RESEARCH ARTICLE

EFFECT OF DIFFERENT GROWING SEASONS ON CORRELATION AND PATH COEFFICIENTS OF YIELD AND YIELD COMPONENTS IN MAIZE (Zea mays L.)

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Manuscript Info

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 maize genotypes 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 (Zea mays 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 countries due 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 abiotic 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...
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 (Hosamani et al., 2018).

Recent years, research articles concerning with correlation and path analysis of yield components in maize were published by several researchers (Amanet al., 2020; Bankole et al., 2019; Belay, 2018; Olawamide and Fayeun, 2020; Ozata et 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 correlations and 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 four rows with 4 m length. Two seeds were sown in each hill and thinning was done at 14 days after sowing and left 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 then 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 significant genotypic 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 Alhussein and Idris (2017) who reported that days to 50% tasseling and silking had no significant but negative correlation with the yield. However, positive and significant correlations of these traits with grain yield disagree with the finding of Belay (2018). The contrasts in this finding could be explained by the differences in genotypes and testesasons and locations used. Significant and positive association of days to 50% anthesis and days to 50% silking is also reported by Patile et 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 (Kearsey and Pooni, 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, Sesay et 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 of direct 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) (Fig 2). 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% silking in 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 Baretta et 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 maize genotypes during 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**        |
| Characters                      | Direct effect | Indirect Effects | 1000 seed wt (kg) | Correlation |
|--------------------------------|---------------|------------------|-------------------|-------------|
| Days to Tasseling (day)        | 0.805         | -1.051           | 0.525             | -0.325      | 0.143           | -0.662**          |
| Days to silking (day)          | -1.074        | 0.788            | -0.401            | 0.537       | -0.202           | -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 weight (kg)          | -0.390        | -0.295           | 0.256             | 0.305       | -0.328           | 0.924             | -0.022          | 0.144           | 0.121            | 0.715**          |
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 maize genotypes during 2020 monsoon season.

| Characters                      | Direct effect | Days to tasseling (day) | Days to silking (day) | Ear length (cm) | Row length (cm) | Ear diameter (cm) | Rows per ear (no.) | Kernels per row (no.) | Shelling percent (%) | 1000 seed Wt (kg) | Correlation |
|--------------------------------|---------------|-------------------------|-----------------------|-----------------|-----------------|--------------------|---------------------|-----------------------|----------------------|----------------------|--------------|
| Days to tasseling              | 0.250         | -0.447                  | -0.277                | 0.336           | -0.034          | -0.032             | -0.014              | 0.234                 | -0.050               | -0.033               |              |
| Days to silking                | -0.434        | 0.257                   | -0.127                | 0.147           | -0.133          | -0.044             | -0.007              | 0.166                 | -0.037               | -0.209               |              |
| Ear length                     | -0.761        | 0.091                   | -0.072                | 0.754           | 0.390           | 0.054              | -0.031              | 0.324                 | -0.054               | 0.694**               |              |
| Row length                     | 0.765         | 0.110                   | -0.084                | -0.750          | 0.393           | 0.053              | -0.033              | 0.317                 | -0.060               | 0.711**               |              |
| Ear diameter                   | 0.554         | -0.015                  | 0.104                 | -0.535          | 0.543           | 0.093              | -0.028              | 0.317                 | -0.048               | 0.985**               |              |
| Rows per ear                   | 0.094         | -0.085                  | 0.203                 | -0.441          | 0.429           | 0.553              | -0.022              | 0.237                 | -0.033               | 0.935**               |              |
| Kernels per row                | -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               | -0.077        | 0.161                   | -0.209                | -0.533          | 0.591           | 0.348              | 0.040               | -0.027                | 0.406                | 0.700**               |              |
| Residual effects               | 0.163         |                         |                       | 0.514           | 0.257           | 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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References:-
1. Alhussein, M.B.and Idris, A.E. (2017): Correlation and path analysis of grain yield components in some maize (Zea mays L.) genotypes. International Journal of Advanced Research and Publications, 1(1): 79-82.
2. Aman, J., Bantte, K., Alamerew, S.and Shathu, D.B. (2020): Correlation and path coefficient analysis of yield and yield components of quality protein maize (Zea mays L.) hybrids at Jimma, Western Ethiopia. International Journal of Agronomy, 2020.
3. Bankole, F., Menkir, A., Olaoye, G., Olakojo, O., and Gedil, M. (2019): Association studies between grain yield and agronomic traits of a MARS maize (Zea mays L.) population under drought and non-stress conditions. Acta Agriculturae Slovenica, 114(1): 75-84.
4. Baretta, D., Nardino, M., Carvalho, I.R., Nornberg, R., de Souza, V.Q., Konflanz, V.A. and da Maia, L.C. (2016): Path analysis for morphological characters and grain yield of maize hybrids. Australian Journal of Crop Science, 11(12): 1655.
5. Belay, N. (2018): Genetic variability, heritability, correlation and path coefficient analysis for grain yield and yield component in maize (Zea mays L.) hybrids. Advances in Crop Science and Technology, 6, 399.
6. Dewey, D.R., and Lu, K. (1959): A correlation and path-coefficient analysis of components of crested wheatgrass seed production. Agronomy Journal, 51(9): 515-518.
7. DoP (Department of Planning). (2019): Myanmar Agriculture at a Glance. Ministry of Agriculture, Livestock and Irrigation. p.44.
8. FAO (Food and Agricultural Organization).(2020): Crop production across the world. https://ourworldindata.org/grapher/maize-yields, available date; 8.12.2020.
9. Homayoun, H. (2011): Study of some morphological traits of corn hybrids. J Agr Environ Sci., 10: 810-813.
10. Hosamani, M., Kuchanur, P.H., Swamy, N.and Karagi, D.S. (2018): Studies on phenotypic correlation and path coefficient analysis of grain yield and its component traits in maize (Zea mays L.) hybrids. Journal of Pharmacognosy and Phytochemistry, 7(5): 1374-1377.
11. Kearsey, M. J.and Pooni, H.S.C.N. (2020): Genotype by environment interaction; Genetical analysis of quantitative traits. Garland Science, pp, 241-265.
12. Mahdy, E.E., Ali, M.A. and Mahmoud, A.M. (2011): The effect of environment on combining ability and heterosis in grain sorghum (Sorghum bicolor L. Moench). Asian Journal of Crop Science, 3(1): 1-15.
13. Olawamide, D.O.and Fayeun, L.S. (2020):Correlation and path coefficient analysis for yield and yield components in late maturing pro-vitamin A synthetic maize (Zea mays L.) breeding lines. Journal of Experimental Agriculture International, 42(1):64-72.
14. Ozata, E., Ikinikaraya, S.U. and Ozturk, A. (2018): Correlation and path coefficient analysis for some ear yield related traits in popcorn (Zea mays var. Everta). Journal of Agricultural, Food and Environmental Sciences, JAFES, 72(2): 169-174.
15. Patil, S.M., Kumar, K., Jakhar, D.S., Rai, A., Borle, U.M. and Singh, P. (2016): Studies on variability, heritability, genetic advance and correlation in maize (Zea mays L.). International Journal of Agriculture, Environment and Biotechnology, 9(6): 1103-1108.
16. Reddy, V. R.and Jabeen, F. (2016): Narrow sense heritability, correlation and path analysis in maize (Zea mays L.). Sabrao Journal of Breeding and Genetics, 48(2): 120-126.
17. Sesay, S., Ojo, D.K., Ariyo, O.J., Meseka, S.K., Fayeun, L.S., Omikunle, A.O.and Oyetunde, A.O. (2017): Correlation and path coefficient analysis of top-cross and three-way cross hybrid maize populations. African Journal of Agricultural Research, 12(10): 780-789.
18. Wright, S. (1934): The method of path coefficients. The Annals of Mathematical Statistics, 5(3): 161-215.

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

| Ent. | Name of variety | Name of local Company/Department | Name of original company | Country of 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 |
|   |   |   | Introduction/Source       | Country    | Type     |
|---|---|---|---------------------------|------------|----------|
| 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 | Introduced hybrid |
| G5 | NK-625 | MyanmaAwba Group Co., Ltd. | SYNGENTA Co., Ltd | Thailand | Introduced hybrid |
| G6 | KMHE-3550 | Myanma 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.)