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RESEARCH ARTICLE

EFFECT OF DIFFERENT GROWING SEASONS ON CORRELATION AND PATH COEFFICIENTS OFYIELD AND YIELD COMPONENTS IN MAIZE (*Zeamays* L.)

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Abstract

Path analysis depicted the strength of association of all independent variables under study on the grain yield. Thus, the study aimed at examining changes in associations and path analysis of yield related traits to yield in post-monsoon and monsoon season. A total of 14 maizegenotypes were evaluated in two growing seasons at the Maize and other Cereal Crops Research Section, Department of Agricultural Research (DAR), Yezin, Nay Pyi Taw, Myanmar. Genotypic correlation and path coefficient analyses were carried out to examine the relationship among the traits under both environments. Yield was positively correlated with ear length, row length, ear diameter, rows per ear, kernels per row, shelling percent and 1000 seed weight but had a negative correlation with days to tasseling and days to silking in both growing seasons with different magnitudes. These traits can be used as the main criteria for grain yield improvement of maize yield in the respective growing seasons. Some traits showed similar direct effects in both growing seasons, however,the link between direct and indirect effects on grain yield depends on respective growing season.

Introduction:-

Maize (Zeamays L.) is an important cereal crop and ranks third among cereal crops after wheat and rice. In Myanmar, maize is mainly grown in monsoon season from May to June and it is grown as post-monsoon crop after rice from October to November (DoP, 2019). According to FAO report (FAO, 2020), grain yield of maize in Myanmar was much lower than average yields of neighboring countriesdue to poor genetic composition of the cultivars, non-availability of good quality seed of varieties with high yield potential and less acclimatization of exotic hybrids due to biotic and a-biotic stresses.Grain yield is the result of the interaction of a number of genetic factors and of environment; and therefore, cannot be considered an isolated way. Thus, it is clear that yield of maize could change depending upon use of cultural practices and growing season. Therefore, the development of improved cultivars/hybrids of maize is the need of the day for specific purposes.

Grain yield is a complex quantitative trait affected by a number of factors and indirect selection for other closely associated traits with yield will be more effective. Thus, the knowledge of inter-relationships between grain yield

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and its contributing components improves the efficiency of breeding programs (Belay, 2018). However, use of correlation makes a constant challenge to the breeders, since most of the characters can be correlated, and often in different directions.Thus, Wright (1934) proposed a method namely path coefficients: partitioning correlation coefficients into direct and indirect effects at genotypic level. Generally, this method provides more information among variables than do correlation coefficients since this analysis provides the direct effects of specific yield components on yield, and indirect effects via other yield components (Hosamaniet al., 2018).

Resent years, research articles concerning with correlation and path analysis of yield components in maize were published by several researchers (Amanet al.,2020; Bankoleet al.,2019; Belay, 2018; OlawamideandFayeun, 2020; Ozataet al.,2018). The results of those finding showed that correlation and direct effect of yield components were different due to use of different genetic sources, time of sowing, characters observed.There has no comparative study for changes in correlation and direct effect of yield component to yield under different growing seasons.Hence, in this study,the main objective was to estimate genotypic correlationsand path coefficients for yield and its components of 14 maize genotypes under different growing seasons, expecting that the results of the present investigation will be of value for maize breeders in Myanmar.

Materials and Methods:-

The experiments were carried out during post monsoon and monsoon season 2020, at Maize and other Cereal Crops Research Section, DAR, Yezin, Nay Pyi Taw, Myanmar which is located at 19° 49' 33″ N; 96° 16 44″ E; 102 m above sea level. In the present investigation, 14 maize genotypes(appendix 1) were evaluated in Randomized Completely Block Design with three replications. Each entry (genotype) was grown at a spacing of 75 cm × 25 cm, in a plot size of fourrows with 4 m length. Two seeds were sown in each hill and thinning was done at 14 days after sowing and leaved single plant per hill. For fertilizer application, Urea, Triple Super Phosphate and Muriate of Potash were applied as basal at the rate of 123.5 kg ha^{-1}, 123.5 kg ha^{-1} and 61.75 kg ha^{-1}, respectively. Then, the first and second sides dressing of 61.75 kg ha^{-1} Urea, 30.86 kg ha^{-1}Muriate of Potash were applied at three weeks after sowing and at five weeks after sowing, respectively. Inter-cultivation was done two times; just before the fertilizer applications which control weeds and also improve soil aeration. Yield and yield components were observed, and analysis of variance was computed. Estimation of variation components and genotypic correlations were calculated and thenit was later partitioned into direct and indirect causes according to Dewey and Lu (1959).

Results and Discussion:-

Estimates of genotypic correlations grain yield and other yield-related traits of maize genotypes grown in 2019 post-monsoon season and 2020 monsoon season are indicated in Table 1, respectively. Grain yield showed positive and significantgenotypic correlations with ear length (0.76, 0.69), row length (0.81, 0.71), ear diameter (0.69, 0.98), kernels per row (0.91, 0.86), shelling percent (0.79, 0.75) and 1000 seed weight (0.71, 0.70) in 2019 post-monsoon and 2020 monsoon, respectively. Positive correlation between rows per ear and grain yield was also observed in both seasons, however, only the result of 2020 monsoon season reveal highly significant.Hence, these traits could be considered for indirect selection criteria to improve grain yield. These results also suggest that this set of characters seem to have great importance in the selection process when it aims genotypes that have high yield. These results are in consistent with earlier report of Belay (2018),and Reddy and Jabeen (2016).

Grain yield was negatively and significantly correlated with days to 50% tasseling (-0.66) and days to 50%silking (-0.63) in tested maize genotypes grown at 2019 post-monsoon season. In 2020 monsoon season, the correlation coefficient was negative and low magnitude. This result indicated that time of maize maturity was more important in post-monsoon season and late maturity may cause more yield reduction as compare with monsoon season. Similar results were observed in finding of AlhusseinandIdris(2017) who reported that days to 50% tasselingand silking had no significant but negative correlation with the yield. However, positive and significant correlations of these traits with grain yield disagreedwith the finding of Belay (2018). The contrasts in this finding could be explained by the differences ingenotypes and testedseasons and locations used.Significant and positive association of days to 50% anthesis and days to 50% silking is alsoreported by Patilet al.(2016). Significant positive association could be observed either due to the strong coupling linkage between the genes or as a result of pleiotropic effects of genes that controlled these characters in the same direction(KearseyandPooni,2020).

Path analysis depicted the strength of association of all independent variables under study on the grain yield. This analysis also allows separating direct effect and their indirect effects through other attributes by partitioning correlation which helps breeders to find out the characters that could be used as selection criteria in maize breeding program. Thus, path coefficient analysis was used to provide further information on the nature of the interrelations among the various characters and their effects on grain yield. The genotypic direct and indirect effects of yield related traits on grain yield resulted from both seasons (2019 post-monsoon and 2020 monsoon) are presented in Table 2 and 3. The coefficient of determination in the path analysis (R^2) has presented magnitude 0.743 in post-monsoon and 0.837 in monsoon, and it has indicated that the 74.3% (post-monsoon) and 83.7% (monsoon) variation in the dependent variable grain yield in the model has been explained through the independent variables.

Among the yield components, ear diameter had maximum direct effect on yield followed by ear length, shelling percent and kernels per row in post-monsoon season 2019 (Table 2 and Fig 1).The positive genotypic correlations of these traits with grain yield were due to the positive indirect effects of these traits through other traits.This indicates that selection for these traits would be effective and it could increase grain yield.In line with the present study, Sesayet al.(2017) reported a positive direct influence of ear diameter and ear length on grain yield of top-cross maize hybrids. Direct negative effects on grain yield were attributed by days to 50%silking, row length, 1000 seed weight and rows per ear which indicated that improvement of these traits is essential before selecting them for high grain yield. Days to 50%silking was important trait on earliness of the maize crop in which the late flowering reflect on delay the maturity periods of the crop and decrease the grain filling stage. The result was shown that the days to silking had negative direct effect (-1.074) on yield due to negative indirect effect of other yield components such as ear length, ear diameter, rows per ear, kernels per row and shelling percent, in addition to their significant and negatively correlated with grain yield. Days to tasseling showed high positive direct effect on yield, however, its correlation with yield was significantly negative. This may be due to reduction of its direct effect by its negative indirect effects by other components. According to results of path coefficient in post-monsoon season, selection of larger ear diameter, longer ear length, higher shelling percent, kernels per row and early silking could be improve grain yield.According to Homayoun (2011), the increase in ear diameter causes an increase in the number of rows and consequently grains per ear, which contributes to grain yield in maize.

In monsoon 2020, different results ofdirect and indirect effect of yield components to grain yield were observed (Table 3). The maximum positive direct effect (0.765) to yield was noticed in row length, followed by ear diameter (0.554)and shelling percent (0.435) (Fig2). Their correlation with yield was also significant and positive. This means that these traits are essential yield components, reflective estimators and selection for them in the tested maize genotypes may lead to a substantial improved grain yield.Rows per ear and yield showed significant positive correlation (0.935), however, its direct effect was lower (0.094) due to negative indirect effect of other characters.Positive direct effect of days to 50% tasseling was diluted by negative indirect effect of other traits such as days to 50% silking, ear length, ear diameter, rows per ear, kernels per row and 1000 seed weight and that its correlation to yield was negative. Days to 50%silkingin this result was shown that it had negative direct effect (-0.434) on yield due to negative indirect effect of ear length, ear diameter, rows per ear and 1000 seed weight, in addition to their non-significant and negatively correlated with grain yield.Ear length, kernels per row, 1000 seed weight had negative direct and their correlation were positive.The positive genotypic correlations of these traits with grain yield were due to the positive indirect effects of these traits through other traits. According to Barettaet al. (2016) finding, if a correlation coefficient is positive but with the negative path direct effect, it can be said that correlation has been caused by their indirect effects; therefore, both to be considered in the selection process. In fact, row length, ear diameter and shelling percent are the best traits for selection to improve grain yield per hectare of the maize hybrid tested in 2020 monsoon season.

Table 1:- Genotypic correlations for yield and yield contributing characters in 14 maizegenotypesduring 2019 post monsoon season (above diagonal) and 2020 monsoon season (below diagonal).

Characters	Days to tasseling	Days to silking	Ear length	Row length	Ear diameter	Rows per ear	Kernels per row	Shelling percent	1000 seed weight	Yield (tha^{-1})
Days to tasseling (day)	1	0.98**	-0.45	-0.61*	-0.28	0.03	-0.65*	-0.54*	-0.37	-0.66**
Days to silking (day)	1.03**	1	-0.45	-0.63*	-0.17	0.09	-0.65*	-0.53	-0.24	-0.63*
Ear	0.36	0.17	1	0.96**	0.06	-0.32	0.97**	0.90**	0.34	0.76**

length (cm)										
Row length (cm)	0.44	0.19	0.99**	1	0.14	-0.20	1.01**	0.91**	0.38	0.81**
Ear diameter (cm)	-0.06	-0.24	0.70**	0.71**	1	0.70**	0.30	0.18	0.80**	0.69**
Rows per ear (no.)	-0.34	-0.47	0.58*	0.56*	1.00**	1	-0.13	-0.05	0.08	0.27
Kernels per row (no.)	0.41	0.20	0.93**	0.98**	0.83**	0.64*	1	0.91**	0.53*	0.91**
Shelling percent (%)	0.54*	0.38	0.74**	0.73**	0.73**	0.54*	0.86**	1	0.38	0.79**
1000 seed weight (kg)	0.65*	0.48	0.70**	0.77**	0.63*	0.43	0.79**	0.93**	1	0.71**
Yield (tha^{-1})	-0.03	-0.21	0.69**	0.71**	0.98**	0.93**	0.86**	0.75**	0.70**	1

* and ** significant at 0.05 and 0.01 probability level, respectively

Table 2:- Direct and indirect effects of yield components on yield 14 maizegenotypesduring 2019 post monsoon season.

Characters	Direct effect	Indirect Effects									Corre-lation
		Days to tasseling	Days to silking	Ear length	Row length	Ear diameter	Rows per ear	Kernels per row	Shelling percent	1000 seed Wt	
Days to Tasseling (day)	0.805		-1.051	-0.404	0.525	-0.325	-0.007	-0.176	-0.172	0.143	-0.662**
Days to silking (day)	-1.074	0.788		-0.401	0.537	-0.202	-0.026	-0.176	-0.167	0.093	-0.628*
Ear length (cm)	0.890	-0.365	0.484		-0.823	0.068	0.086	0.263	0.286	-0.134	0.755**
Row Length (cm)	-0.855	-0.494	0.675	0.857		0.163	0.056	0.275	0.287	-0.150	0.813**
Ear Diameter (cm)	1.160	-0.226	0.187	0.052	-0.120		-0.189	0.082	0.056	-0.310	0.692**
Rows per ear (no.)	-0.272	0.022	-0.101	-0.280	0.175	0.809		-0.036	-0.017	-0.032	0.268
Kernels per row (no.)	0.271	-0.524	0.698	0.866	-0.868	0.350	0.036		0.289	-0.208	0.910**
Shelling percent (%)	0.316	-0.438	0.566	0.805	-0.777	0.205	0.015	0.247		-0.149	0.790**
1000 seed	-0.390	-0.295	0.256	0.305	-0.328	0.924	-0.022	0.144	0.121		0.715**

weight (kg)											
Residual effect	0.257		Coefficient of determination = 0.743								

* and ** significant at 0.05 and 0.01 probability level, respectively

Table 3:- Direct and indirect effects of yield components on yield in 14 maizegenotypesduring 2020 monsoon season.

Characters	Direct effect	Indirect Effects									Corre-ation
		Days to tasseling	Days to silking	Ear length	Row length	Ear diame-ter	Rows per ear	Kernels per row	Shelling percent	1000 seed Wt	
Days to tasseling (day)	0.250		-0.447	-0.277	0.336	-0.034	-0.032	-0.014	0.234	-0.050	-0.033
Days to silking (day)	-0.434	0.257		-0.127	0.147	-0.133	-0.044	-0.007	0.166	-0.037	-0.209
Ear length (cm)	-0.761	0.091	-0.072		0.754	0.390	0.054	-0.031	0.324	-0.054	0.694**
Row length (cm)	0.765	0.110	-0.084	-0.750		0.393	0.053	-0.033	0.317	-0.060	0.711**
Ear diameter (cm)	0.554	-0.015	0.104	-0.535	0.543		0.093	-0.028	0.317	-0.048	0.985**
Rows per ear (no.)	0.094	-0.085	0.203	-0.441	0.429	0.553		-0.022	0.237	-0.033	0.935**
Kernels per row (no.)	-0.034	0.102	-0.087	-0.707	0.748	0.459	0.060		0.375	-0.061	0.856**
Shelling percent (%)	0.435	0.135	-0.166	-0.566	0.557	0.404	0.051	-0.029		-0.072	0.749**
1000 seed weight (kg)	-0.077	0.161	-0.209	-0.533	0.591	0.348	0.040	-0.027	0.406		0.700**
Residual effects	0.163	Coefficient of determination = 0.837									

** significant at 0.01 probability level

Conclusion:-

Yield was positively correlated with ear length, row length, ear diameter, rows per ear, kernels per row, shelling percent and 1000 seed weight but had a negative correlation with days to 50% tasseling and days to 50% silking in both growing seasons with different magnitudes. Path analysis revealed different results depending on growing season. In post-monsoon season, ear diameter is the largest positive direct effect on grain yield followed by ear length in tested maize genotypes at post-monsoon season, whereas the maximum positive direct effect to yield was recorded for row length and ear diameter in monsoon growing. Hence, these characters could be considered in the improvement of maize grain yield for specific growing season.

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Appendix 1:- List of tested maize hybrids and their sources.

Ent.	Name of variety	Nameof local Company/Department	Nameof original company	Countryof origin	Remark
G1	Asia Seed A-55	Asia Seeds Co., Ltd.	CIMMYT	China-Myanmar	Introduced hybrid
G2	Asia Seed A-99	Asia Seeds Co., Ltd.	CIMMYT	China-	Introduced

				Myanmar	hybrid
G3	AA-737	Green Farm Dev. Co., Ltd.	Agro Great Co., ltd and U-Farm Co., ltd	Thailand	Introduced hybrid
G4	GT-722	Seven Tigers Trading Co., Ltd	Crop Research Center Thailand	Brazil	Introduced hybrid
G5	NK-625	MyanmaAwba Group Co., Ltd.	SYNGENTA Co., Ltd	Thailand	Introduced hybrid
G6	KMHE-3550	Myanmar Toe TetAung Co., Ltd.	Kaveri Seed Company limited	India	Introduced hybrid
G7	CP-111	CPP Fertilizer Co., Ltd	CP Group Co., Ltd	Thailand	Introduced hybrid
G8	NK-621	MyanmaAwba Group Co., Ltd.	SYNGENTA Co., Ltd	Thailand	Introduced hybrid
G9	TSF-1633	CPP Fertilizer Co., Ltd	CP Group Co., Ltd	Thailand	Introduced hybrid
G10	YZI-10-054	DAR	On-going Project (DAR)	Myanmar	inbred
G11	YZI-10-095	DAR	On-going Project(DAR)	Myanmar	inbred
G12	PAC-999	Hein Htet San Co., Ltd.	Pacific Seed Co., Ltd	Thailand	Introduced inbred
G13	C7	DAR	On-going Project(DAR)	Myanmar	inbred
G14	YZCI-16-019	DAR	On-going Project(DAR)	Myanmar	inbred

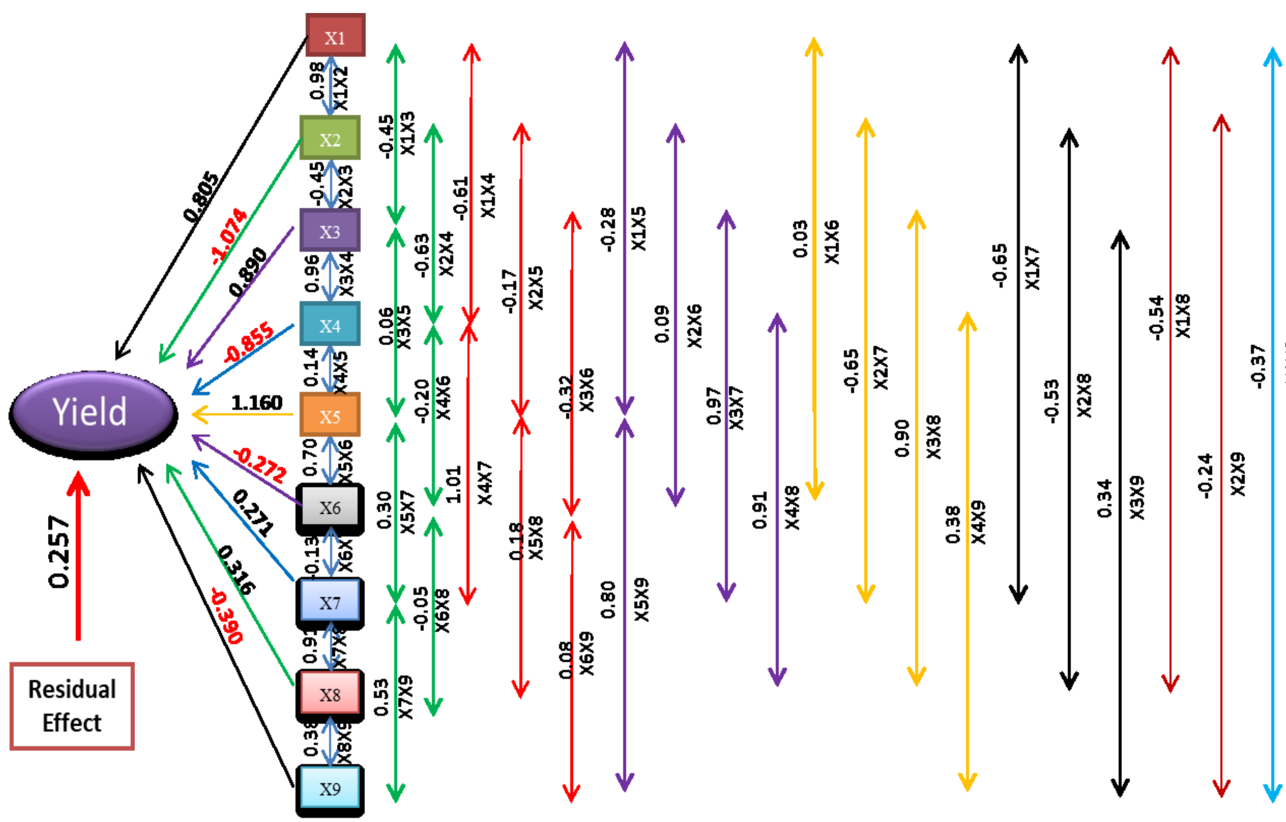

Figure 1:- Diagrammatic representation of direct and indirect influence of yield components on grain yield of maize during 2019 post-monsoon. Single arrow lines indicate path coefficients and double arrow lines indicate correlation coefficient. (X1 = Days to tasseling, X2 = Days to silking, X3 = Ear length, X4 = Row length, X5 = Ear diameter, X6 = Rows per ear, X7 = Kernels per row, X8 = Shelling percent (%) and X9 = 1000 seed weight (kg).

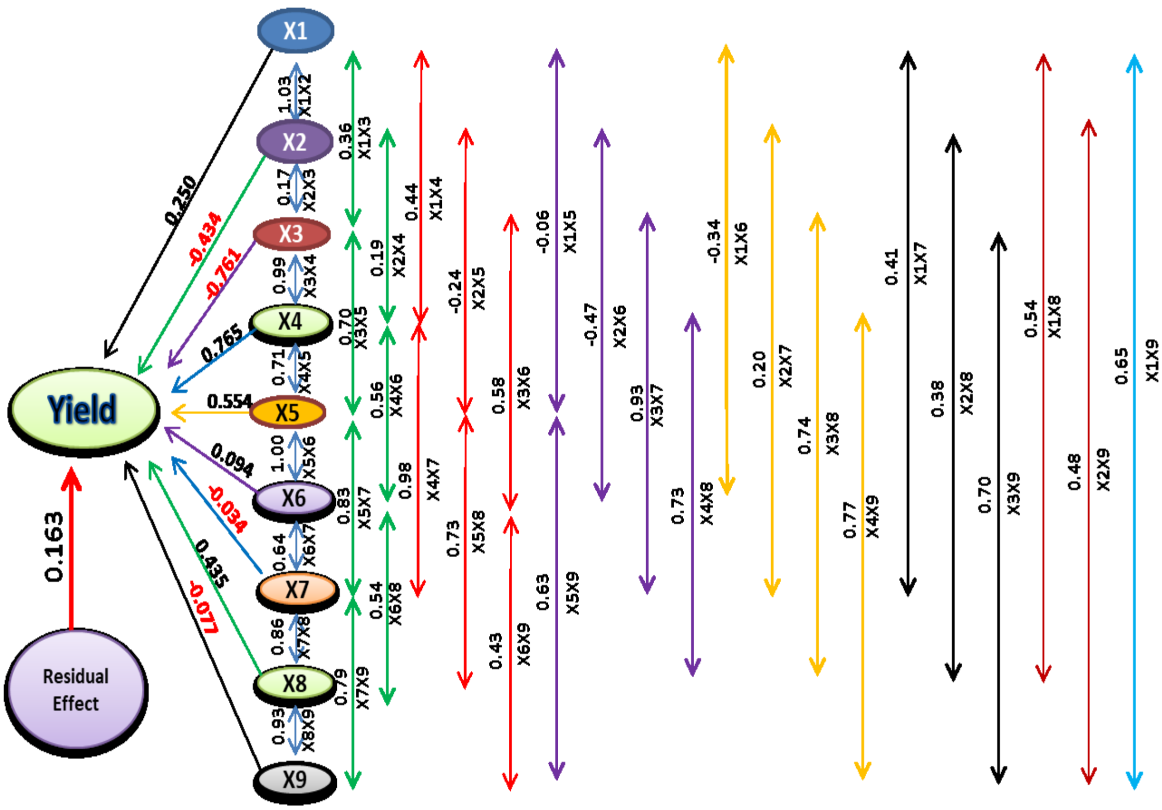

Figure 2:- Diagrammatic representation of direct and indirect influence of yield components on grain yield of maize during 2020 monsoon.

Single arrow lines indicate path coefficients and double arrow lines indicate correlation coefficient. (X1 = Days to tasseling, X2 = Days to silking, X3 = Ear length, X4 = Row length, X5 = Ear diameter, X6 = Rows per ear, X7 = Kernels per row, X8 = Shelling % and X9 = 1000 seed weight.