Plant Archives Volume 20 No. 1, 2020 pp. 2023-2029 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

COMPARATIVE STUDY ON INTERRELATIONSHIP BETWEEN PHYSIO-BIOCHEMICAL ATTRIBUTES AND GRAIN YIELD AT TWO DIFFERENT NITROGEN LEVELS.

Aditi Eliza Tirkey[*1], N.S.Barua[2], Akashi Sarma[2], Prakash Kalita[3] and Samindra Baishya[4]

[1*]Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005 (Uttar Pradesh) India.
[2]Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat-785013 (Assam) India.
[3]Department of Crop Physiology, Assam Agricultural University, Jorhat-785013 (Assam) India.
[4]Department of Biochemistry and Agricultural Chemistry, Assam Agricultural University, Jorhat-785013 (Assam) India.

Abstract

The present study was carried out to compare the direct and indirect effect of various physio-biochemical traits on grain yield per plant at two different nitrogen levels *viz.* 80 kg N ha^{-1} and 0 kg N ha^{-1}. Ten local maize genotypes were evaluated for nine traits in randomized block design. ANOVA for completely randomized block design carried out for nine biochemical, Physiological and Yield traits revealed significant differences for all genotypes. At N_0 condition GCV estimates for traits like fat, ash, test weight and grain yield per plant were found to be in the high range while at N_{80} condition GCV estimates for traits like fat, nitrogen use efficiency, test weight and grain yield per plant were found to be in the high range. High estimates of heritability in broad sense were observed for all the traits at both the conditions N_0 and N_{80} condition. Expected genetic advance as percent of mean at 5% was found to be high for all the traits at both conditions. Grain yield per plant had high positive and significant correlation with plant nitrogen and NUE at N_0 condition. Grain yield per plant showed high positive and significant correlation with protein, plant nitrogen, grain nitrogen and NUE at N_{80} condition. The phenotypic path coefficient analysis at N_0 condition revealed that fat content, protein content, ash, plant nitrogen, NUE, test weight on the other hand at N_{80} condition traits viz. fat content, ash, plant nitrogen, grain nitrogen and NUE had positive direct effects in grain yield per plant therefore these traits can be considered for indirect selection criteria for maize grain yield. The direct influence of these traits was reinforced by its indirect effect mainly *via* protein content at N_0 level and *via* protein content and grain nitrogen at N_{80} level.

Key words: maize, correlation, Path coefficient, starch, fat, protein.

Introduction

Maize being one of the staple food in the world is known as queen of cereals because of its high production potential and wider adaptability. Maize kernel is composed of approximately 73% starch, 10% protein and 5% oil, with the remainder made up of fiber, vitamins and macro-and micronutrients (Wang *et al*., 2012). The composition is majorly controlled by the genetics of the endosperm sink, the maternal plant parent and the environment (Nuss and Tanumihardjo, 2010). Previously varieties having greater yield have had more starch and less protein contents (Scott and Blanco, 2009) have been released. However, kernel composition has been successfully manipulated by selection which changed the nutritional value of the grain (Welch and Graham, 2004). Yield, starch, fat, protein and ash are complex quantitative characters governed by large number of genes and are greatly affected by environmental factors. Hence, the selection of superior genotypes on Yield, starch, fat, protein and ash is not effective. For a rational approach towards the improvement of Yield, starch, fat, protein and ash, selection has to be made for their components. Association of Fat, protein, starch, ash and yield with their attributes thus, assumed special importance as the basis for selecting desirable strains. The genetic

***Author for correspondence :** E-mail: elizztirkey@gmail.com

correlation between different characters of maize plant is also because of either linkage or plieotrophy (Harland, 1939). Nowadays development of varieties with better nitrogen use efficiency (NUE, *i.e.* grain yield per unit of nitrogen from soil including fertilizer) is becoming a necessity both to allow the maintenance of a sufficient profit margin for the farmer and to preserve ground water from nitrate pollution. A new breeding aim could be to develop varieties adapted to low N-input and having better quality. Many studies show a genetic variability for NUE at a given level of nitrogen fertilization, with a significant genotype × nitrogen fertilization (G×N) interaction.

Maize oil is a rich source of nutritive oil with least detrimental effect on human health. The energy value of corn oil is approximately 2.25 times that of starch. It appears that the oil content of the corn grain may be increased as much as three per cent without loss in yield.

Plant breeders are interested in developing cultivars with improved yield and better quality which can be grown in low nitrogen input. In order to achieve this, the breeders aim in selecting desirable genotype in early generations or delaying intense selection until advanced generations. For developing varieties which have better nitrogen use efficiency along with good quality parameters, the selection criteria may be yield or one or more of the yield component characters. Breeding for high yield crops require information on nature and magnitude of variation in the available material, relationship of yield with other agronomic characters and the degree of environmental influence on the expression of these component characters. To enhance the yield productivity and quality in low input system, genetic parameters and correlation studies between yield and yield components and biochemical traits are per requisite to plan a meaningful breeding programme to develop high yielding inbreds and hybrids with better nitrogen use efficiency.

Table 1: List of genotypes with its place/state of collection.

Entry No.	Name of the entry	Place/state of collection
1	PAC 740	Advanta (company hybrid)
2	Thengthe bara	Assam
3	Nagaland red collection	Nagaland
4	Mimban sen	Mizoram
5	Khonjai chujauk	Manipur
6	Khayarghutu	Assam
7	Thengthe amuba	Assam
8	Kotho	Nagaland
9	MIZ -7	Mizoram
10	Yellow color maize	Nagaland

Material and Methods

The present investigation was carried out at Instructional-Cum-Research (ICR) farm of Assam Agricultural University, Jorhat, during *Rabi* season of 2015-16. The experimental materials in the present study comprised of ten maize germplasms collected from different regions of North East India and a proprietary hybrid namely, PAC-740. The basic information about the maize germplasms used in the study is presented in table 1.

Soil analysis was done before layout of the experiment and after harvest. Representative samples of soil were collected from a depth of 20-25 cm dried, sampled and analysed for pH, Organic matter, available Nitrogen, phosphorous and potassium. The results of the analyses are given in table 2a and 2b.

Individual experiment was conducted in randomised complete block design (RCBD) with three replications at each level of nitrogen (N) applied, *i.e.* 0 kg and 80 kg. Nitrogen fertilizer in form of granular urea was applied in soil. In experiment with N_{80}, full dose of phosphatic (SSP) and potasic (MOP) fertilizers along with half dose of nitrogenous fertilizer (Urea) were applied at the time of final land preparation as basal dose and the remaining half of nitrogenous fertilizer was top dressed twice, one at knee-height and tasselling stage. In experiment with N_0, full dose of phosphatic (SSP) and potasic (MOP) fertilizers were applied and neither any nitrogenous fertilizer nor any other source of nitrogen was applied. Observations were recorded on biochemical, physiological and yield parameters such as starch, fat,

Table 2a: Result of soil analyses from sample collected before field preparation.

Soil order	Inseptisols
texture	Sandy loam
pH	4.06
Organic matter	1.23 % (medium)
Available N	363.77 Kg/ha (medium)
Available P_2O_5	5.13 Kg/ha (low)
Available K_2O	174.26 Kg/ha (medium)

Table 2b: Result of soil analyses from sample collected after harvest.

Soil order	Inseptisols
texture	Sandy loam
pH	4.4
Organic matter	2.22 % (medium)
Available N	298.77 Kg/ha (medium)
Available P_2O_5	11.23 Kg/ha (low)
Available K_2O	189.20 Kg/ha (medium)

Table 3: Analysis of variance for nine biochemical, physiological and yield traits at N_0 and N_{80} condition.

Source of variation	df	ST	FT	PN	ASH	PN2	GN	NUE	KWT	GYP
mean sum of squares at N_0 condition										
Replicate	2	0.65	0.78	0.17*	0.002	0.002	0.004*	69.93	5.45	249.79
Treatments	9	137.40**	5.80**	6.28**	0.24**	0.08**	0.16**	789.43**	293.82**	2658.85**
Error	18	3.19	0.25	0.03	0.001	0.002	0.001	200.58	3.73	352.87
mean sum of squares at N_{80} condition										
Replicate	2	17.22	0.008	0.026	0.005*	0.01	0.001	21.38	23.93	764.78
Treatments	9	352.15**	27.84**	6.17**	0.10**	1.05**	0.16**	386.39**	1173.56**	15397.76**
Error	18	10.63	1.00	0.09	0.001	0.013	0.002	16.67	10.48	323.77

*Significant at selection intensity at 5%,** Significant at selection intensity at 1%.
Legend: ST- starch, FT-fat, PN- protein, ASH- ash, PN2-plant nitrogen, GN- grain nitrogen, NUE- nitrogen use efficiency, KWT-weight of 100 grains and GYP-yield per plant

protein ash, plant nitrogen, grain nitrogen, nitrogen use efficiency, weight of 100 grains and yield per plant. The starch content in seed sample was estimated by the Anthrone method described by Chopra and Konwar, (1976). Crude fat extract was determined from an oven dried sample using a Soxhlet's extraction apparatus (AOAC, 1970). Total nitrogen was estimated using Kjeldahl's method as modified by Scales and Harrison, (1920) and converted to protein values by multiplying nitrogen percentage with the factor 6.25. The ash content was determined as described in the methodology of AOAC, (1970). All the plants in a plot were harvested and fresh dehusked ears were weighed in kg. The grain yield was calculated by the formula given below. This was converted to ear weight at zero per cent moisture by adjusting for the moisture content recorded at harvest and grain yield per plant was calculated using the formula given below in g/plant:

Grain yield per plant (g/plant) =

$$\frac{\text{Fresh ear weight}}{\text{Number of plants per plot}} \times \frac{\text{shelling percentage}}{100} \times \frac{100 - \text{Mi}}{100} \times \left(\frac{100}{85}\right) \times 1000$$

Where, shelling percentage at harvest for i^{th} entry was calculated as follows: (*grain weight*) / (*ear weight*) × 100

M_i = moisture content in the grain at harvest for i^{th} entry. Grain samples were collected at harvest in air tight polythene bags for each entry. The per cent moisture content in the grains was determined for each entry on the day of harvest by Electronic Moisture Tester.

The plot means were subjected to the following statistical and biometrical analyses and all statistical analyses and biometrical analysis were done by using Windostat Version 9.2. The analysis of variance for the varieties for each trait in each nitrogen level was performed. The mean data for each trait were subjected to analysis of variance following randomized complete block design of the field experiment. The partitioning of the total variance was done according to Fisher's method. Genetic parameters were estimated for each character from ANOVA. Genetic variance (σ^2_g), phenotypic variance (σ^2_p) and environmental variance (σ^2_e) for each trait were computed according to Burton and Devane (1952 and 1953). Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated from these variances in terms of respective standard deviation as percentage of the grand mean. Heritability (h^2) in broad sense and the expected genetic advance (G_s) were calculated following Allard, (1960). Expected genetic advance was then expressed as percentage of the grand mean according to the procedure proposed by Johnson *et al.*, (1955). The correlation was estimated from analysis of variance and covariance as suggested by Searle, (1961). The path analysis was worked out following the methodology proposed by Dewey and Lu, (1959).

Result and Discussion

ANOVA for completely randomized block design carried out for nine biochemical, Physiological and Yield traits revealed significant differences for all genotypes (Treatments) indicating presence of Sufficient genetic variation among the genotypes tested for all the traitsat both the levels of nitrogen. Replication MSS at N_0 condition were found to be significant for protein content and nitrogen content in the grain and at N_{80} condition ash content was found to be significant suggesting presence of difference in soil factors at the experimental location. Okoruwa, (1999) reported significant differences among cultivars for 1000-kernel weight and biochemical traits *viz.*, starch, protein, fat and total sugars.

Mean, Range, estimates of GCV, PCV, heritability and genetic advance for nine traits including biochemical, Physiological and Yield traits of maize at N_0 and N_{80} condition are presented in table 2. Mean for starch content at N_0 condition ranged from 32.41 g starch per 100 g moisture free sample to 55.38 g while at N_{80} condition it ranged from 42.15 g 75.02 g starch per 100 g moisture free sample. Mean for crude fat content in seed at N_0

Table 4: Mean along with GCV, PCV, h^2 and Genetic advance.

	ST	FT	PN	ASH	PN2	GN	NUE	KWT	GYP
N_0 condition									
Mean	42.11	5.55	7.80	1.25	1.38	1.25	73.93	32.25	102.95
Range lowest	32.41	3.17	5.50	0.90	1.20	0.88	50.87	17.78	66.94
Range highest	55.38	7.17	10.10	1.86	1.68	1.62	100.40	49.16	155.36
GCV	15.88	24.51	18.50	22.47	11.78	18.54	18.95	30.49	26.93
PCV	16.44	26.09	18.65	22.68	12.14	18.68	26.95	31.07	32.53
h^2	0.93	0.88	0.98	0.98	0.94	0.98	0.50	0.96	0.69
Gen.Adv as % of mean	31.61	47.42	37.80	45.85	23.53	37.89	27.46	61.63	45.93
N_{80} condition									
Mean	61.19	6.58	8.79	1.71	4.50	1.41	38.79	30.54	178.98
Range lowest	42.15	1.67	6.50	1.45	3.80	1.04	23.20	17.65	92.43
Range highest	75.02	12.50	11.41	2.02	5.28	1.83	52.03	84.19	274.73
GCV	17.44	45.43	16.20	10.90	13.06	16.20	28.62	64.46	39.60
PCV	18.23	47.90	16.56	11.04	13.30	16.56	30.49	65.33	40.86
h^2	0.92	0.90	0.96	0.98	0.96	0.96	0.88	0.97	0.94
Gen.Adv as % of mean	34.35	88.77	32.63	22.18	26.41	32.64	55.33	131.04	79.08

condition ranged from 3.17% on moisture free basis to 7.17% on the other hand at N_{80} condition it ranged from 1.67% to 12.50%. Protein content in seed ranged from 5.50% to 10.10% at N_0 condition on moisture free basis alternatively at N_{80} condition it ranged from 6.50% to 11.41%. Ash content in seed at N_0 ranged from 0.90% to 1.86% while at N_{80} condition it ranged from 1.45% to 2.20%. Mean for plant nitrogen at N_0 condition ranged from 1.20% to 1.68% while at N_{80} condition it ranged from 3.80% to 5.28%. Mean for Grain nitrogen ranged from 0.88% to 1.62% while at N_{80} condition it ranged from 1.04% to 1.83%. Mean for Nitrogen use efficiency ranged from 50.87 $kg.kg^{-1}$ to 100.40 $kg.kg^{-1}$ at N_0 condition while at N_{80} condition it ranged from 23.20 $kg.kg^{-1}$ to 52.03 $kg.kg^{-1}$. Mean for test weight for maize at N_0 ranged from 17.78g to 49.16g while at N_{80} condition it ranged from 17.65g to 84.19g. For grain yield per plant mean values ranged from 66.94g to 155.36g while at N_{80} it ranged from 92.43g to 274.73g.

GCV at N_0 ranged from 11.78 for plant nitrogen to 30.49 for test weight while at N_{80} condition it ranged from 11.04 for ash content in grain to 64.46 for test weight. At N_0 condition GCV estimates for traits like fat, ash, test weight and grain yield per plant were found to be in the high range while at N_{80} condition GCV estimates for traits like fat, nitrogen use efficiency, test weight and grain yield per plant were found to be in the high range according to the scale for GCV classified by Robinson *et al.*, 1949. PCV at N_0 ranged from 12.14 for plant nitrogen to 32.53 for grain yield per plant while at N_{80} condition it ranged from 10.90 for ash content in grain to 65.33 for test weight. At N_0 condition PCV estimates for traits like fat, ash, nitrogen use efficiency, test weight and grain yield per plant were found to be in the high range while at N_{80} condition PCV estimates for traits like fat, nitrogen use efficiency, test weight and grain yield per plant were found to be in the high range according to the scale for PCV, classified by Robinson *et al.*, 1949.

High estimates of heritability in broad sense according to scale for Heritability, classified by (Robinson *et al.*, 1949) was observed for all the traits at both the conditions N_0 and N_{80} condition. Expected genetic advance as percent of mean at 5% was found to be high for all the traits at both conditions.

The estimation of correlation coefficients indicates only the nature and extent of association between yield and yield attributes, but does not show the direct and indirect effects of different yield contributing attributes on yield per se. Grain yield per plant is dependent on several characters which are mutually associated. Phenotypic correlation of

Table 5: Phenotypic correlation matrix at N_0 Condition.

	ST	FT	PN	ASH	PN2	GN	NUE	KWT
ST	1							
FT	0.7368**	1						
PN	0.8212**	0.7848**	1					
ASH	0.8049**	0.5782**	0.5596**	1				
PN2	0.895**	0.7045**	0.7877**	0.6866**	1			
GN	0.8206**	0.7853**	1**	0.5589**	0.788**	1		
NUE	0.2557	0.0349	0.2651	0.0749	0.2721	0.2643	1	
KWT	0.6962**	0.6873**	0.767**	0.3699**	0.7271**	0.7684**	0.0288	1
GYP	0.5693	0.3223	0.5261	0.3494	0.6285**	0.5255	0.915**	0.3186

**Significant at 1% level, * Significant at 5% level nine traits at N_0 condition in *Zea mays* L. is presented in table 5. The correlation coefficients were classified as weak (<0.3), moderate (0.3-0.7) and strong (>0.7) on the basis of their absolute values according to Dospekhov, 1984. From the table 5 it was revealed that all the traits were positively correlated with the other traits. Starch content had strong, positive and significant correlation with fat content (0.7368), protein (0.8212), ash (0.8049), plant nitrogen (0.895), grain nitrogen (0.8206) and test weight (0.6962). Fat content showed strong, positive and significant correlation with protein content (0.7848), ash (0.5782), plant nitrogen (0.7045), grain nitrogen (0.7853) and test weight (0.6873). Protein showed strong, positive and significant correlation with ash (0.5596), plant nitrogen (0.7877), grain nitrogen (1) and test weight (0.767). Ash content was found to show strong, positive and significant correlation with plant nitrogen (0.6866), grain nitrogen (0.5589) and test weight (0.3699) while plant nitrogen showed strong, positive and significant correlation with grain nitrogen (0.788) and test weight (0.7271). Grain nitrogen showed strong, positive and significant correlation with test weight (0.7684). Grain yield per plant had high positive and significant correlation with plant nitrogen (0.6285) and NUE (0.915) at N_0 condition. None of the traits showed significant correlation with NUE but all traits showed positive but weak correlation with NUE. Strong correlation between traits indicate that these attributes were more influencing the grain yield per plant in maize and therefore, were important for bringing improvement in grain yield per plant.

Phenotypic correlation of nine traits at N_{80} condition in *Zea mays* L. is presented in table 6. The correlation coefficients were classified as weak, moderate and strong on the basis of their absolute values according to Dospekhov, 1984. From the table 6 it was revealed that starch content had strong, positive and significant correlation with fat content (0.8919), protein (0.9233), plant nitrogen (0.8031), grain nitrogen (0.9223) and NUE (0.4108) while it showed moderately strong, negative and significant correlation with test weight (-0.6891). Fat content showed strong, positive and significant correlation with protein content (0.9084), plant nitrogen (0.7732) and grain nitrogen (0.9086) while it showed moderately strong, positive and significant correlation with NUE (0.4331) and moderately strong, negative and significant correlation test weight (-0.6328). Protein showed strong, positive and significant correlation with plant nitrogen (0.8554), grain nitrogen (1) and NUE (0.4671) moderately strong, negative and significant correlation test weight (-0.6201). This was in line with the findings of M. Premlatha and A. Kalamani, (2010) who said that protein content and oil content was positively and nonsignificantly correlated with yield. Ash content was found to show weak, positive and significant correlation with test weight (0.383) while plant nitrogen showed strong, positive and significant correlation with grain nitrogen (0.8555) and NUE (0.6692) while correlation with test weight was found to be moderately strong, negative and significant (0.7271). Grain nitrogen showed strong, positive and significant correlation with test weight (-0.478). Grain yield per plant showed high positive and significant correlation with protein (0.6449), plant nitrogen (0.8438), grain nitrogen (0.6446) and NUE (0.9612) this opposed the finding of Tomov and Ivanov, (1988) who showed that correlation coefficient between grain yield and protein content was low in hybrids but was supported by Dwivedi and Godawat, (1994) who found positive and significant correlation of protein content and oil content with grain yield. Tomov and Min, (1995) observed that as grain yield increased, crude protein content decreased with greater maturity. Sivakumar, (1996) studied that the oil was significantly and positively correlated with protein. Cao Yong Guo *et al*., (1999) concluded that oil content also increased seed protein but reduced yield, 100-grain weight. Kumar and Kumar, (2000) reported positive and significant correlation of oil content with grain yield per plant.

To measure the direct and indirect association of one variable through another on the end product path coefficients were calculated at phenotypic level. The observed correlation coefficients of grain yield per plant were partitioned into direct and indirect effects. In the present investigation starch content, fat content, protein content, ash content, plant nitrogen, grain nitrogen, NUE and test weight were used as dependable variables with other traits.

Strong correlation between traits indicate that these attributes were more influencing the grain yield per plant in

Table 6: Phenotypic correlation matrix at N_{80} Condition.

	ST	FT	PN	ASH	PN2	GN	NUE	KWT
ST	1							
FT	0.8919**	1						
PN	0.9233**	0.9084**	1					
ASH	-0.2858	-0.0198	-0.0783	1				
PN2	0.8031**	0.7732**	0.8554**	-0.0748	1			
GN	0.9223**	0.9086**	1**	-0.0764	0.8555**	1		
NUE	0.4108**	0.4331**	0.4671**	0.0596	0.6692**	0.4665**	1	
KWT	-0.6891**	-0.6328**	-0.6201**	0.383*	-0.478**	-0.6188**	-0.1978	1
GYP	0.5738	0.5894	0.6449**	0.0385	0.8438**	0.6446**	0.9612**	-0.3129

**Significant at 1% level, * Significant at 5% level

Table 7: Phenotypic Path matrix of grain yield per plant at N_0.

	ST	FT	PN	ASH	PN2	GN	NUE	KWT
ST	-0.0578	-0.0426	-0.0475	-0.0465	-0.0517	-0.0474	-0.0148	-0.0402
FT	0.0252	0.0342	0.0268	0.0198	0.0241	0.0268	0.0012	0.0235
PN	1.2957	1.2382	1.5777	0.8829	1.2428	1.5777	0.4183	1.2101
ASH	0.0318	0.0229	0.0221	0.0395	0.0271	0.0221	0.003	0.0146
PN2	0.379	0.2983	0.3335	0.2907	0.4234	0.3337	0.1152	0.3079
GN	-1.3345	-1.2771	-1.6263	-0.909	-1.2816	-1.6263	-0.4298	-1.2496
NUE	0.21	0.0287	0.2177	0.0615	0.2235	0.217	0.8211	0.0236
KWT	0.02	0.0197	0.022	0.0106	0.0209	0.0221	0.0008	0.0287
GYP	0.5693	0.3223	0.5261	0.3494	0.6285	0.5255	0.915	0.3186
Partial R^2	-0.0329	0.011	0.8301	0.0138	0.2661	-0.8547	0.7513	0.0092
R square = 0.9938, Residual effect =0.0784								

maize and therefore, were important for bringing improvement in grain yield per plant.

The phenotypic path coefficient analysis at N_0 condition (Table 7) revealed that fat content (0.0342), protein content (1.5777), ash (0.0395), plant nitrogen (0.4234), NUE (0.8211), test weight (0.0287) had positive direct effects in grain yield per plant while starch content (-0.0578) and grain nitrogen (-1.6263) had negative direct effect on grain yield per plant.

Selection based on these traits with positive direct effect may help in improvement of quality of grain and also grain yield per plant on the other hand selection based on traits with negative effect may be ineffective. Plant nitrogen had the highest direct effect on grain yield per plant. All the traits had positive correlation with grain yield per plant. Positive indirect effect of starch content on grain yield per plant was exhibited by all the traits except grain nitrogen. Fat content exhibited positive indirect effect on grain yield per plant *via* protein (1.2382), ash (0.0229), plant nitrogen (0.2983), NUE (0.0287) and test weight (0.0197). Positive indirect effect of protein content on grain yield per plant was seen through traits like fat (0.0268), ash (0.0221), plant nitrogen (0.3335), NUE (0.2177) and test weight (0.022). For ash, plant nitrogen, NUE and test weight positive indirect effect on grain yield per plant was exhibited through all the traits except starch and grain nitrogen. Grain nitrogen had positive indirect effect on grain yield *via* all the traits except starch.

The phenotypic path coefficient analysis at N_{80} condition (Table 8) revealed that fat content (0.0061), ash (0.0121), plant nitrogen (0.3828), grain nitrogen (0.2459) and NUE (0.7108) had positive direct effects in grain yield per plant while starch content (-0.0806) protein (-0.2025) and test weight (-0.019) had negative direct effect on grain yield per plant. Selection based on these traits with positive direct effect may help in improvement of quality of grain and also grain yield per plant on the other hand selection based on traits with negative effect may be ineffective. Plant nitrogen had the highest direct effect on grain yield per plant. All the traits had positive correlation with grain yield per plant except test weight (-0.3129). Positive indirect effect of starch content on grain yield per plant was exhibited by all the traits except plant nitrogen and ash. Positive indirect effect of fat, plant nitrogen and grain nitrogen on grain yield per plant was exhibited by all the traits except starch, plant nitrogen and ash. Positive indirect effect of protein content on grain yield per plant was seen through traits like fat (0.0056), plant nitrogen (0.3275), grain nitrogen (0.2459), NUE (0.332) and test weight (0.0118). For ash positive indirect effect on grain yield per plant was exhibited through starch (0.023), protein (0.0158) and NUE (0.0424). NUE had positive indirect effect on grain yield *via* all the traits except starch (-0.0331) and protein (-0.0946). Positive indirect effect of test weight on grain yield per plant was exhibited by starch (0.0555), protein (0.1256) and ash (0.0046).

Residual effect at both conditions were found to be less than one suggesting that the number of traits considered were enough for the analysis.

Table 8: Phenotypic Path matrix of grain yield per plant at N_{80}.

	ST	FT	PN	ASH	PN2	GN	NUE	KWT
ST	-0.0806	-0.0719	-0.0744	0.023	-0.0647	-0.0743	-0.0331	0.0555
FT	0.0055	0.0061	0.0056	-0.0001	0.0047	0.0056	0.0027	-0.0039
PN	-0.187	-0.184	-0.2025	0.0158	-0.1732	-0.2025	-0.0946	0.1256
ASH	-0.0035	-0.0002	-0.0009	0.0121	-0.0009	-0.0009	0.0007	0.0046
PN2	0.3075	0.296	0.3275	-0.0286	0.3828	0.3275	0.2562	-0.183
GN	0.2268	0.2234	0.2459	-0.0188	0.2104	0.2459	0.1147	-0.1521
NUE	0.292	0.3079	0.332	0.0424	0.4757	0.3316	0.7108	-0.1406
KWT	0.0131	0.012	0.0118	-0.0073	0.0091	0.0118	0.0038	-0.019
GYP	0.5738	0.5894	0.6449	0.0385	0.8438	0.6446	0.9612	-0.3129
Partial R^2	-0.0462	0.0036	-0.1306	0.0005	0.3231	0.1585	0.6832	0.0059
R square = 0.9979, Residual effect =0.0455								

Conclusion

The success of a breeding program depends upon the genetic variation in the materials at a hand. Strong association with grain yield per plant an be due to high direct effects of the characters. Hence, direct selection for these characters would be very effective.

Therefore these results will be useful for choosing populations to be used in developing new maize populations with improved characters.

Acknowledgement

Author is highly obliged to the Department of Plant Breeding and Genetics, Department of Crop Physiology, Department of Biochemistry and Agricultural Chemistry, Assam Agricultural University, Jorhat for providing lab facilities and encouragement due to which this research paper could be completed.

References

Allard, R.W. (1960). Principle of Plant Breeding. John Wiley and Sons Inc., New York, USA.

AOAC (1970). Official Methods of Analysis (10th ed.) Association of Official Analytical Chemists, Washington, D.C

Anonymous (2009). Package of practices for *kharif* crops of Assam. Department of Agriculture and Assam Agricultural University.

Burton, W.G. and E.H. Devane (1953). Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agron. J*., **45:** 478-481.

Cao Yong Guo, Kong Fanling and Son Ton Ming (1999). Effects of populations improvement for high oil content maize and selection method evaluation. *J. China agric. Univ*., **4:** 83-89.

Chopra, S.L. and J.S. Kanwar (1991). Analytical agricultural chemistry. New Delhi, Kalyani Publishers.

Dewey, D. and K.M. Lu (1959). Correlation and Path Coefficient and Path Coefficient Analysis of Components of Crested Wheat Gross Production. *Agronomy Journal.*, **51:** 515-518.

Dospekhov, B.A. (1984). Field experimentation. Statistical procedures. Mir Publishers, Moscow.

Dwivedi, R. and S.L. Godawat (1994). Correlation between quality and ear/yield traits in maize (*Zea mays* L.) and their path coefficient analysis. *Madras agric. J*., **81(3):** 125-127.

Harland, S.C. (1939). The genetics of cotton, John Than Cape, London, 18-23.

Johnson, H.W., H.F. Robinson and R.E. Comstock, (1955). Estimation of genetic and environmental variability in soybeans. *Agron. J*., **47:** 314-318.

Kumar, N.M.V. and S. Kumar (2000). Studies on characters association and path coefficient for grain yield and oil content in maize (*Zea mays* L.). *Ann. agric., Res*., **21:** 73-78.

Premlatha, M. and A. Kalamani (2010). Correlation studies in maize (*Zea mays* L.). *International Journal of Plant Sciences*., **5(1):** 376-380.

Nuss, E.T. and S.A. Tanumihardjo (2010). Maize: A paramount staple crop in the context of global nutrition. *Compr. Rev. Food Sci. Food Saf*., **9:** 417-436.

Okoruwa, A.E., J.G. Kling and B.B. Maziya-Dixon (1999). Physical, chemical and water absorption properties of improved, tropical, open pollinated maize cultivars. *African Crop Sci. J*., **7:** 153-163.

Paztor, K., Z. Gyori and S. Szilagyi (1998). Changes in the protein, starch, ash, fibre and fat contents of maize parental lines and hybrids. *Noventy texmeles*., **47:** 271-278.

Robinson, H.F., R.E. Comstock and P.H. Harvey (1949). Estimates of heritability and the degree of dominance in corn. *Agronomy Journal*.

Scales, F.M. and A.P. Harrison (1920). Boric acid modification of Kjeldahl method for crops and soil analysis. *J. Ind. Eng. Chem*., **12:** 350-352.

Scott, M.P. and M. Blanco (2009). Evaluation of the grain methionine, lysine and tryptophan contents of maize (*Zea mays* L.) germplasm in the germplasm enhancement of maize project. *Plant Genet. Resour*., **7:** 237-243. doi:10.1017/S1479262109264148.

Sivakumar, N.S.V. (1996). Genetic Studies on yield, oil, protein and other associated characters in the crosses involving high oil lines in maize (*Zea mays* L.). M.Sc. Thesis, College of Agriculture, Rajendranagar, India.

Tomov, N. and D.N. Min (1995). Expression of heterosis in maize. *Ratstenier Dni-Nauki.*, **2791:** 20-26.

Tomov, N. and S. Ivanov (1988). Yield and grain protein content in high protein maize hybrids. *Formatsionnyi-Byulleten Po Kukurze*, **7:** 151-167.

Wang, L., Q. Wang, H. Liu, L. Liu and Y. Du (2012). Determining the contents of protein and amino acids in peanuts using near-infrared reflectance spectroscopy. *J. Sci. Food Agric*., doi:10.1002/jsfa.5738

Welch, R.M. and D. Graham (2004). Breeding for micronutrients in stable food crops from a human nutrition perspective. *J. Exp. Bot.*, **55:** 353-364. doi:10.1093/jxb/erh064.