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PREDICTION OF DRY MATTER DIGESTIBILITY OF MAIZE *(Zea mays)* FODDER FROM CHEMICAL COMPOSITION

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To predict the digestibility of whole maize plant and its morphological fractions from its chemical composition. samples of whole plant. leaf and stem of Akbar, Neelurn, U.M.-81 and I.Z.-31 cultivars of maize fodder were collected at different growth stages. All the samples were analyzed for their chemical composition. Dry matter digestibility of whole maize fodder and its morphological fractions was determined by using *in vitro* fermentation technique. It was observed that neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemicellulose and lignin were significantly but negatively correlated with *in vitro* dry matter digestibility (IVDMD) of whole maize plant, leaf and stem. Significant but negative correlations were also observed between various cell wall components and IVDMD of different cultivars of maize plant and its morphological fractions. However, variations in correlation values existed at various growth stages of maize plant. Based on correlations. several prediction equations were developed to work out IVDMD from various cell wall constituents of whole maize plant., leaf and stem.

Key words: cultivars, dry matter digestibility, prediction equations for IVDMD

INTRODUCTION

In Pakistan. major summer fodder crops include maize, sorghum and millet. Maize is an important crop grown basically for grain but also is a popular fodder for livestock. The yield per hectare of maize fodder is 14.80 tonnes (Bhatti and Khan, 1996). Maize fodder provides adequate energy and protein for growth and milk production (Choudhry, 1983). Maize has always higher *in vitro* dry matter digestibility (IVDMD) as compared to other fodder crops (Lloveras, 1990).

In recent years. much of forage breeding work in the country has been directed towards varietal improvement for production of high quality forages. Its evaluation must rest on measuring the real or the predicted utilization values by the animals. Rapid and accurate methods such as the *in vitro* fermentation technique and chemical methods of Van Soest are now available for the evaluation of digestibility of dry matter by using small amount of plant material. A suitable method for estimating dry matter digestibility (DMD) would be of tremendous value to plant scientists in screening their materials where digestion trials are not practicable. Several workers have developed the regression equations to predict the nutritive value of leguminous and non-leguminous forages (Virk et al., 1986; Gupta and Sagar, 1987; Sharma et al., 1988). However, such work has not been undertaken in Pakistan to evaluate the local crops in a comprehensive manner. A study was therefore, conducted with the following objectives:

i) To investigate the relationship between chemical composition and *in vitro* dry matter digestibility of whole maize plant and its morphological fractions.
ii) To develop prediction equations for estimating IVDMD for chemical composition of different cultivars of maize plant.

MATERIALS AND METHODS

Four approved maize cultivars; Akbar, Neelum, U.M.-81 and I.Z.-31 were cultivated from March to June. in the experimental fields of the University of Agriculture. Faisalabad. The experimental fields were fertilized with urea at the rate of 57kg N/hectare. The fertilizer was applied about 20 days after sowing at the time of first irrigation and the fields were irrigated six times with canal water during the experimental period. The representative samples of maize fodder were harvested from different parts of the experimental fields at seedling (wk I), early growth (wk 5). flowering (wk 9), milk/dough (wk 11) and mature (wk 14) stages of growth. The morphological fractions such as leaves and stems were also collected at different growth stages. The leaves (blade + sheath) were separated manually from stem. All fodder samples were chaffed into 2-3 cm pieces and dried at 60°C to a constant weight to determine the dry matter (AOAC, 1990). The dried fodder samples were ground and saved for further analysis.

The structural components such as neutral detergent fibre (NDF), acid detergent fibre (AD F), hemicellulose. cellulose and lignin were determined following the method developed by Van Soest and Robertson (1985). The *in vitro* digestion technique (Troelsen, 1971) was used for measuring the dry matter digestibility. Correlation (r) between IVDMD and structural constituents of whole maize plant and its morphological fractions were worked out according to the following formula:

$$r = \frac{\Sigma(X - \bar{X})(Y - \bar{Y})}{\sqrt{\Sigma(X - \bar{X})^2 (Y - \bar{Y})^2}}$$

Where r = correlation between IVDMD and structural constituents

X = *in vitro* dry matter digestibility (IVDMD)
Y = structural constituent $\bar{X}$ = mean IVDMD
$\bar{Y}$ = mean structural constituent

In case of significant correlation, regression equations were developed. Linear regression Y = a + bx was worked out. Multiple regression and correlation analysis was also applied. Since no advantage was observed with multiple correlation/regression over simple correlation/regression, therefore, simple correlations/regressions were reported. Standard errors were also calculated for each equation. Minitab computer program (Minitab, 1994) was used for the above analysis.

RESULTS AND DISCUSSION

1. Morphological Fractions

Relationship Between IVDMD and Structural Constituents: Correlation coefficients between various cell wall components and IVDMD of whole maize plant and its morphological fractions were computed and prediction equations were developed. The correlations and prediction equations for whole maize plant, leaf and stem have been shown in Fig. I, 2 and 3. All the structural constituents had significant (P < 0.0 I) but negative correlations with IVDMD of whole maize plant, leaf and stem. Gupta and Sagar (1987) reported that all the structural components were significantly and negatively correlated with IVDMD of maize plant. They worked out correlation coefficients as -0.95, -0.86, -0.67, -0.55 and -0.82 for NDF, ADF, lignin, cellulose and hemicellulose, respectively, whereas in the present study the respective correlation coefficients were -0.945, -0.941, -0.917, -0.906 and -0.941 respectively. Hunt et al. (1993) reported that correlation coefficients for whole plant and *in situ* DM degradability with NDF, ADF, cellulose, lignin and starch were -0.85, -0.80, -0.79, -0.58 and -0.69 respectively in six maize hybrids cut at three stages of plant maturity. Although these studies have shown a close agreement with the findings of the present study, but the correlation values determined in this study Were a little higher.

By applying these prediction equations, it will be rather easy to estimate the nutritive value of maize fodder. Gupta and Sagar (1987) established several prediction equations for Indo-Pak forages. Based on the correlations, it was suggested that NDF and/or ADF contents of forages were better predictors than other chemical components. The estimation of NDF and ADF contents of forages is comparatively easier and time saving too. Virk et al. (1992) reported that IVDMD of different forages can be predicted from CP, NDF, cellulose content and ADF: IVDMD = -565.58 + 0,46CP + 1,21 NDF + 1.39CC - 0.37ADF. It was also observed from the present results that in whole maize plant I % increase in various cell wall constituents such as NDF, ADF, cellulose, hemicellulose and lignin, resulted in a decrease of 0.35, 0.60, 0.79, 0.93 and 2.59 % respectively in dry matter digestibility. In the leaf fraction of the plant, the respective values were 0.35, 0.55, 0.73, 0.82 and 2.75 %, whereas in stem the dry matter digestibility was depressed by 0.38, 0.56, 1.10,0.84 and 2.19 % with an increase of I % NDF, ADF, cellulose, hemicellulose and lignin respectively. It was thus concluded that lignin may be the main cell wall component which negatively affected IVDMD in all plant fractions.

2. Maize Cultivars: Correlations were calculated between IVDMD and cell wall constituents of different cultivars of whole maize plant and its morphological fractions. Significant (P < 0.0 I0) correlations were observed between various structural constituents and IVDMD of whole maize plant, leaf and stem (Table 1). Cell wall components namely NDF, ADF, cellulose, hemicellulose and lignin were found to be negatively correlated with IVDMD of different cultivars. Higher concentration of structural constituents is generally associated with lower IVDMD. Higher concentration of lignin also depresses digestibility of structural carbohydrates in forages. It is, therefore, apparent that the advancement in plant age will have a detrimental effect on nutritional value of forages. Tile digestibility of various cultivars of whole maize plant, leaf and stem was also affected by advancing stage of maturity.

A number of regression equations were worked out for various cultivars of whole maize plant and its morphological fractions to predict percent IVDMD on the basis of various cell wall components. Regression equations along with correlation coefficients (r) and standard errors (S.E) of whole maize plant, leaf and stem are given in Table 1.

3. Growth Stage: Correlation coefficients between IVDMD and various structural constituents of whole maize plant, leaf and stem within different stages were also computed (Table 2). Variations in correlation values existed at various growth stages. Mostly non-significant correlations were observed among cell wall components and IVDMD. Positive correlation values were found at various growth stages. It may be due to smaller number of samples and variations in the digestibility of different cultivars. Costantini and Vincenzi (1993) also reported that chemical composition.and organic matter digestibility (OM D) were all highly correlated. Organic matter digestibility, ADF, NDF and crude fibre correlation values were high and were influenced by plant species and number of samples. They further reported that this factor might also explain the positive correlation coefficients between acid detergent lignin and OMD.

The results indicated that an increase in structural constituents has negative effect on the palatability and digestibility of whole maize plant and its morphological fractions. It may be concluded that the neutral detergent fibre and acid detergent fibre were the better predictors of digestibility of maize foddef than other cell wall components. It is, therefore, suggested that the prediction equations may be applied for the estimation of nutritive value of maize fodder and can as well be employed by research workers in the field of forage evaluation for early screening of maize cultivars.

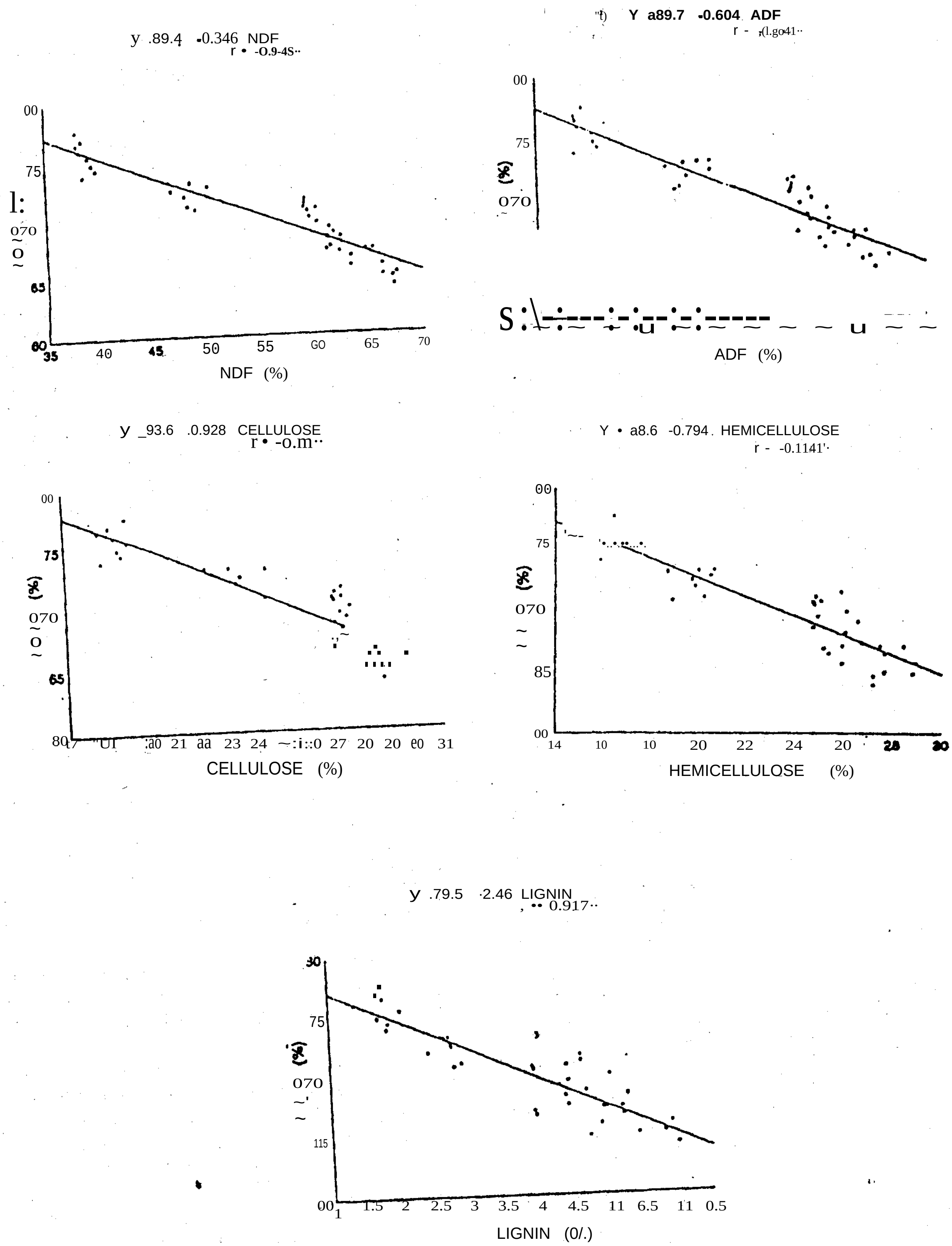

Fig.1 Regression lines / predication equations showing the relationship between IVDMD and various cell wall components of whole maize plant.

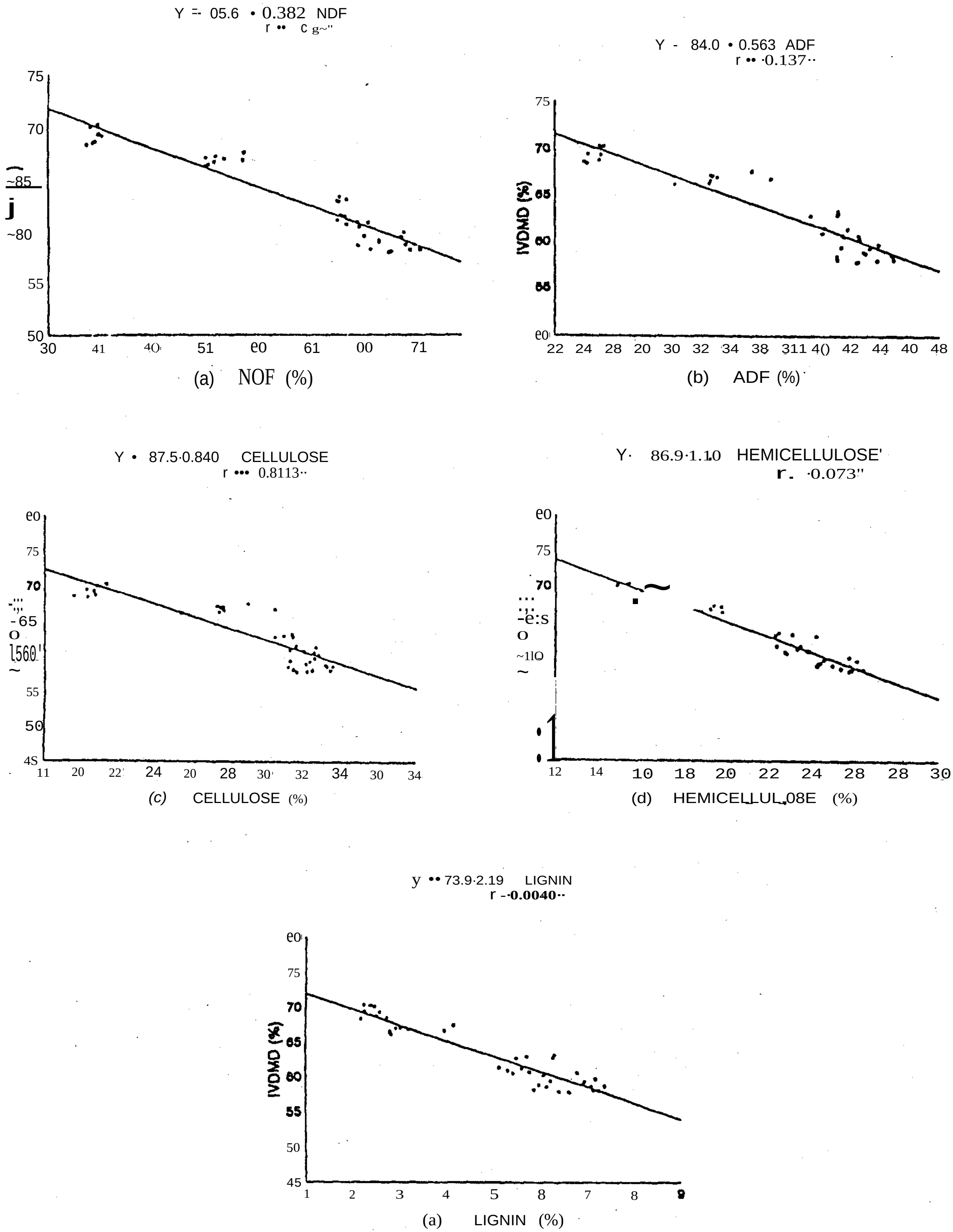

Fig.2 Regression lines / predication equations showing the relationship between IVDMD and various cell wall components of leaf of maize plant.

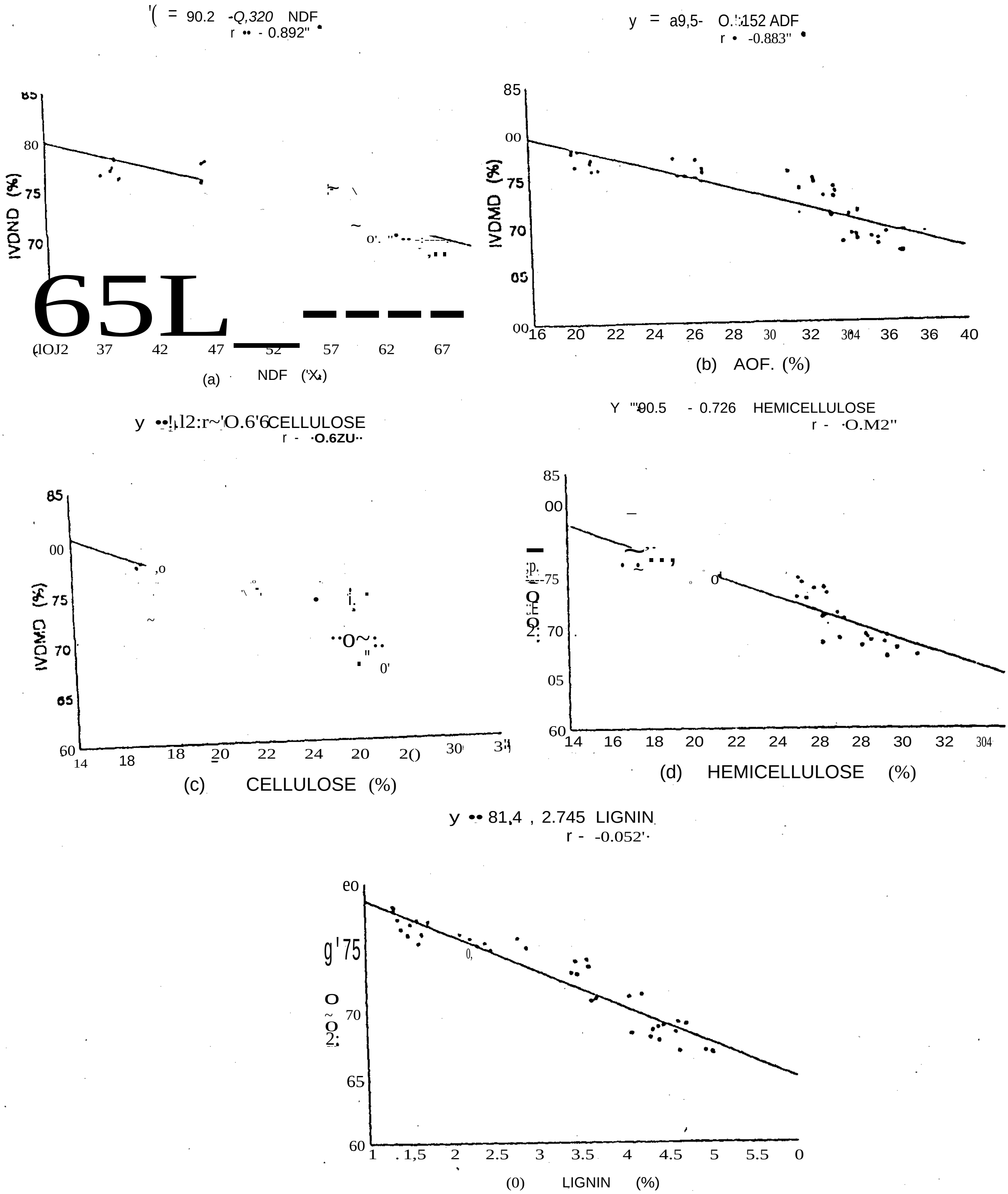

Fig.3 Regression lines / predication equations showing the relationship between IVDMD and various cell wall components of stem of maize plant.

Table [illegible]. Prediction equations for [illegible] wall [illegible] its [illegible]

Varieties	Whole plant			Leaf			Stem		
	Regression equations	Correlation (r)	S.E	Regression equations	Correlation (r)	S.E	Regression equations	Correlation (r)	S.E
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= 87.0 [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	0.947**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= 81.4 [illegible]	0.974**	[illegible]	Y= [illegible]	0.974**	[illegible]
[illegible]	Y= 81.[illegible]	[illegible]**	[illegible]	Y= 81.[illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= 81.[illegible] 74 [illegible]	[illegible]**	[illegible]	Y= [illegible]	[illegible]**	[illegible]
[illegible]	Y= [illegible]	[illegible]**	[illegible]	Y= [illegible] 74 [illegible]	[illegible]**	[illegible]	Y= [illegible]	0.974**	[illegible]

** = Significant ($P < 0.01$).

Table 2. Correlation values of various cell wall components with DMD of whole maize plant and its morphological fractions at different stages of growth

Growth stages	NDF	ADF	Cellulose	Hemicellulose	Lignin
	Structural components				
Whole plant					
Seedling	-0.710*	0.408NS	+0.085N~	-0.788*	_0.538NS
Early growth	-0.325~	+0.152N~	+0.333NS	-0.428N~	_0.671NS
Flowering	-0.710'	_0.90~s	-0.652N~	-0.221l'IS	-0.835**
Milk/ dough	6.10N~	-0.333"	+0.469NS	-0.656N~	-0.802
Mature	-0.845'"*	-0.713*	+0.533NS	-0.63jNS	-0.884**
Leaf					
Seedling	-0.288N~	-0.733*	_0.579NS	+0.691N~	-0.746'
Early growth	_0.378NS	_0.312NS	-0.198N~	_0.119NS	-0.77:-:
Flowering	_0.493NS	-0.745'	_0.358NS	-0.236N~	_0.670NS
Milk/ dough	-0.578~	-0.370N~	_0.411NS	-0.45~s	_0.599NS
Mature	-0.792'	_0.414NS	_0.145N~	_0.634NS	_0.508NS
Stem					
Seedling	+0.426~	+0.688N~	+0.719*	_0.384NS	_0.263C'iS
Early growth	+0.580NS	+0.560NS	+0.499N~	_0.703NS	+0.618"s
Flowering	_0.280NS	_0.113NS	_0.672NS	_0.017NS	+0.717"'S
Milk/ dough	-0.41:jN'	+0.246N~	_0.279N~	-0.747'	-0.121'"s
Mature	+0.156NS	+0.223NS	_0.162NS	_0.156NS	tOA15"s

NS = Non-significant; * = Ssignificant (P<0.05); ** = Significant (P<O.OI).

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