DIFFERENT STAGES OF MATURITY AND THEIR RELATIONSHIP WITH SOME OF THE AGRONOMIC TRAITS IN CORN (*ZEA MAYS* L.)

by

MOHAMMAD ASLAM

B.Sc. (Hons.), University of Peshawar, Pakistan, 1965

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1979

Approved by:

Clyde E. Wassom
Major Professor

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Agricultural development has been of prime importance to the survival and cultural development of man and the prosperity of nations throughout history. With the steady increase in human population, it is urgent to increase agricultural production either by bringing more area under cultivation or by increasing the yield potential of crops per unit of time and area. The first alternative is limited by natural factors; the second, on the other hand, can provide a real tool in human hands to fight against hunger and starvation. In addition to genetic and environmental factors which affect the yield potential of a crop, physiological and morphological aspects play important roles. Plant breeding has contributed substantially to greater agricultural productivity. One of the most important contributions of plant breeding has been the development of better varieties. This has frequently been accomplished by adjusting the growth cycle, i.e., selecting genotypes better suited to the available growing season.

Much has been achieved in corn improvement through breeding so that well adapted varieties are available for most areas. Farmers, however, in the hope of increased yields, prefer longer maturing varieties than those developed for their particular area and/or environments, ignoring the risk and danger of frost injury.

In general, the longer a crop takes to mature, the higher the yield. Maturity is an important consideration in corn breeding; the wide variability in length of pre- and post-flowering periods provides an important basis for selection.

Many investigators have contributed to the total knowledge of maturity. Shaw and Thom (51) and Hallauer and Russell (25) reported a relatively constant period from silking to physiological maturity. On the other hand, Hillson and Penny (28), Daynard et al. (19), Johnson and Tanner (30), and Carter and Poneleit (9) indicated that corn genotypes differ in duration of the reproductive phase.

Besides the genetic constitution of different genotypes of a population, the physiological and morphological traits like leaf area, plant height, ear position, etc. affect yield directly. There is evidence that many of these characteristics are related to maturity in one way or another, and variation in different stages of maturity does affect these aspects of the crop and ultimately the yield. Primary emphases of this study are different stages of maturity and their relationships with different agronomic characteristics and yield.

Objectives of this study are to: (a) screen the population and identify groups of genotypes which differ in maturity, (b) study the different stages of maturity of each group, and (c) study the relationship between stages of maturity and physiological responses of the crop, especially yield.

LITERATURE REVIEW

The term "maturity" has not been defined or used in literature with any degree of consistency. Apparently, none of the definitions are equally acceptable to plant breeder, physiologist, agronomist, or farmer. Three measurements of maturity which have been used frequently in classifying the maize inbreds and hybrids are: silking date, physiological maturity (formation of black layer at the placenta of "kernel"), and grain moisture at harvest. The silking date and grain moisture are the most common measures because they are easy to obtain. The physiological maturity has gained more importance in recent years, as this is the time when maximum dry matter accumulation is completed in the kernel. Voluminous literature has been presented on different aspects of corn maturation and related studies, indicating that high yields are achieved by hybrids and varieties which can utilize maximum length of growing season. In other words, the longer the maize crop takes for growth and development in the field, the higher it produces. Since the time of ripening is critical in the regions where frost is a threat or in the areas where the system of farming is reduced to rotation of corn and winter cereals, a point of diminishing return in augmenting yields in this way may be reached.

Grain yield is of primary interest, and is mainly a function of two developmental phases: the vegetative phase, which determines the number of kernels per ear, and the reproductive phase, which affects the size of the kernel. Little has been studied on the precocity of individual phases and their relationship to yield and other agronomic traits. Such information may be useful to maintain the total growth period of a genotype, but lengthen seed maturation period with the same or increased yield.

Days to Flower

Skreekantaradhya and Mahadevappa (55) observed non-additive and dominant gene action influenced genetic control of days to silk. Similar results were obtained by Griesbrecht (24) in his study of inheritance of time of silking and pollen shedding in maize. The earliness appeared to be due mainly to dominant genes Jones, (31). Rasmusson and Tew (46), in a study with barley, also obtained intermediate to high heritability values of .54 to .99 for vegetative period.

In early work, Hopper (29) found a range of 57-89 days from planting to flowering in 16 varieties of different maturity groups. These differences were due to environmental conditions, date of planting, and varietal inheritance.

Hanway and Russel (27) divided the vegetative period into two stages 0-2.5 (emergence to 10th leaf visible) and 2.5-5 (2.5 to silking). They reported a variation of 16-30 days for the stage 2.5 to 5 for different hybrids. The stage 0-2.5 was essentially the same length for all hybrids.

The variation in maturation of different maize varieties is mainly due to vegetative period. This is the period which determines the total mass of leaves; varieties with shorter period develop smaller areas of assimilating leaves and consequently should be less productive Shaw and Thom (50).

Misovic (38) showed significant difference in the interval between emergence and flowering of ear among individual varieties, lines and hybrids. Inbred lines displayed the greatest range (50 to 80 days) as compared to varieties and hybrids. Similarly, Maurin J. et al (37) reported a wide variation in length of vegetative period in 26 different hybrids and varieties of corn.

In a study of selection for early flowering in three semi-exotic synthetics, Troyer and Brown (56) shifted days to silk 1.8 days earlier, decreased moisture content 1.2%, and increased yield 1.00 q/ha per cycle of selection. In another similar study (57), silking was shifted 1.7 days earlier per cycle for a total of 7 days for five cycles of selection in three early synthetics, and 2.0 days earlier per cycle for a total of 10 days for a late synthetic. The response to selection was less in advanced generations.

Grain Moisture

Beil (4) selected on an individual plant basis in early versions of DeKalb "M" and "F" synthetic populations and moved the mean of early "F" population from 69.8 to 68 days and of "M" from 69.9 to 68.1 days in three cycles of selections. A drop of moisture content from 27.2 to 25% and 26.4 to 24.4% in "M" and "F", respectively, was also observed.

Hillson and Penny (28) reported differences in rate of drying for different crosses. Those involving lines which had fast-drying character were the earliest to silk and required much more time from silking to physiological maturity. A variation of 53-61 days from silking to physiological maturity has been reported.

Seed Maturation

Many investigators Daynard and Duncan (17), Rench and Shaw (47), and Johnson and Tanner (30) agreed that the black layer formation indicates the attainment of maximum dry matter accumulation in the kernel.

Results have differed regarding the length of the period from silking to grain maturity. It was suggested earlier by Dessureaux et al. (21) that inbred lines and hybrids of corn of contrasting maturity vary in rate of moisture depletion and dry matter accumulation. Not only the time of flowering and time at which physiological maturity is completed should be considered for an adequate measure of maturity. However, Shaw and Thom (51) soon after reported a constant period of 51 days from silking to maturity, and that, because of constancy, time of maturity could be predicted at silking time.

Similar results were reported by Misovic (38) and Hallauer and Russell (25), who observed a constant duration of 60 days after silking to reach a grain moisture of 36.4% and 63 days to reach a grain moisture of 34.6%. Singh et al. (53) also recorded a constant period of 36 days from silk to maturity regardless of silking date. In contrast, Potlog et al. (43) studied ear development in nine stages and reported variation in the ear development period. Larger variation was observed in later stages of development as compared to early stages. In a later study, Hanway and Russell (27) obtained 43 to 60 days variation in number of days required after silking to maximum dry matter in the ear.

Maturation Days

Daynard (18) and Poneleit et al. (41) reported wide genetic variation for black spot maturity and grain filling duration. Genotypes differed in growing degree days requirement (GDD) for black spot maturity and grain filling period Poneleit et al. (42). GDD requirement for black spot formation and filling period varied from 2406 to 3254 and 992 to 1478, respectively. Similar results were obtained by Carter and Poneleit (9) where GDD requirements varied from 1337 to 1808 and from 512 to 821 for black layer maturity and kernel filling period, respectively.

Grain Filling

Rench and Shaw (48) obtained large significant differences in filling period length. The total variation, 45-70 days, was due to variety, planting, and environment. Planting date accounted for 0 to 8 days variation in filling period and environment caused 10 to 20 days difference.

Cross (15) indicated significant differences among hybrids and years for grain filling period, rate of filling, grain yield and thermal units to silking. Significant interaction between hybrids and years was reported for moisture content at harvest.

The number of leaves on a mature corn plant has been regarded as a genetically controlled varietal characteristic. Leaf number varies with environmental conditions, season, planting date, and genotype. Leaves have generally been considered as the chief photosynthetic organ of the maize plant, although other parts like husks, stem, etc. may contribute somewhat. Total number of leaves on a maize plant was used as an index of growing period as early as 1932, (36).

Earliness and Leaf Area

Recent work on the relation between earliness and leaf number is in agreement with early research. The longer season hybrids not only produce larger leaf area per plant, but also tend to maintain green leaf area for a longer time than early hybrids Eik and Hanway (22). Bonciavelli and Monotti (8) also obrained a larger leaf area index (LAI) value of 5 for late flowering hybrids as compared to LAI of 4 for early ones.

Hanway (26) reported one leaf was added approximately every three days of the vegetative period and showed a close association between number of leaves and total period of development from emergence to silking.

Chase et al. (11) obtained a highly significant positive correlation between mean number of leaves per hybrid plant and mean days from planting to anthesis. A positive correlation between moisture at harvest and the above two traits was also obtained. Similar results were presented by Chase and Nanda (12), suggesting the number of leaves per plant as a criteria in the determination of maturity.

Nozzolin (40) in Italy and Kotova et al. (34) in USSR found the correlation coefficient $r = +0.916 \pm 0.016$ and $r = + .75$ respectively for number of leaves and length of vegetative period.

The number of leaves is mainly determined genetically and there is a positive relationship between leaf number and growing period Belej et al. (5).

Inheritance of Maturity

Quinby (44), working on maturity genes in sorghum, reported that number of leaves on a sorghum plant depended on the time of floral initiation.

The delayed floral initiation was associated with initiation of more leaves. Yamaguchi (58) noted that short plant selection in Tuxpeno population of maize resulted in 22 leaves per clum instead of 24 leaves as in the original population; this was associated with three days reduction in growth duration. Incorporation of the Br_2 (bracetic) gene did not change the leaf number.

Boneparte and Brawn (7) studied 23 maize genotypes in 26 environments (21^{o}N Mexico to 49^{o}N Manitoba) and observed a positive relationship (.699 - .959) between number of leaves and 50% flowering.

Allison and Daynard (2) observed that leaf area per plant measured shortly after silking was considerably greater in the late flowering varieties than in earlier ones. They found approximately proportionate change in leaf area and number of days to silking, when vegetative period was shortened by increase in initial temperatures.

Height and maturity of genotypes are recognized by breeders to be determining factors for the ecological adjustment of a variety to a particular region and finally in expression of yield. Most genetic studies reveal a close association between genes for maturity and height.

Yang (59) suggested that only a few genes control silking time or plant height and that they are approximately similar in effect for the two traits. A similar conclusion was reached by Rao and Goud (45) indicating that gene action for plant height and maturity in sorghum is essentially the same. They found additive gene action predominated for the above traits.

Anderson (3) reported a good correlation between plant height and number of days to flowering in maize. Late maturing hybrids were taller and had more internodes, as compared to early maturing varieties Singh (54).

Comparing two genotypes of sorghum, Quinby (44) observed that 'SM90' and '90M' differed only at Locus 1; SM90 was recessive ma_1 and 90_M was dominant Ma_1. The dominance at Locus 1 increased duration to flowering by 53 days, leaf number by 92%, plant height by 77%, and doubled the dry weight of the plant.

In an experiment by Troyer and Brown (57), selecting for early flowering over five generations shortened days to silk 1.7 days, reduced plant height 6.0 cm, and decreased ear height 4.1 cm each generation. Ear height was strongly associated with plant height and therefore also with days to silk. Similar trends for different traits were observed earlier (56) using three semi-exotic synthetics at different plant densities.

Cross and Zuber (14) reported a high correlation between number of days from planting to flowering and plant height. The relationship was low or insignificant when considered over a wide range of environmental conditions.

Yield

Phsiological maturity is defined as time of maximum dry matter accumulation in the kernel. More recent research on black layer formation indicated the suitability of this criterion as a tool to determine physiological maturity. The interval between pollination and physiological maturity establishes the length of grain filling period. This grain filling duration contains three significant phases of grain development:

(1) lag period, emergence of silk to 18 days maximum, (2) phase of linear grain filling, and (3) phase in which dry matter accumulation declines, terminating at black layer formation. Failure to use physiological maturity as a measure of maturity has been due to a controversy over duration of the grain filling period and variations associated with it.

In early work with maize, Berzsenyi-Jonosits (6) reported a positive correlation between grain yield and the vegetative period in early maturing hybrids. Similar results were obtained by Chuchmii (13) in different maturity groups.

Chase (10) studied the relation between yield and silking date in corn hybrids having equal moisture at harvest. Dry grain weight increased 56 pounds per acre for each day delay in silking time. He concluded that higher yields were possible in early hybrids which flower late and lose moisture rapidly after physiological maturity, and that they would compare favorably with those that flower early and dry slowly later in the season.

In a recent study, Beil (4) indicated that the interval between planting and anthesis contributed most to the variability for yield, suggesting that this interval was an important criterion to improve overall productivity.

Hanway and Russell (27) observed that duration of dry matter accumulation in the grain at a rapid rate varied among the hybrids and resulted in markedly different yields.

Daynard (16) stated that eighty percent of the differences in yield among hybrids were due to grain filling period differences, and that 15% difference accounted for rate of grain formation. In another study, Daynard et al. (18) reported that the effective filling period duration (EFPD) might be more closely related to yield than the interval from silking to black layer. However, in a more recent work, Daynard and Kannenberg (20) concluded that both were equally good measures of differences in length of reproductive period because both were equally correlated with grain yield.

Kozimec and Klimendo (35) found in a comparison of short vs. longer vegetative period that most of the shorter term hybrids outyielded Bukovina 3, which had the longer vegetative period.

Sanchez (49), in a study of 306 progenies of four S_1 lines, got a positive correlation between silking date and ear moisture at harvest, but the correlation between the silking date and yield was negative. A correlation coefficient value of r = 0.462 to 0.674 between dry matter of mature kernel and vegetative phase was observe Misovic (38), while the coefficient value for yield and reproductive phase was 0.704 to 0.845. Grain filling period had a direct effect on yield, while the rate of filling was of minor magnitude Cross (15).

Fischer (23) compared early and late groups of composites for different traits. Early groups 'Lotes 88,' '89,' '89B' reach 30% moisture content 4.8 days earlier than the late groups, but the black layer was 3.5 days later in late maturing groups. The early groups had significantly lower yield. The differences were probably due to fewer ears per plant, kernel number (54%) and kernel size (85% of the late group). Kernel size was directly influenced by grain filling rate.

MATERIALS AND METHODS

Genetic Sources

'Lote 81,' a broad base composite derived from tropical maize germplasm, was used in this study. Field tests were planted at two locations, Ashland Agronomy Farm, Kansas State University, Manhattan; and Talaltizapan, Mexico, in cooperation with CIMMYT.[1] Over 500 families from Lote 81 were planted at Talaltizapan during the winter 1977 to develop sub-populations with differential silking date and maturation period responses. The families were developed by making plant-to-plant crosses (full-sib-families) and self-pollinations within maturity groups on the basis of flowering dates. The crop was harvested at early stages of maturity and each pollinated ear was examined for black layer. Plants were also examined to detect other possible causes of black layer formation, i.e., diseases or mechanical damage, etc.

The selected ears were grouped into four sub-populations designated as follows:

Group 1	Early flowering + Early black layer formation
Group 2	Late flowering + Early black layer formation
Group 3	Early flowering + Late black layer formation
Group 4	Late flowering + Late black layer formation.

The approximate planting-to-flower-to-maturity relationships are displayed in Fig. 1. Since the quantity of seed was limited, only ten entries were included in the trial to insure a sufficient amount of seed for a replicated trial at two locations.

[1]CIMMYT = Centro Internacionl de Mejoramiento de Maiz y Trigo

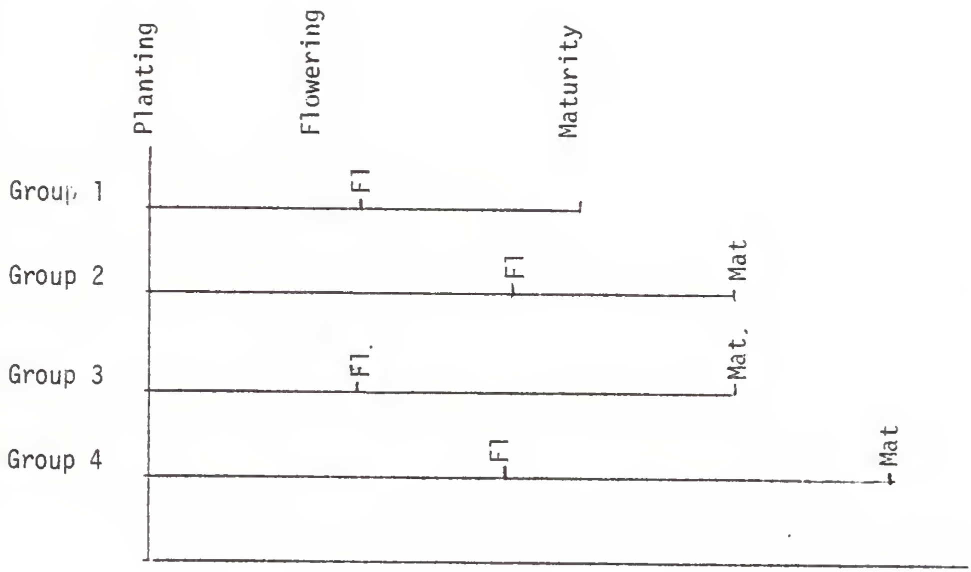

Fig. 1. Four sub-populations derived from basic population Lote 81.

Four groups totaling 40 entries, ten in each group, were planted at Manhattan in May 1978, and the same entries were planted at Talaltizapan in the 1978 normal season. Due to severe wind and hail storm damage to the Talaltizapan, 1978B crop, a supporitng trial was planted during November 1978. It consisted of sixteen entries in each group. These 16 entries were not the same as those used in tests at Manhattan and Talaltizapan 1978 normal season.

Experimental Design

One row plots five meters long with 75 cm row-to-row and 33 cm between plants were used at each location. A randomized complete block design was used for all tests. Two hundred kg/hec of nitrogen fertilizer was used at Manhattan. At Talaltizapan, 150 kg and 90 kg/hec, respectively, N and P_2O_5 were applied. The fertilizer was applied preplanting in one application, at both locations, and the trials were conducted under irrigated conditions.

The Ashland Agronomy farm of KSU is situated at 35^{o}N latitude at about 335 m elevation, and consists of a silt loam soil. Talaltizapan is located at 19^{o}N latitude at 950 m elevation, and is a loamy clay soil type with an alkaline reaction.

At Manhattan, five plants were randomly selected at the five-leaf stage. The fifth leaf of each tagged plant was marked to provide a base for the leaf count. Total number of leaves were counted after tasseling was completed in all the plots. The number of leaves above the ear were also counted. At Talaltizapan the same procedure was used for leaf number count, but nine plants were sampled instead of five.

Silking date was recorded for all the entries in both the replications at both locations, using number of days from planting to fifty percent silk.

After pollination was completed, the ear leaves of five randomly selected, guarded plants were measured for length from tip to base and for maximum leaf width, to estimate the leaf area. The areas of individual leaves were calculated by using the formula Montgomery (39):

$$A = \text{leaf length} \times \text{maximum width} \times .75$$

Total leaf area per plant was the summation of all leaves on a plant.

At brown silk stage, four guarded plants were randomly selected to estimate the plant height and ear position of each entry. Plant height was recorded by measuring the distance from the ground to the flag leaf, while ear height was the distance from the ground to the base of the uppermost ear on the selected plant.

It was difficult to observe and determine the exact date of black layer completion in each entry, especially in yield trials with single row plots and two replications. The experiment was harvested in early maturity stage to provide information to assist in the determination of early and late groups. Since facilities were limited, a single date of harvest was used at Manhattan. All plots of the experiment were harvested on one day. The harvest date was selected on the basis of apparent crop maturity. After the harvest was completed and fresh weight for each plot recorded, two rows of kernels from each ear of an entry were shelled and mixed. A sample of one-hundred kernels from the bulked seed was taken and the black layer grades on the basis of kernel counts with (1) no color, (2) brown, (3) black, were made. A scale of 0-10 was used.

This was done for each entry of both replications. The mean grade of twenty entries in two replications represented the estimated grade of black layer for each group. In addition, estimated days from mid-silking to physiological maturity and planting to final maturity were also recorded.

Two harvests were made at Talaltizapan. The first consisted of harvesting half the plot after a constant duration of 63 days from flowering for each entry. The second harvest was done at complete maturity. Similar procedure for grading of black layer was used for Manhattan.

The Kansas grain yield was obtained by harvesting the whole plot and adjusting for the missing plants, if necessary, by using the formula Jugenheimer (32):

$$\text{Corrected weight} = \text{Field weight} \times \frac{(\text{hills/plot} - (.3 \times \text{missing hills/plot})}{(\text{hills/plot} - (\text{missing hills/plot})}$$

Moisture at harvest was also recorded and the final grain yields were adjusted to 15% moisture.

At Talaltizapan, half of each plot was harvested for yield. The harvested plants were of uniform competition and later yields were calculated for full plot size. The dry weight was obtained by placing seed in an oven to dry grain, shelling ears, and weighing seed.

RESULTS AND DISCUSSION

To determine the relationship between flowering date and some agronomic traits, the different maturation groups were observed for silking date and black layer formation differences.

The mean number of days from planting to 50% silking for four groups at each of the two locations is presented in Table 1. The analysis of variance showed statistically significant differences between Group 1 and Group 2 for flowering at the 5% level. At Manhattan, Group 2 flowered 3.6 days later than Group 1. The difference between Group 4 and Group 3 was 3.25 days. The data from Talaltizapan 78B showed a delay of 1.4 days for Group 2, relative to Group 1, and 1.6 days for Group 4.

Group 2 took 3.44 days and Group 4 took 4.12 days longer for completion of 50% silk at Talaltizapan 79A plantings. The results agreed with those reported by Troyer and Brown (56, 57) and Beil (4), who observed that early maturity classes silked 1 to 8 days earlier.

Table 2 presents the mean number of days from mid-silk to the completion of black layer formation for different groups and locations. In this case, Group 1 and Group 3 were of similar vegetative duration, but maturation comparisons, that is, duration from mid silk to physiological maturity differed highly significantly among the three locations.

Maturation differences between Group 2 and Group 4 were significant at Manhattan and Talaltizapan 79A planting, but not in the Talaltizapan 78B trial. That may be due to the misclassification of plants for black layer formation due to severe wind and hail storm damage after flowering.

Table 1. Average number of days from planting to 50% silk for the four groups.

Group	Manhattan 78 (days)	Talaltizapan 78B (days)	Talaltizapan 79A (days)
1	75.30	76.35	72.46
2	78.90	77.72	75.90
3	73.85	76.33	72.03
4	77.10	77.88	76.15
LSD (.05)	1.34	1.26	1.11
σ for Error term	.94	1.09	1.66
σ between families/group	3.64	2.56	1.56

Table 2. Estimated mean days for seed maturation (mid-silk to black layer) and black layer formation scores.

Group	Manhattan (days)	Talaltizapan 78B (days)	Talaltizapan 79 (total points/300)
1	54.75	65.30	275.13
2	55.15	67.61	276.66
3	60.70	68.66	249.38
4	60.10	69.05	254.16
LSD (.05)	.41	1.54	9.18
σ for Error term	.29	1.08	7.95
σ between families/group	5.31	5.48	6.09

In general, the results agree with findings of other workers such as Daynard (18), Poneleit (41), and Rench and Shaw (47).

Mean number of leaves per plant and leaves above the ear is presented in Table 3. No significant differences were observed for total leaf number in two of the three tests. Comparisons of Group 2 vs. Group 1 and Group 4 vs. Group 3 at Talaltizapan 79A showed significant differences for total leaf number. Differences in the leaves above the ear were not significant, but in one case only, where Group 4, when compared to Group 3, showed a significant increase in leaf number.

At Manhattan and Talaltizapan 78B, the late vs. early flowering groups were not significant but a positive trend for increased number of leaves and late flowering was observed.

Group 2 and Group 4 delayed flowering by 3.6 and 3.25 days at Manhattan and 3.44 days and 4.12 days at Talaltizapan 79A; the increase in number of leaves for delay flowering was close to one leaf per three days in both the cases. At Talaltizapan 78B, Group 2 and Group 4 delayed flowering by 1.4 and 1.6 days, and increased leaf number .01 and .08, respectively.

The above results agreed with findings of Hanway (26). One reason for significant differences at Talaltizapan 79A may have been that the seed used for this test was from the second cycle of selection, while the C_1 seed was used at Manhattan and Talaltizapan 78B.

The means for total leaf area per plant for all groups and locations are presented in Table 4. Late flowering groups had significantly more leaf area at Manhattan but not at Talaltizapan. The increased leaf area per plant of late flowering groups at Manhattan may have been due to

Table 3. Average number of leaves/plant and leaves above ear/plant.

Groups	Manhattan		Talaltizapan 78B		Talaltizapan 79A
	L/P	L/EP	L/P	L/EP	L/P
1	16.075	6.75	18.672	5.52	17.718
2	17.312	7.03	18.684	5.56	18.250
3	16.225	6.48	19.061	5.98	17.419
4	17.687	6.91	19.140	5.77	18.363
LSD (.05)	N.S.	.354	N.S.	N.S.	.281
σ for Error term	3.20	.25	2.48	1.03	.25
σ between families/ group	1.57	1.2	2.28	1.46	1.00

L = Total Leaves

L/EP = Leaves above ear

Table 4. Mean leaf area/plant.

Groups	Manhattan	Talaltizapan 78B
	m^2	m^2
1	.672	.87
2	.936	.82
3	.741	.83
4	.931	.88
LSD (.05)	.07	N.S.
for Error term	.05	.85
between families/group	.55	.56

greater length and width of leaves. The total leaf number for this group was insignificantly greater at this location.

The means for plant and ear heights are given in Table 5. Differences between maturity groups were not statistically significant within black layer classes at both locations. At Manhattan, Group 2 vs. Group 1 was 4.62 cm taller, while Group 4 vs. Group 3 was 7.51 cm taller. A positive trend between plant height and late flowering was also found at Talaltizapan, where late groups surpassed the early flowering groups by 8.08 cm and 3.21 cm in plant height. No significant differences for ear height were found between different maturity groups. There was a positive but non-significant relationship between plant and ear height, hence flowering date and ear height.

Table 6 contains the mean grain weight per plot for the different groups and locations. The earliest group, Group 1, produced significantly lower grain weight at the 10% level of significance. Group 4, which required maximum time from planting to black layer formation, produced significantly higher grain weight.

Group 3 relative to Group 2 had a short vegetative phase and long reproduction phase, yet the periods from planting to physiological maturity were essentially the same. The two groups did not differ significantly but the yields of Group 3 were consistently higher at all locations.

Table 5. Mean plant and ear heights (cms)

Group	Manhattan		Talaltizapan 78B	
	P.H. (cm)	E.H. (cm)	P.H. (cm)	E.H. (cm)
1	207.15	111.58	156.57	68.91
2	211.77	115.71	164.65	74.75
3	207.55	107.41	161.65	70.63
4	215.06	115.20	164.86	73.36
LSD (.05)	N.S.	N.S.	N.S.	N.S.
σ for Error term	95.65	21.26	19.87	23.38
σ between families/ group	7.89	6.92	6.70	5.68

Table 6. Mean grain wt. per plot (15% moisture)

Group	Manhattan (grams)	Talaltizapan 78B (grams)	Talaltizapan 79A (grams)
1	1027.2	1461.0	5081.63
2	1149.3	1365.9	4985.16
3	1254.5	1580.1	5407.50
4	1446.9	1785.8	5563.19
LSD (.05)	385.0	427.40	629.26
σ for Error term	138.47	298.65	545.39
σ between families/group	322.46	523.87	765.07

SUMMARY AND CONCLUSIONS

A broad-base population of corn, Lote 81, was studied to identify groups with varying maturation periods and to determine their influence upon yield and other agronomic characteristics during the winter of 1977. Replicated field tests were conducted at two locations during 1978 and 1979 at Ashland Agronomy Farm, KSU, Manhattan, and Talaltizapan, Mexico. The different maturity groups were observed for some agronomic traits including leaf number per plant, leaf area, plant height, ear position, and grain yield.

1. Late flowering groups required significantly more days for completion of 50% silk than early flowering groups at all locations.
2. Groups late in physiological maturity took significantly more days from mid-silk to black layer formation at all locations, except in one case at Talaltizapan 78B, where Group 4 compared to Group 2 has longer reproductive phase but statistically not significant.
3. Total leaf number for different maturity groups were not significantly different for two of three locations. At Talaltizapan 79A planting late flowering groups, Group 2 and Group 4 showed a significant increase at 5% level in leaf number. The leaves above the ear showed significant difference only in one case where late flowering Group 4 was compared to early flowering Group 3.
4. Leaf area per plant was significantly greater for late flowering at Manhattan but not at Talaltizapan. Late

black layer formation did not affect the leaf area in any case.

5. No significant differences for either plant height or ear position were found among groups of different maturities. A positive trend of increased plant and ear height was observed for late flowering in all groups and locations. It appeared that there was a close association between plant height, ear height, and days to mid-silking.
6. The comparison of Group 2 vs. Group 3 for yield was of main interest in this study, where the two groups differed for their vegetative and reproductive periods but of same total maturity. The two groups did not show statistically dignificant differences for yield, but Group 3 with longer grain filling period consistently yielded more at all locations.

REFERENCES

1. Allen, James T., Guy W. McKee and Joseph H. McGahan. 1973. Leaf number and maturity in hybrid corn. Agron. J. 65:233-235.

2. Allison, J. C. S. and T. B. Daynard. 1979. Crop Sci. 19:1-4.

3. Anderson, E. 1959. Zapalate Chico: An important chapter in history of maize and man. Congreso de Americanas. San Jose, Costa Rica.

4. Beil, G. M. 1975. Proceeding of the 30th annual corn and sorghum research conference. Dec. 9-11. Chicago, Illinois. pp. 131-149.

5. Belej, J. and S. Ozkay. 1970. A contribution to the determination of the length of the vegetative period in maize on the basis of the number of leaves. Pl. Br. Abst. 41:346. 1971.

6. Berzsenyi-Janosits, L. 1958. Does late maize give higher yield? A contribution to the evaluation of maize hybrids. Pl. Br. Abs. 29:756 (1959).

7. Bonaparte, E. E. N. A. and R. I. Brawn. 1976. Effects of different environments on leaf number and duration to flowering in corn. Can. J. Plant Sci. 56. pp. 699-704.

8. Bonciavelli, F. and M. Monotti. 1975. Growth analysis of hybrid corn of different earliness. Maidjce 20:39-55.

9. Carter, M. W. and C. G. Poneleit. 1973. Black layer maturity and filling period variation among inbred lines of corn (<u>Zea mays</u> L.) Crop Sci. 13:436-439.

10. Chase, Sherret S. 1964. Relation of yield and number of dyas from planting to flowering in early maturity maize hybrids of equivalent grain moisture at harvest. Crop Sci. 4:111-112.

11. Chase, Sherret S. and Devandar K. Nanda. 1967. Number of leaves and maturity classification in <u>Zea mays</u> L. Crop Sci. 7:431-432.

12. __________do__________1967. Relation between leaf number and maturity in maize. American J. Bot. 52:628.

13. Chuchmii, I. P. 1970. Relationship between yield and earliness of ripening of maize hybrids in the central forest-steppe zone of the Ukraine. Pl. Br. Abs. 42:283 (1972).

14. Cross and M. S. Zuber. 1973. Interrelationships among plant height, number of leaves, and flowering dates in maize. Agron. J. 65: 71-74.

15. Cross, H. Z. 1975. Diallel analysis of duration and rate of grain filling of seven inbreds of corn. Crop Sci. 15:532-535.

16. Daynard, T. B. 1969. The black layer: Its relationship to grain filling and yield. Proceedings of 24th annual corn and sorghum research conference. Chicago, Illinois. pp. 49-54.

17. Daynard, T. B. and W. G. Duncan. 1969. The black layer and grain maturity in corn. Crop Sci. 9: 473-476.

18. ______________. 1970. Report of the 25th northeastern corn improvement conference, New York, USA. Feb. 13-14.

19. ______________. J. W. Tanner, and W. G. Duncan. 1971. Duration of the grain filling period and its relation to grain yield in corn (_Zea mays L._) Crop Sci. 11:45-48.

20. ______________. L. W. Kanenberg. 1976. Relationship between length of the actual and effective grain filling period and the grain yield of corn. Can. J. Plant Sci. 56:237-242.

21. Dessureaux, L., N. P. Neal, and R. A. Brink. 1948. Maturation in corn. J. Am. Soc. Agron. 40:733-45.

22. Eik, K. and J. J. Hanway. 1965. Some factors affecting development and longevity of leaves of corn. Agron. J. 57:7-12.

23. Fischer, K. 1978. Grain filling and moisture loss among some special project materials. Personal communication.

24. Giesbrecht, J. 1960. The inheritance of time of silking and pollen shedding in maize. Can. J. Genet. Cytol.

25. Hallauer, A. R. and W. A. Russell. 1961. Estimate of maturity and its inheritance in maize. Crop Sci. 2:289-294.

26. Hanway, J. J. 1963. Growth stages of corn. Agron. J. 55:487-92.

27. Hanway, J. J. and W. A. Russell. 1969. Dry matter accumulation in corn (_Zea mays_ L.) plant: Comparison among single cross hybrids. Agron. J. 61:947-951.

28. Hillson, M. T. and H. L. Penny. 1965. Dry matter accumulation and moisture loss during maturation of corn grain. Agron. J. 57:150-153.

29. Hopper, T. H. 1925. Composition and maturation of corn. North Dakota Agr. Exp. Sta. Bull. No. 192.

30. Johnson, D. R. and J. W. Tanner. 1972. Calculation of the rate and duration of grain filling in corn. Crop Sci. 12:485-486.

31. Jones, C. M. 1954. An inheritance study of corn maturity. Plant Br. Abs. 25:176.

32. Jugenheimer, R. W. 1976. Corn improvement, seed production and uses. W. Interscience p. 428.

33. Kapas, S. 1961. An investigation on the connection between earliness and productiveness in maize hybrids. Pl. Br. Abs. 33:188.

34. Kotova, G. P. and N. F. Sahov. 1969. Growth characteristics of self pollinated lines (maize). Pl. Br. Abs. 40:374.

35. Kozimec, M. V. and P. D. Klimenko. 1965. The productiveness and growth period of some maize hubrids under the conditions of the forest steppe of the Ukrainian USSR. Pl. Br. Abs. 40:88.

36. Kuleshov, N. N. and A. L. Novinenko. As cited in Misovic (37).

37. Maurinja, H., Randzepa, L. and M. Juraze. 1970. Features of growth and development of maize hybrids and varieties in Latvian USSR. Pl. Br. Abs. 40:96.

38. Misovic, S. M. 1972. The relation between the flowering phase and the length of vegetative period and the time of full maturity of corn (Zea mays L.). J. Sci. Ag. Res. 76:83-116.

39. Montgomery, E. G. 1911. Correlation Studies in Corn. Neb. Ag. Exp. Stn. Rep. 24:108-159.

40. Nozzolin, V. 1963. Il numero delle foglie quale indice della lunghezza del periodo vegetativo nel mais. Maydica Bergamo 8: No. 1: Suppl. 149, p. 34.

41. Poneleit, C. G., K. C. Evans and M. W. Carter. 1971. Genetic variation for black spot maturity in corn. Proceeding abstracts of paper and address presented at the 68th annual convention of Association of Southern Agriculture Workers, Inc. Jacksonville, Florida. 31 Jan. 3 Feb., 1971.

42. ______________, and M. W. Carter. 1972. Black spot maturity and filling period variation among inbred lines of corn. Agron. Abst. 58 C-4 Division

43. Potlog, A. S. et al. 1967. Investigation of stage of organogenesis and vegetative phases of hybrid maize. Pl. Br. Abs. 40:963.

44. Quinby, J. R. 1967. The maturity genes in sorghum. Adv. Agron. 19:267-305.

45. Rao, J. M. V. and J. V. Goud. 1977. Inheritance of plant height and maturity in sorghum. I. Inheritance of height, maturity and their components. Mysore J. Agr. Sci. 11:269-275.

46. Rasmusson, I. M. and T. L. Tew. 1979. Vegetative and grain filling periods of growth in barley. Crop Sci. 19:5-9.

47. Rench, W. E. and R. H. Shaw. 1971. Black layer development in corn. Agron. J. 63:303-305.

48. Rench, W. E. and H. R. Shaw. 1972. Climatic influence on the length of the filling period of Zea mays L. Agron. Abst. p. 169. 1971.

49. Sanchez, C. H. 1969. The relationship between yield and moisture in S_1 maize lines. Pl. Br. Abs. 43:153.

50. Shaw, R. H. and H. C. S. Thom. 1951a. On the phenology of field corn, and the vegetative period. Agron. J. 43:9-15.

51. Shaw, R. H. and H. C. S. Thom. 1951b. On the phenology of field corn, silking to maturity. Agron. J. 43-541-546.

52. Sieglinger, J. B. Leaf number of sorghum stalks. J. of Amer. Soc. Agron. 2:636-642.

53. Singh, T. P., R. Singh and L. B. Chaudry. 1969. Determination of maturity of maize hybrids. Plant Br. Abs. 42:583.

54. Singh, T. P. 1970. Usefulness of plant characters of maize in predicting agronomic traits. Madras Agric. J. :447-448.

55. Sreekantavadhya, R. and M. Mahadevappa. 1969. Investigations on the inheritance of days to silking in maize. Mysore J. Agr. Sci. 3:233.

56. Troyer, A. F. and W. L. Brown. 1972. Selection for early flowering in corn. Crop Sci. 12:301-303.

57. Troyer, A. F. and W. L. Brown. 1976. Selection for early flowering in corn: seven late synthetics. Crop Sci. 16: 767-772.

58. Yamaguchi, J. 1974. Varietal traits limiting the grain yield of tropical maize. II. The growth and yield of tall and short varieties. Soil Sci. Pl. Nutr. 20:145-154.

59. Yang, Yun-Kuei. 1949. A study on the nature of genes controlling hybrid vigor, as it affects silking time and plant height in maize. Agron. J. 41:309-312.

ACKNOWLEDGEMENTS

I wish to express my gratitude and appreciation to Dr. C. E. Wassom for his invaluable guidance and encouragement during the entire course of the study. My sincere appreciation is extended to Dr. G. M. Paulsen and Dr. A. D. Dayton for their guidance, encouragement and constructive criticisms.

Special appreciation is expressed to Dr. E. W. Sprague, Dr. K. S. Fischer, Dr. T. Izuno, Dr. F. E. A. Palmer of CIMMYT for their invaluable cooperation.

Sincere gratitude to the Govt. of Pakistan for granting me the fellowship to achieve this accomplishment.

DIFFERENT STAGES OF MATURITY AND THEIR RELATIONSHIP

WITH SOME OF THE AGRONOMIC TRAITS IN CORN (ZEA MAYS L.)

by

MOHAMMAD ASLAM

B. Sc. (Hons.), University of Peshawar, Pakistan, 1965

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1979

A broad-base population of corn (*Zea mays* L.), 'Lote 81,' was studied to identify groups with varying maturation periods and to determine their influence upon yield and other agronomic characteristics during the winter of 1977. Replicated field tests were conducted at two locations during 1978 and 1979, at Ashland Agronomy Farm, KSU, Manhattan, and Talaltizapan, Mexico. The different maturity groups were observed for some agronomic traits including leaf number per plant, leaf area, plant height, ear position, and grain yield.

Significant differences were observed among groups for days to mid-silk. Late flowering groups flowered 3.6 and 3.3 days later at Manhattan. The differences between late and early groups at Talaltizapan 78B were 1.4 and 1.6 days. At Talaltizapan 79A, the late flowering groups (Gr 2 and Gr 4) delayed flowering by 3.5 and 4.1 days when compared with early flowering groups (Gr 1 and Gr 3). Significant differences were found for days from mid-silk to physiological maturity at two locations. Talaltizapan 78B trial did not show significant differences among groups. The leaf number was statistically significant for different maturity groups at Talaltizapan 79A. Leaf number per plant and days to mid-silk were positively correlated for this trial. Differences in the number of leaves above the ear were not significant among groups at any location. A significant increase in leaf area per plant was observed for late flowering at Manhattan only.

A non-significant but positive association has been observed between plant height, ear height, and days to 50% silking in all groups and locations. The yield differences were not statistically significant, but groups with longer grain filling periods produced more than those with shorter grain filling duration at all locations.