	-0.09	0.12		
GY	0.49*	0.50*	0.19	0.17	-0.03	0.26	0.60**	0.10	-0.20	-0.45	1

*Significant at 5%; **significant at 1% probability levels. P ≤0.05 (0.404);p ≤0.01 (0.515); PH= plant height, EP= ear/plant, DT= days to 50% tasseling, DS= days to 50% silking, MD= maturating date, EH= ear height, FW= field weight, TGW= thousand grain weight, GFP= grain filling period, SP= shell percentage, GY= grain yield.

thousand grain weight and grain filling period. Ear height was found to have positively related with field weight and grain yield. However, a positive but no correlation existed among days to 50% tasseling, days to 50% silking, days to maturity and ear/plant. Negatively no correlations were observed in thousand grain weight, grain filling period and shell percentage with grain yield (Table 3). This was an contrary to what has been reported by Haq et al., (2005) that ear height negatively correlates with days to 50% tasseling and days to 50% silking. Lee et al. (2001) reported plant height and ear height are positively correlated with each other.

Days to 50% tasseling were positively correlated with days to 50% silking; ear/plant and maturation date (Table 3). This result is in agreement with findings by Chase and Nanda (1967). This trait showed negative and no correlations with thousand grain weight, grain filling period and shell percentage. A week correlation was noted between plant height and ear height with grain yield, positive but had no correlation with grain yield, ear corn per plant and field weight. Meanwhile a negative and no correlation existed in thousand grain weight, grain filling period and shell percentage. Positive but low levels of correlations were noted between days to 50% silking with grain yield, ear height, maturating date, ear/plant and field weight. Umakanth et al. (2000) reported grain yield to be negatively correlated with days to silking which was in contrast to these results. Negative correlation was observed in thousand grain weight and shell percentage.

Maturation date were positively correlated with days to 50% tasseling, days to 50% silking, grain filling period and husk cover. There were positive but low level between maturation date and plant height, number of ear/plant, ear height, field weight, thousand grain weight and shell percentage. There were also negative or no correlation with grain yield and thousand grain weight. Shell percentage and husk cover were moderately correlated with maturating date (Table 3). This was in contrast to what has been reported by Guilin et al., (1998) that there are strong negative correlation between grain filling rate and maturation date.

Field weight was found to have a positive relation with plant height, ear height, grain yield, and moderate correlation with husk cover. Positive but low level relationship had been noted with thousand grain weight, grain filling period, shell percentage, husk cover of 50% tasseling and maturating date. A negative and no correlation existed with days to 50% silking. Thousand grain weights were found to have negative and no correlation with days to 50% tasseling, days to 50% silking, maturation date and husk. There were also positive and no correlation existed between field weight and grain filling period, shell percentage, grain yield, plant height, and ear height and field weight.

Ear/plant was noted to have positive correlation with field weight, husk cover, plant height and ear height. Positive but low level existed between ear/plant with grain yield, days to 50% tasseling, days to 50% silking, maturation date, grain filling period and shell percentage. Altenbas and Algan (1993) observed positive correlations between grain yield and days to silking as well as tasseling, however Umakanth et al. (2000) results were contrary to this. Negative relationship was found between ear/plant and thousand grain weight. Grain filling period was positively correlated with maturation date. In case of ear/plant, a positive but low level of correlations existed with shell percentage, husk cover, plant height, ear height, days to 50% tasseling, days to 50% silking field weight and thousand grain weights, but there was negative and no correlation with grain yield (Table 3). This was in contrast with what has been reported by Guilin et al. (1998) that ear/plant is positive correlated with grain yield. Positive but low level of correlations were observed between shell percentage with maturation date, field weight thousand grain weights and grain filling period. Negative correlation observed between ear/plant

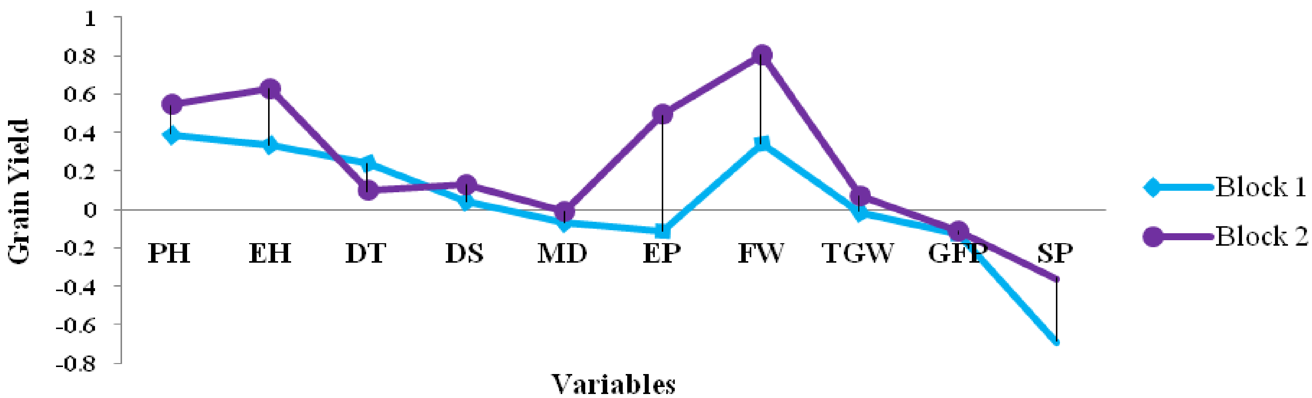

Figure 3. Correlation between grain yields with other agronomic traits in 22 maize genotypes based on blocks. (PH= plant height, EH= ear height, DT= days to 50% tasseling, DS= days to 50% silking, MD= maturating date, EP= ear/plant, FW= field weight, TGW= thousand grain weight, GFP= grain filling period, SP= shell percentage GY= grain yield).

with grain yield and with plant height, ear height, days to 50% tasseling, days to 50% silking, thousand grain weight, and husk cover did not observed any correlations. Husk cover was positively correlated with grain yield, plant height and days to 50% tasseling, days to 50% silking and maturation date (Table 3).

From Table 3, field weight positively correlated highest (0.59) with grain yield followed by ear height (0.49), and plant height (0.49). Shell percentage showed negative correlation (-0.45) with grain yield which was. Positive but low level of correlations were observed between grain yield and days to 50% silking (0.16), days to 50% tasseling (0.19), ear corn per plant (0.26) and thousand grain weight (0.10).

Grain yield and other trait association

The linear regression in Figure 4B suggests that higher plant heights tend to produce higher grain yield, but the relationship was not perfect. Thus knowledge of plant height does not suffice for an entirely accurate prediction of grain yield. A deduction can be made that either the effect of plant height on grain yield differs among individuals. R value of 24.2% meant that 24.2% of grain yield was attributable to plant height and that the remaining was attributed to other traits. A positive correlation (0.49) was found between grain yield and plant height. Meanwhile Figure 4A showed that R value of 25.70% meant that 25.7% of grain yield was attributable to ear height. A positive (0.49) or moderate correlation was found between grain yield and ear height. The linear model of days to 50% tasseling accounted for only 4% of the total variation in grain yield, and that 96% was determined by other traits. A positive (0.19) or weak correlation was found between grain yield and days to 50% tasseling (Figure 4C). In addition, a day to 50% silking was responsible for in grain yield. A positive (0.16) and weak correlation was found between grain yield and days to 50% silking (Figure 4D). No regression was found between grain yield and maturation date meant that maturating date did not influence any portion of grain yield. A negative (-0.025) or no correlation was also found between grain yield and maturating date (Figure 4E). However there was positive correlation between grain yields and ear/plant, field weight and grain weight by 5.6, 36.1 and 2% of grain yield respectively (Figure 4F, G and H). There was negative linear regression between grain yield and grain filling period and it is suggested that longer grain filling period tend to produce higher grain yield. A deduction can be made that either the effect of grain filling period on grain yield differs among individuals, or that factors other than grain filling period such as plant height and ear/plant influence grain yield. R value of 3.6% means that grain filling period was responsible for 3.6% of grain yield, and that 36.4% of grain yield was determined by other traits also such as plant height and ear/plant A negative (-0.19) or no correlation was found between grain yield and grain filling period (Figure 4I). Shell percentage was responsible for 24.2% of grain yield, and that 75.8% was determined by other traits. A negative (-0.45) correlation was found between grain yield and shell percentage (Figure 4J).

Conclusions

In order to develop promising genotypes, it is essential to know the different traits particularly associated with grain yield, which is the most ultimate objective in any breeding program. The purpose of this research was to study genetic correlation among various quantitative characters in maize to find out yield characters responsible for high maize grain yield, especially in the tropical environment of Malaysia. Positive (0.59) correlations were identified between grain yield and field weight, followed by ear

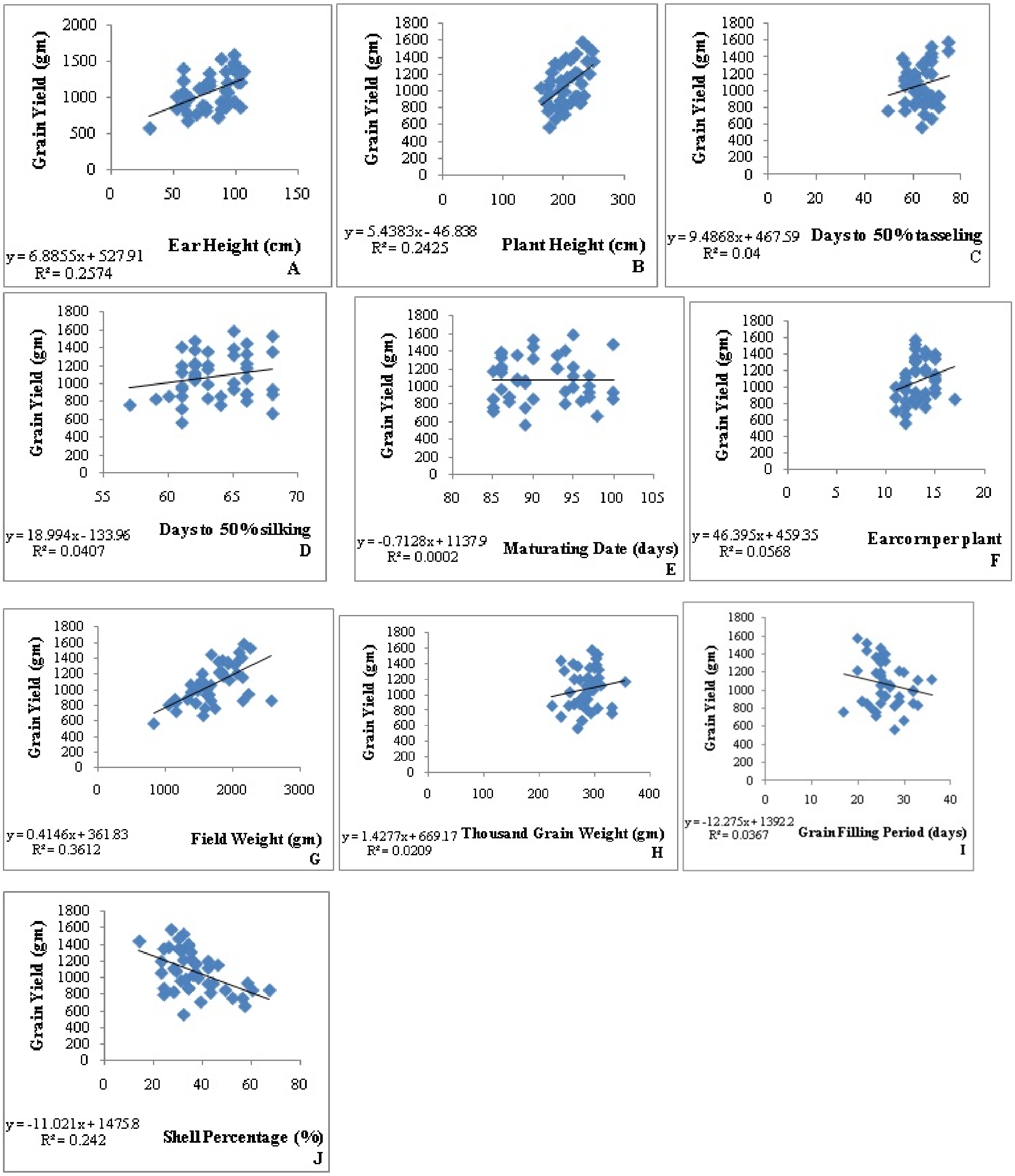

Figure 4. Comparative simple regression lines between grain yield with other agronomic traits. (A; Grain Yield with ear height, B; Grain yield with plant height, C; grain yield with days to 50% tasseling, D; days to 50% silking, E; grain yield with maturating date, F; grain yield with ear corn per plant, G; grain yield with field weight, H; grain yield with thousand grain weight, I; grain yield with grain filling period, J; grain yield with shell percentage).

height and plant height. Traits positively correlating highest correlation with grain yield such as field weight, ear height, plant height and shell percentage can be chosen as superior characteristics to help improve maize grain yield.

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