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THE EFFECT OF STRATIFIED MASS SELECTION FOR THE DEVELOPMENT OF AN EARLY MATURITY, HIGH YIELDING MAIZE (Zea mays L.) POPULATION.

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Halima Elmi Awale

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By

Halima Elmi Awale

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ABSTRACT

THE EFFECT OF STRATIFIED MASS SELECTION FOR THE DEVELOPMENT OF AN EARLY MATURITY, HIGH YIELDING MAIZE (*Zea mays L.*) POPULATION

By

Halima Elmi Awale

Mass selection for early maturity (ES) and high yield (HYS) genotypes was made in a maize (*Zea mays L.*) population, Michigan Synthetic #9. The population, together with a single cross hybrid, detasseled at flowering and used as a control, was grown in genetic isolation. Using 10 percent selection intensity, one hundred early onset ears and one hundred twenty one ears for high yield were selected for further evaluation in a second cycle.

The results indicated that high yield (HYS) genotypes had a 5.32 percent yield advantage but flowered one day later, on the average than the cycle zero population. Early genotypes had a 5.46 percent yield reduction which also associated with reduction in whole plant size.

Comparison of grain weight showed that the selected progenies had a lower dry weight than their respective parents. It was concluded that visual selection would not be a reliable method for the creation of a high yielding, early maturing sub-population.

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I dedicate this thesis to my parents, Elmi Awale and Fatuma Kadiye for their efforts through all my life, to my lovely daughter Yasmin Ali Salad, and finally to the memory of my late husband Ali Salad Jama who encouraged me to pursue my graduate studies.

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I would also like to thank the Food and Agricultural Organization of the United Nations for financing my study program; the Somali Agricultural Research Institute for giving me study leave; Crop and Soil Science Department for the use of their facililies and; finally, the corn breeding crew for their help on planting and harvest.

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INTRODUCTION

Mass selection is the oldest and simplest breeding scheme used for the improvement of crop plant. It has been used both intuitively and systematically as a method of corn population improvement ever since mankind first recognized the potential of corn as food, feed and fuel. The primary method used has been to select individual plants based on their phenotypic performance for a specific trait and bulking seeds of the selected individuals *en masse* to constitute an "improved" population.

The early development of improved and adapted corn varieties can be attributed to successful mass selection by farmers, societial leaders and later, plant breeders working toward specific production objectives. However, late in the first quarter of this century the prevalent belief among most plant breeders was that a production plateau had been reached and that selection for yield within adapted varieties was no longer an effective strategy. At the same time, scientists were obtaining remarkable yield responses with corn hybrids changing the entire corn breeding focus from open pollinated varieties to an emphasis on hybrid production.

Although several years or even decades were to pass before hybrid corn actually replaced open-pollinated varieties on a majority of farms, little was done to evaluate or improve

upon mass selection as a strategy for yield enhancement. Thus, the thought prevailed that this method was ineffective for yield improvement.

Relatively recent work at the Nebraska Experiment Station and at other locations in the United States have indicated that large amounts of additive genetic variance for yield exist in open-pollinated corn varieties. Therefore selection either among superior single plants or among the progenies of identified plants should be effective in increasing the frequency of favorable additive genes for improved yield.

Even in the early eras of corn improvement, mass selection had been an effective improvement strategy for traits that were highly heritable, but its effectiveness for improving traits with low heritability, such as yield, was questioned.

Early maturing, high-yielding attributes in corn are obvious goals for short growing season locations where moisture or other growth factors are limiting. Flowering date is a highly heritable trait which responds to mass selection. Generally, early flowering is highly and negatively correlated with yield. It is important to understand correlated traits when employing them to indirectly select for a complex character such as yield. Flowering date interacts with duration of the growing season in two ways: first, it measures the length of the vegetative stage determining the amount of leaf area available for photosynthesis, and also it measures

the length of the grain filling period.

Troyer and Brown (1972) reported that days to silking is a primary selection criterium, since it shows a straightforward response to selection. It is however not the only measure of earliness. Kernel moisture at harvest is important since it provides a measure of the stage of maturity at the end of the growing season.

Apart from results obtained on highly heritable traits which have been studied for many decades, low heritable traits have been studied more recently and significant responses to selection have been obtained. Gardner (1961) practiced mass selection using a gridded system to reduce the enviornmental variations among the plants. He found a gain in yield of 3.9 percent per cycle. He explained that the effectiveness of this procedure was due to the following reasons: first, the selected population, Hays Golden, was grown in genetic isolation to maintain the full advantage of selection differential; secondly, a grid or subplot system of plant - to - plant evaluation was employed to minimize environmental variances, which in turn reduced the confounding effects of genotype by environment interaction. Other techniques used to increase precision of selection included providing irrigation so that moisture did not become a limiting factor in grain production, and retention of remnant seed to permit a direct measure of selection effectiveness over cycles.

The objectives of this thesis research were to: 1) select genotypes with early onset of ears with considerable yielding abilities; 2) investigate how much yield must be sacrified when selecting only early maturing types; and 3) study the effect of mass selection in corn population development.

Literature of Review

During the first quarter of this century, it was concluded that mass selection was no longer effective in improving yield of adapted open-pollinated varieties of corn and, as a result, the majority of the plant breeders abandoned mass selection. According to Sprague (1955), mass selection for improvement of maize dates back to its domestication. He pointed out that no critical information on this method was available from the early literature, but that there is considerable indirect evidence that mass selection has been reasonably effective in improving the yield or at least adaptation of maize populations. Most of the open-pollinated varieties in the United States were developed by mass selection. A modification of mass selection called ear-to-row breeding utilizing progeny testing was initiated by Hopkins at the Illinois Experiment Station in 1896 to modify chemical composition and other agronomic factors in maize (Dudley et al., 1974). The earlier results appeared to be promising, and the method was adapted by many breeders. However, the results with respect to yield proved to be rather disappointing. Since this method was limited to the measurement of one row at one location, it did not give an adequate evaluation of the parental genotype nor did it account for the effects of genotype by environment interaction. Montgomery (1909) reported a gain of 9 bushels per acre from four years (1903 - 1907) of ear-to-row breeding at the Nebraska Experimental Station. However, ear-to- row selection data for the years 1911 to 1917, reported by Kiesselbach (1922), showed no difference between the original Hogue's Yellow Dent and the selected populations.

Mass selection has been practiced to improve maize (*Zea mays* L.) populations regardless of the magnitude of heritability estimates of the traits involved. However, the effectiveness of mass selection depends on the heritability of the trait under selection. In recent decades successful selection has been carried out by this method for many traits such as flowering date, leaf angle, photosynthetic efficiency, ear height, ear length, disease and insect resistance, and grain yield.

Early flowering as a desirable trait has been improved through mass selection. Troyer and Brown (1972) selected within three late, semi-exotic maize synthetics for earliness using a 5 percent selection intensity. After six generations, flowering date had been changed significantly with an average reduction of 1.8 days per cycle. In another study of mass selection for early flowering using seven late synthetics, Troyer and Brown (1976) observed that effect of selection per cycle averaged 1.7 days. Strong correlated responses to selection for earliness were found for lower grain moisture,

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lower plant height, and higher stalk breakage. They also observed that early flowering increased yields among late flowering populations when longer grain filling is advantageous and decreased yields among early genotypes when larger plant size is more important.

Hallauer and Sears (1972) using mass selection reduced the interval from planting to silking by 20 days in a population cross between early lines and exotic germplasm. On average they achieved a reduction of 3.8 days per cycle. Furthermore, this reduction was associated with decrease in plant height by 15 cm per cycle in three cycles of selection. Fortubel (1981) practiced mass selection to reduce the number of days to silking in two corn populations, (Purdue Syn. Aoz and Purdue Syn. Boz) by 1.8 and 2.2 days, respectively. Troyer (1990) evaluated three adapted synthetic populations of maize for early flowering. Selection response for five cycles indicated a significant decrease in the following traits : the flowering period; kernel moisture; plant and ear height; silk delay; and grain yield. And at the same time Troyer found that stalk breakage increased significantly. He concluded that the decrease in yield due to selection was closely associated with decrease in plant size, which probably reduced photosynthetic capacity.

Leaf angle is also another trait that was benefited from the mass selection method. Ariyanayagam et al., (1974) carried out four generations of bidirectional phenotypic selection for leaf angle in a maize variety, using two leaf angle determinations. Regression coefficient of 3.82 and 10.18 degrees over cycles of selection were found with an average change of 10 to 12 percent per cycle in each direction. Selection for more erect leaf orientation resulted in shorter plant height, later maturity, and increased resistance to lodging. Grain yield variations attributable to leaf angle were small and statistically insignificant when tested at two plant densities.

Mass selection has also been used to study photosynthetic efficiency in maize populations. Crosbie et al., (1981) evaluated two maize populations for higher and lower carbon dioxide exchange rates (CER). After five cycles of recurrent phenotypic selection for higher CER, an increase of 1.6 and 1.3 percent per cycle were obtained for CER during vegetative and grain filling stages respectively. Three cycles of selection for lower CER reduced the trait by 0.7 percent at the vegetative stage but no significant change was observed during the grain filling stage. In a similar report, (Crosbie and Pearce, 1982) the effect of CER on agronomic traits in two maize populations was studied. Five cycles of selection for higher carbon dioxide exchange rate showed significant reduction in plant and ear heights, and also reduced the percentages of plants affected by root and stalk lodging. Three cycles for lower carbon dioxide exchange rates indicated that days of selection to 50 percent pollen shed increased significantly across cycles. No grain yield variations were noted in either directions among the three selection cycles.

Selection for ear placement through mass selection has given satisfactory results. In six years of mass selection for low and high ear placement in a maize variety, Smith (1909) derived two subpopulations with ear heights of 82 and 170 centimeters, respectively. Vera and Crane (1970) subjected two synthetic populations of maize to two cycles at 50 percent of selection intensity. A reduction of 4.5 centimeters per cycle for lower ear height was obtained with no indication of increased percentage of moisture in the grain at harvest time. A slight change in yield and lodging were observed but these changes were not statistically significant. A similar study of the same population but using 20 percent selection intensity was evaluated by Acosta and Crane (1970). Ear height was reduced by about 24 percent in both selected sub-populations when compared to control populations after four cycles of selection.

Williams and Welton (1915) reported eight years of mass selection for ear length on a corn variety, Clarge. They concluded that ear length was mainly due to environmental effects, and therefore, the selection for this trait would be ineffective. This was based on the premise that an environmentally induced differences would not be passed on to future generations. This conclusion was challenged by Sprague (1966) whose study indicated that ear length was highly heritable. He found that ineffectiveness of selection was due to the consequence of the procedures used by Williams and Welton rather than an absence of genetic variability. In another review of heritability studies for different traits presented by Hallauer and Miranda, (1981) ear length had an average heritability value of 38.1 percent based on 36 different estimates.

Ten cycles of divergent mass selection in two subpopulations were effective in changing ear length in both phases of selection (Cortez-Mendoza and Hallauer, 1979). The response to selection for a short - ear and a long - ear was 0.32 and 0.64 centimeters per cycle of selection respectively. Hallauer (1968) determined the effect of divergent selection for ear length *per se* on grain yield in Iowa Long Ear Synthetic. Preliminary results for selection for long - ear types appeared to be effective, but no increase in grain yield was observed. However, selection for a short - eared type did result in reduced grain yield. Plants of the long - ear type were taller, later silking and had higher grain moisture at harvest. The reverse effect was measured in plants with short ears.

After 20 cycles of mass selection in maize, Odhiambo (1985) reported that the average 1000 kernel weight for large and small seed size were 368.90 and 122.47 grams, respectively, compared to 284.87 grams for the original population. The total increase in seed size in large seeded population was 29.5 percent, while the total decrease in seed size in the small seeded population was 57.0 percent. Selection for large seed increased seed size by 1.6 percent per cycle but had no effect on total yield. However, small seed size selection decreased seed size by 2.5 percent per cycle and significantly reduced yield.

Jenkins et al. (1954) reported that three cycles of mass selection was effective in reduction the susceptibility of corn to leaf blight (*Helminthosporium turcicum*). Similar success were found when the method was used to look for insect resistance. Zuber et al. (1971) reported a progress for reducing earworm (*Heliothis zea*,(*Boddie*) damages in two corn populations Synthetics "C" and "S". After ten generations of mass selection for resistance to earworm, highly significant reductions in numbers of ears damaged had been achieved. The percentage of ears with kernel damage for Synthetic "C" was reduced from 80.8 to 58.7 percent with an average reduction per generation of 2.76 percent. For Synthetic "S" the results were even better and the percentage of damage was reduced from 64.5 to 39.2 percent with an average reduction of 2.81 percent per generation.

Effective selection for prolificacy has been achieved through mass selection. Lonnquist (1967) obtained a yield increase of 6.28 percent per cycle after five generations of selection for prolificacy in Hays Golden. This result was equivalent to ten generations of selection for yield *per se* in the same variety. Mareck and Gardner (1979) obtained results similar to those of Lonnquist. In their studies in Hays Golden ten cycles of selection for prolificacy were about as effective in increasing yield as 15 generations of selection for yield. Gabauer (1979) evaluated the progress for mass selection for prolificacy in maize grown at two plant densities. He obtained genotypic correlations of number of primary ears per 100 plants in both populations. Mass selection carried out at high density was as effective as selection at low density.

Torregroza and Harpstead (1967) using divergent selection for prolificacy, obtained an increase in yield and number of ears per plant by 14 and 28 percent respectively when selection had been based solely on a multiple ear plant phenotype. On other hand, selection for single ears reduced yield by 5 percent, while the number of ears per plant also decreased by 7 percent compared to the original population.

Based on an average of 2-years data, Torregroza (1973) reported that in the 11th generation of selection for multiple ears per plant a gain of 48 and 35 percent in prolificacy and grain yield respectively compared to the original population. Selection for a single ear per plant showed a decrease of 16 and 7 percent in yield and number of ears per plant. This research was carried out in a very late maturing, tropical highland, open-pollinated variety of maize. Lantin (1980) carried out an evaluation of 10 cycles of mass selection for prolificacy in two Synthetic varieties, BS 10 and BS 11. Although significant response for increased number of ears was obtained, no correlated response for grain yield was observed in either synthetic varieties.

Kincer et al., (1976) reported that total number of ears produced per plant increased 13.2 percent in five generations of mass selection. This increased an average of 33.1 percent over the original variety, Jellicorse.

Coors and Mardones (1989) reported twelve cycles of mass selection for prolificacy in a maize population, Golden Glow. They observed that the prolific plants increased by 2.4 and 3.3 percent per cycle in 1985 and 1986, respectively. Similar increases noted in grain yield per plant were 2.0 and 3.0 percent per cycle, and increases in grain yield per hectare were 2.0 and 2.8 percent per cycle. Grain moisture, flowering dates, and period between silk emergence and anthesis decreased in the same selection experiment.

The genetic improvement of maize is dependent upon the type of gene action involved. A number of studies have reported that a considerable amount of additive genetic variance is present in maize varietal populations. Sprague and Tatum (1942) obtained estimates of the variances associated with combining ability for grain yield in maize. They reported that the variance for specific combining ability was found to be larger than the variance for general combining ability. Hull (1945) reported that the genetic variance in adapted

varieties is largely nonadditive, in which case progress from mass selection would not be expected. He also suggested that if overdominance exists, then the heterozygote is favored and the effect of selection is toward an equilibrium point with respect to gene frequencies. In the overdominance model where Aa represents the superior locus, both alleles remain in the population and contribute to genetic variation, but further selection would be ineffective beyond the 0.5 equilibrium point. Comstock and Robinson (1948) proposed a model in which additive and dominance genetic variance for yield and other traits in maize could be estimated utilizing certain mating designs and assuming no epistasis and equilibrium with respect to segregation of linked genes. Robinson, Comstock, and Harvey (1955) utilized the Comstock and Robinson (1948) mating designs to estimate the genetic component and thereby determining the relative importance of additive and dominance genetic variances in three southern (U.S.) varieties of maize. They concluded that additive genetic variance for grain yield and other traits was considerably greater than dominance variance, and that overdominant loci were not the single most important source of genetic variability in the varieties studied. Lonnquist (1949) indicated that progress for increased yield should be possible in open-pollinated maize varieties when selection is based on progeny tests. Consequently, his assumption was that additive genetic variance must be present. Gardner and Lonnquist (1959) studied

F_2 and F_8 random mating generations from a cross between two cornbelt inbred lines and found that additive genetic variance exceeded dominance variance in all characters evaluated. Later studies by Lindsey, Lonnquist, and Gardner (1962); Cota and Gardner (1966); Williams, Penny and Sprague (1965); Compton, Gardner, and Lonnquist (1965); and Goodman (1965) to estimate additive genetic variance of grain yield and other traits showed considerable additive genetic variance for yield and supported the belief that single gene action predominates in corn. Lonnquist (1961) pointed out that the choice of tester used to evaluate lines depends upon the breeder's objectives. A broad gene base tester is used if selection is for general combining ability, which would identify the contributions of additive gene effects. A narrow gene base, such as an inbred line or single cross, is employed if selection is for specific combining ability and has been interpreted as reflecting specific gene interactions. In the case with mass selection, the effectiveness of recurrent selection for general combining ability is dependent upon the presence of additive genetic variance for grain yield in the material under selection.

Lonnquist (1964) believed that the weaknesses associated with the early methods of corn improvement were: lack of control of parentage, poor plot techniques, and a reduced intensity of selection for yield because of too much attention being given to "show card" traits. The most obvious limitation of mass selection as a method of population improvement is that it is

based upon phenotypic selection of plants in a single location planting. The observed yield of a plant in such planting is usually thought of simply as $P_i = m + G_i + e_i$ when the genetic X environment interactions and measurement error are included in e. A more realistic model would include measurements made over years in multiple locations. It may be described by :

$$P_{ijk} = m + G_i + L_j + Y_k + GL_{ij} + GY_{ik} + LY_{jk} + GLY_{ijk} + e_{ijk}$$

where,

m = population mean.

G_i = Genotypic value of i^{th} genotype.

L_j = effect of j^{th} location.

Y_k = effect of k^{th} year.

GL_{ij} = Interaction of i^{th} genotype and j^{th} location.

GY_{ik} = Interaction of i^{th} genotype and k^{th} year.

LY_{jk} = Interaction of j^{th} location and k^{th} year.

GLY_{ijk} = Interaction of i^{th} genotype, j^{th} location and k^{th} year.

e_{ijk} = Effect of unexplained random influences encountered during the particular growing season.

The genetic effect (G_i) is made up of additive, dominance, and epistatic gene complexes. Progress from mass selection is based mainly on the additive portion of the genetic variance. The location effect (L_j), although treated as a major influence, may be considered also to consist of a complex of submacroenvironmental effects at a given location. Some control over the later variations can be realized by

subdividing the area into a series of subblocks and practicing selection within each unit. The phenotypic differences on which selections are made are likely to be the result of interaction effects of environment with the particular genotypes selected as much as the result from genetic differences of the type and degree sought. In other words, phenotypic differences are no guarantee that genotypic differences actually exist. This would be particularly true after a few generations of effective selection in a population where additive genetic variance is somewhat limited. The problems associated with differentiation of genotypic differences can be overcome in varying degrees depending partly on breeder's willingness to lengthen the generation interval through the use of progeny evaluation procedures (Lonnquist,1964).

For traits that have relatively low heritability like yield, mass selection has resulted in limited progress. Thus, breeders abandoned the method due to the paucity of additive genetic variability as the major cause of the failure to improve maize yield through mass selection. However, the procedure became an effective tool when Gardner (1961) modified the method. That is, stratified mass selection, whereby environmentally induced plant - to - plant differences are limited to those occurring within relatively small strata of the overall nursery. Using this system with timely irrigation to reduce the environmental effects, selection was

made in each stratum of 40 plants such that seed of the highest yielding 10 percent of each stratum was used to produce the next generation. This stratified mass selection was used to improve two subpopulations of Hays Golden, irradiated and nonirradiated. The irradiated population was a sample from the original variety of Hays Golden that was exposed to 1.28×10^{13} thermal neutrons per cm^2. The control was similarly sampled from the original variety H.G., but was untreated. The two subpopulations were planted in separate isolations. After four generations of stratified mass selection, Gardner estimated an average gain of 3.93 percent in yield per year over the original population. Furthermore, there was an increase in grain moisture by 8 percent over the original Hays Golden. He concluded that mass selection not only increased yield, but also made late maturing plants more fully utilize the available growing season. After six cycles of selection of same variety, Lonnquist (1966) obtained a gain of 2.1 percent per cycle.

Other reports by Gardner (1968, 1969) revealed a rate of 2.7 percent increase per cycle in the Hays Golden. A reduction in yield was observed after the 15th cycle and it was hypothesized that it was due to lack of response between genotype by environment interactions in later cycles of selection (Gardner, 1977, 1978; Mareck and Gardner, 1979). In Mexico, Johnson (1963) obtained a gain of 11 percent per cycle in grain yield in a tropical variety after three cycles of

selection. Josephson et al. (1974) evaluated fourteen generations of mass selection for yield in Jellicorse variety. They obtained 13.1 percent increase in yield over the fourteen generations of selection with no further increase shown beyond the tenth generation. Eberhart et al. (1967) reported an increase in yield of 7.42 percent in Kitale Composite Syn 3 with one cycle of mass selection. After ten cycles of selection, Darrah et al. (1978) obtained a gain of 1.13 percent per cycle. An increase in yield of 1.5 percent after three cycles of selection was reported by Hallauer and Wright (1963) in the maize variety, Iowa Ideal. They mentioned that the increase in yield was associated with an increase in harvest grain moisture, root lodging, and dropped ears. Two cycles later, Hallauer and Sears (1969) obtained a nonsignificance increase in yield for the same variety. Hallauer and Sears (1969) also reported no yield improvement in Krug and Iowa Ideal maize varieties after six and five cycles of selection, respectively. The authors hypothesized that the nonsignificance may be due to one or more of the following factors: (1) paucity of additive genetic variance; (2) imprecise plot techniques to minimize the confounding effects of the environment; (3) insufficient testing to detect the small differences and to estimate the true value between the different cycles of selection, particularly in the later generations; and (4) a low intensity of selection due to the exclusion of stalk - lodged phenotypes. This exclusion

prevented the phenotypic expression of yield for individual plant genotypes that could be selected visually. It was their conclusion, that the use of higher plant density resulted a situation where neither variety was able to express its yielding abilities. In addition, lack of irrigation caused environmental variation that prevented the selection of the highest possible yielding genotypes. The use of rectangular plots instead of square ones increased the soil variation among the subunits measured in the experiment.

Romerio and Lopez (1968), practicing selection for yield while giving preference to prolific plants, improved a Hondrous Early Composite by 12 percent after four generations. Hakim et al. (1969) reported a gain of 9 percent in yield and 4 percent over environments when evaluation and selection were done in the same season. Shauman and Gardner (1970) showed that selection increased yields by 3.31, 2.93, and 4.5 percent per cycle relative to Hays Golden for selected irradiated, control, and prolificacy populations respectively. In all three populations, significant positive regression coefficients were found for number of prolific plants, ear height, and days to flower. El-Bouby et al. (1971) subjected an open - pollinated variety of maize to three cycles of mass selection and reported a grain yield increases of 8.9 percent per cycle. Genter and Eberhart (1974) reported no significant progress in yield but obtained good responses in plant and ear height. Arboleda-Rivera and Compton (1974) developed three

subpopulations through mass selection for grain yield and prolificacy in three different seasonal conditions (rainy season, dry season, and both rainy and dry seasons). The results showed that grain yield and prolificacy of the rainy season selections increased 10.5 and 8.8 percent per cycle respectively, when the test is done during the rainy season. The same population evaluated in the dry season produced 0.8 and 1.0 percent gain per cycle for grain yield and prolificacy respectively. Under dry season evaluation the gain of selection in grain yield was only 2.5 percent per cycle, whereas in the rainy season it was 7.6 percent per cycle. Similarly, prolificacy was also estimated and the gain was 11.4 percent per cycle in rainy season and 4.4 percent per cycle under dry season. While tests both rainy and dry season indicated that the gain in yield were 5.3 and 1.1 percent per cycle. For prolificacy, the gains were 7.0 and 3.3 percent per cycle respectively. Obilana (1974) obtained a 16 percent gain in grain yield of Nigerian Composite "B" after four cycles of mass selection. Osuna-Ayala (1976) estimated the effect of stratified mass selection in six cycles using a 10 percent selection intensity. The results indicated that the increases in gain of selection in grain yield per cycle for dent composite and flint composite were 2.82 and 3.45 percent, respectively.

Genter (1976) applied mass selection to incorporate desirable traits from 25 Mexican races of maize into a single

population with early maturity and plant type that would be useful to temperate zone maize breeders. Ten cycles of selection were completed. He reported that over the 10 cycles, yield increased 171 percent, days to mid-silk decreased by 11 days, and moisture at harvest decreased 7.7 percent. The ratio of plant - to - ear height decreased through C_{10}, ear height average 115 centimers or, 50 percent of plant height. Average time between pollen shed and silk emergence decreased from 9.1 to 7.0 days. Selection had little effect on root lodging, but stalk lodging increased.

Haraguchi et al. (1976) reported an evaluation for high and low yielding genotypes selected in an Andean maize variety, Kullo. After two cycles of selection their measurements indicated an average gain in yield of 15.2 and 12.2 percent for high and low yield genotypes respectively. They concluded that mass selection has been an efficient method to achieve adaptation and varietal improvement. Moro et al. (1976) reported that after one cycle of selection for improved yield in an opaque-2 population, progress of 11.5 percent by stratified mass selection and 5 percent by phenotypic mass selection had been achieved.

Samir (1978) compared direct and indirect methods of mass selection in a maize synthetic. He reported that variation in grain yield among three selection cycles was significant. The first two cycles of each methods of selection indicated an increasing trend in yield, while the third cycle was not

effective. Average gains obtained per cycle from direct and indirect selections were 3.0 and 4.6 percent respectively.

Mulamba et al. (1983) reported a gain of 6.9 percent in yield with a 0.49 percent per cycle after fourteen cycles of mass selection. Increased yield was accompanied by later flowering, increased root and stalk lodging, increased grain moisture at harvest, and higher ear placement. Estimates of genetic variability among S_1 progenies for grain yield showed a decrease in genetic variance for S_1 and half-sib populations, but no change for the mass - selected population. Compton, Mumm and Mathema (1979) reported that mass selection for adaptation and prolificacy resulted in yield increases without changing other traits related to it. In their study, they found that selection for increased grain yield in exotic populations resulted in more progress than in the two adapted maize populations (NC and NEC).

Mass selection in other crops

Mass selection has also been used in other crops for improvement. Doggett (1965) discussed mass selection systems for sorghum where gains for seed yield were greater and seed set problems were fewer than in the original populations.

Rattunde et al. (1989) reported on determinations of the feasibility of mass selection for 19 agronomic traits using both a single plant and progeny - mean basis in pearl millet. They observed that heritabilities estimated on progeny - mean basis were all significantly larger than zero, while on a

single plant basis heritabilities were highest for traits,such as panicle length, plant height, and seed weight.

Romero and Frey (1966) reported a mass selection procedure for reduction of plant height in oat population. All panicles of mass-selected and unselected were clipped to the same height as a check variety. Mean plant height and genetic variability were decreased. Positive correlations were found between plant height and heading date, and between heading date and yield. Chandhanmutta and Frey (1973), using the F_6 bulks obtained from a mixture of seed samples from 160 oat crosses, reported on selection procedures for increased panicle weight. During two generations of selection the heaviest 10 percent of panicles from each of 6000 hills were bulk threshed. Evaluation showed that the selection procedure increased panicle weight by 7.5 percent and grain yield by 5.6 percent per cycle. These changes were associated with increased plant height and a later heading date. The authors attribute the increase in grain yield to increased number of seeds per panicle and also increased seed weight. Improvement in grain yield was achieved because the frequency of lines with mean yield above 35 g/plot gradually increased. Since populations of autogamous species are closed with respect to genetic recombination, mass selection operates only upon genotypes already present; that is, the ranges for distribution of any trait are the same for all three populations, C_0, C_1, and C_2.

Derera and Bhatt (1972) reported on mass selection used in homogeneous and heterogeneous populations of wheat which were stratified for seed size and later tested for yield. Mass selection in heterogeneous and heterozygous F_2 bulks showed reduction in variance. There was a shift in means between large and small seed size, kernel weight, grain weight per spike and grain yield per plot. The results showed that selection for larger seeds increased yield by 33 percent whereas small seed size decreased the yield by 7 percent.

Fehr and Weber (1968) reported on mass selection for seed size and specific gravity in soybeans and their effect upon protein and oil contents. They found that selection combination of large seed and high specific gravity resulted in maximum progress for high protein and low oil content. Conversely, maximum progress for low protein and high oil contents came from selection for small seed and low specific gravity.

Matzinger and Wernsman (1968) reported that four cycles of mass selection for inreased green leaf production in tobacco (*Nicotiana tabacum*), resulted in an average increase of 44 g per plant per cycle, with no evidence that genetic variability of the population had been reduced.

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MATERIALS AND METHODS

Michigan Synthetic #9 formerly, Michigan High Protein Synthetic #1 was used in this study. The population was developed at Michigan State University by Dr. Rossman[1]. This variety was developed by selection from materials that had good combining ability. It was also characterized as having high yield capability and earliness, and was used over a period of years as a potential source of lines for the breeding program. Records indicate that the following single crosses had been combined to form the synthetic population. The crosses are :

54-70 MS24A X 54-76 W23	54-68 M13 X Oh51 HP
W25 HP X W23 HP	R53 HP X Oh51 HP
W9 HP X HP	W10 HP X MS 24-2 HP
R53 HP X MS24A HP	HP X W23
R25 HP X HP	54-70 X 54-74
54-72 X 54-73	

In the first year of the study, the Synthetic #9 was planted in an isolated field. A single cross hybrid[2] was chosen as check. The synthetic and hybrid were planted on

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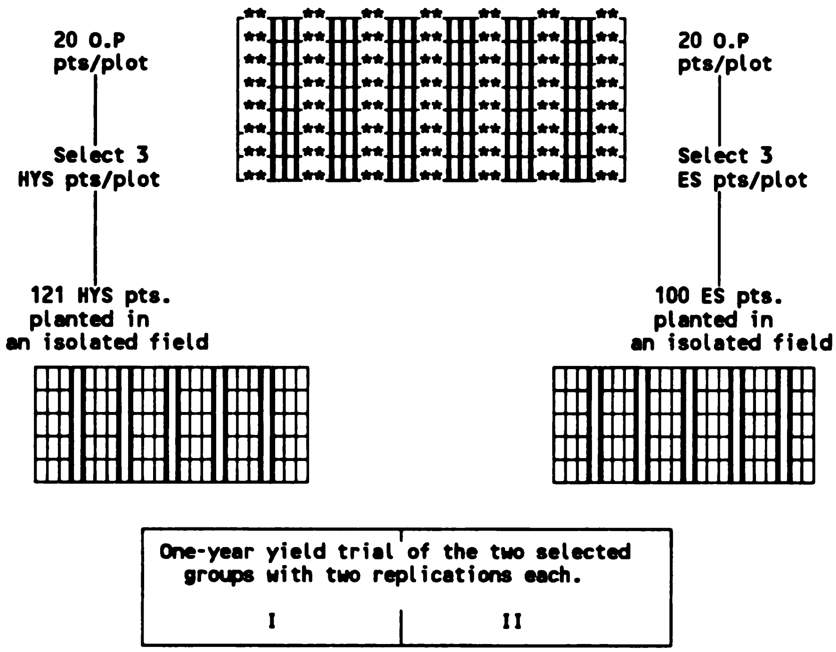
[1] Dr. Rossman died in November 1989 making it impossible to determine the exact methods used to form this synthetic or to estimate the degree of inbreeding which may have taken place during the maintenance of the seed stocks.

[2] Great Lakes hybrid, GL 582.

THE SCHEMATIC DESIGN OF THE RESEARCH



- population (Mich. Syn. #9)

** - single cross (control)

- male rows (two rows) composite of selected plants

- female rows (four rows) each ear planted in one row

Figure 1. Shows the schematic plan of how the thesis material was planted and evaluated for two years.

May 18, 1989 alternately in six and two rows respectively. A total of about 7900 plants of the synthetic and single cross were planted in the isolated block.

A grid system proposed by Gardner (1961) was used to divide the field into seven ranges, which in turn were subdivided into forty two small plots of equal sizes. Each plot was made up of 6 rows 3.648 meters long and 0.912 meters apart. This resulted in plot area of 19.962 square meters each.

Three weeks before flowering initiation, 20 plants from the rows of Michigan Synthetic #9 plus 5 plants from the adjacent rows of the single cross hybrid were selected and tagged in each plot. This selection was based on the vegetative appearance of individual plants in relation to the hybrid. Plant selection was made on the basis of vigor, freedom from disease, and good appearance. The single cross hybrids were detasseled before the pollen shedding in order to avoid contamination.

During the 1989 season, the following records were taken: 1) first and last days of pollen shedding; 2) first and last days of silking; 3) plant and ear heights; 4) harvest weight 5) dry weight, and 6) root and stalk breakages. Days to silk, harvest and dry weight were the only data analyzed.

At harvest time, the yield of each selected ear was weighed separately, dried until all ears reached constant moisture, then weighed again. These selected ears were

compared to the mean grain yield of the adjacent single cross row (control) and these weights were expressed as the percentages of the single cross yield. Early flowering and the three highest yielding plants of each plot were selected and used to create the next generation. Each selected ear represented an entry in the 1990 modified ear - to - row selection nursry.

In the 1990 season, the selected ears were grouped to form two sets of nursery materials: a) earliest silking, with the highest available yield, and b) highest yield in an early silking category. The early group was composed of 100 selected families (ears), each representing an entry. The high yielding groups was composed of 121 families, each of which served as a separate entry. A randomized complete block design with 3 replicates was used for both early and high yielding trials. One replication of each trial was planted in an isolated block, and selected ears were used as a female rows. A composite of seed from all selected families specific to each trial was used as pollinator for the females lines. The ratio of female to male rows was 4:2. In addition to the two isolated blocks, a preliminary yield trial was carried out utilizing the two other replicates of each group. These were grown in a separate field where the plots were two rows of 6 meters long with 0.9 meters between rows.

All cultural practices were the standard practices used in the corn breeding yield trials. During the growing period nitr

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nitrogen fertilizer was applied twice, once at planting time and second application before flowering at rate of 140 lbs/acre. The field recieved a weed control treatment after planting at 0.88 lbs of atrazine, bladex 2.65 lbs, and 3.5 pints of dual per acre.

The following data were collected during the growth and development periods:

1. Median days to pollen shed determined as the number of days from planting to the time when 50 percent of the plants in the plot were shedding pollen.
2. Median days to silking determined as the number of days from planting to the time when 50 percent of the plants in the plot were silking.
3. Plant height in centimeters measured on 5 randomly selected competitive plants measuring from the ground level to the last flag leaf.
4. Ear height in centimeters measured from the ground level to the node bearing the top ear (primary ear). The average of those 5 selected plants were computed per plot.
5. The number of plants per plot was counted separately at physiological maturity.
6. Moisture content at harvest was measured from the samples taken from each plot using M.C.S. 101 moisture tester.
7. The number of stalk lodged plants was determined by counting the number of plants per plot that were broken below the primary ear. The the proportion of upright was calculated

by this relationship:

100 - [(SLP/PPLT) x 100].

where: SLP = The number of stalk lodged plants per plot.

PPLT = The number of plants per plot.

8. The number of root lodged plants was also determined by counting the number of plants per plot that were leaning 30 degrees or more from the vertical.

9. The number of plants per plot with leaf rust was counted.

10. Adjusted Grain Yield:

a) The total grain yield per plot was determined by adding the total shelled weight of the individual ears per plot at harvest. This was adjusted to 15.5% moisture. The relationship used was:

[(100-m)/84.5] x SGW = adjusted yield(kg/ha) to 15.5% moisture.

where: m = moisture content of the wet grain.

SGW = shelled grain weight in kgs.

b) Grain yield in kg per hectare was calculated using this relationship:

Grain yield (kg/ha) = 10,000 m^2/ Area per plot m^2 *adjusted grain yield.

Statistical Analysis

The analysis of variance for the traits under study were done using a linear additive model for randomized complete block design (Steel and Torrie, 1980).

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$Y_{ij} = \mu + P_i + r_j + e_{ij}$;

where:

Y_{ij} = observed value for the j^{th} population in the i^{th} replication (i = 1,2,3, and j = 1,2,3,4,.....100, Or 121);

μ = overall mean effects;

P_i = effect of i^{th} population;

r_j = effect j^{th} replication, j = 1,2,3 with replications considered random variables.

e_{ij} = the random error associated with the plot of i^{th} population in j^{th} replication.

It is assumed that the error terms are normally and independently distributed with mean 0 and variance σ^2.

In the results, Comparisons between selected plants in the first cycle progeny (C1) and their parental variety (C0), Michigan Synthetic #9 were made. These comparisons Show frequency distributions between the progenies (C1) and their parents (C0) of both early (ES) and high yielding selections (HYS) trials. Also comparisons of early and high yileding selections were made.

TABLE 1. Shows the general form of the analysis of variance for individual traits.

Source	df	MS	EMS
Total	pr - 1		
Replication	r - 1	M_r	$\sigma^2_e + p\sigma^2_r$
Population	p - 1	M_p	$\sigma2_e + r\sigma^2_p$
Error	(r-1)(p-1)	M_e	σ^2_e

where: p = the number of entries in the population;

r = the number of replications;

σ^2_r = variance among plots within replications;

σ^2_p = variance among the populations;

Me, Mp, Mr = respective mean squares.

RESULTS

The results of the first year are included in the appendix (tables 1a-42a). The mean, standard deviation and error were calculated for each plot separately in both Michigan Synthetic #9 and the single cross hybrid used as the control. Selection was based on the performance of individual plants. Yield performance expressed in percentages was compared to the mean of the selected plants in the adjacent row of the single cross control. Early plants as measured by onset of silking date, and high yielding plants of each plot were selected to be evaluated in the next generation in an ear to row yield selection experiment.

The analysis of variance for early selection (ES) and high yielding selection (HYS) genotypes grown in 1990 are presented in tables 2 and 3. The results of ES showed that highly significant differences existed among genotypes for pollen shed, silking dates, plant height, ear height, grain yield and moisture content in the grain at harvest time. Stalk lodging was significant at 5 percent, while plant stand was nonsignificant. Similarly, HYS genotypes were highly significant different for pollen shed, silking, grain yield and moisture content in the grain. Plant height and plant stand were significant only at 5 percent level while ear

TABLE 2. MEAN SQUARES FOR EIGHT TRAITS OF EARLY SELECTION (ES) GENOTYPES DERIVED FROM MICHIGAN SYNTHETIC #9, YEAR 1990.

Source of variation	Degree of freedom		Pollen shed	Silking date	Plant ht.	Ear ht.	Moistur content	plant stand	stalk lod.	Yield
Replication	1/a	2/b	21.78	16.24	2523.3	1632.5	17.76	37144.6	1612.9	46034351.35
Genotypes	99	99	4.65**	5.02**	249.8**	156.7**	3.12**	11.96ns	136.5*	1021530.0**
Error	99	198	2.50	2.56	118.6	88.9	1.86	12.56	84.15	619838.0
Total	199	299								
Mean			68.07	72.05	178.09	84.0	25.77	39.62	24.14	4800.86
CV (%)			2.32	2.22	6.11	11.28	5.29	8.94	38.00	16.40

*,** Indicate significance at 0.05 and 0.01 probability levels, respectively.

ns Indicate nonsignificance.

a - Df indicate for two replications: pollen, silk, plant and ear height, and moisture content.

b - Df indicate for three replications: grain yield, plant stand and stalk lodging.

TABLE 3. MEAN SQUARES OF EIGHT TRAITS OF HIGH YIELDING SELECTION (HYS) GENOTYPES DERIVED FROM MICHIGAN SYNTHETIC #9, YEAR 1990.

Source of variation	Degree of freedom		Pollen shed	Silking date	Plant ht.	Ear ht.	Moistur content	plant stand	stalk lod.	Yield
Replication	1/a	2/b	32.00	37.29	2436.0	1853.9	32.36	40567.4	1759.4	95330324.5
Genotypes	120	120	6.91**	8.17**	224.7*	140.9ns	3.76**	20.07*	171.7ns	1307184.1**
Error	120	240	3.94	4.69	141.1	107.81	1.72	12.21	143.06	675259.21
Total	241	362								
Mean			69.37	73.59	186.13	91.75	27.01	39.41	28.84	5070.71
CV (%)			2.86	2.94	6.38	11.32	4.85	8.86	41.47	16.21

*,** Indicate significance at 0.05 and 0.01 probability levels, respectively.

ns Indicate nonsignificance.

a - Df indicate for two replications: pollen, silk, plant and ear height, and moisture content.

b - Df indicate for three replications: grain yield, plant stand and stalk lodging.

height and stalk lodging were nonsignificant. Stalk lodging showed a high coefficient of variation in both experiments revealing the difficulty of precisely measuring this trait.

The inherent differences among traits of the ES and HYS populations are revealed by contrasting the eight traits evaluated for each. In general, the HYS population is different from the ES for all traits evaluated. However, the difference appears to be clearly significant with respect to plant height, ear height, stalk lodging and grain yield.

Mean separation for eight agronomic traits of one hundred twenty one and one hundred entries for both HYS and ES are presented in tables 4 and 5 respectively. Grain yield for HYS ranged from 3524.6 to 6620.5 kg/ha. The highest yield was produced by entry No. 93, while the lowest was produced by entry No. 21. In the case of ES, the grain yield ranged between 3430.0 and 6353.8 kg/ha. The highest producing genotype was entry No. 94 and the lowest produced by entry NO. 48.

Comparison of mean plant (186.1 vs 178.1 cm) and ear heights (91.8 vs 84.0 cm) for HYS showed slightly higher plant and ear heights than ES. Also ES showed less stalk lodging than HYS (24.1 vs 28.8%).

Grain yield frequency distributions of both HYS and ES derived from Michigan Synthetic #9 are presented in figure 2. The frequency distributions show that the lower and upper tails of HYS lie outside of the lower and upper tails of ES.

TABLE 4. MEAN VALUES FOR EIGHT AGRONOMICAL CHARACTERISTICS OF HUNDRED TWENTY ONE GENOTYPES SELECTED FOR HIGH YIELD FROM MICHIGAN SYNTHETIC #9 AT MSU RESEARCH FARM.

ENTRY NO.	GRAIN YIELD KG/HA	MOIST URE %	POLLEN SHED	SILK	PLANT HT cm	EAR HT cm	PLANT STAND	STALK LODG. %
93	6620.5	26.3	68.5	72.5	167.7	80.4	40.7	29.9
97	6442.3	25.7	67.5	71.0	197.1	100.1	42.7	27.9
88	6384.3	23.5	66.0	70.5	202.1	99.7	40.0	30.1
90	6273.0	27.6	69.5	73.0	192.0	96.6	40.3	19.5
39	6163.6	26.2	67.0	71.0	183.4	94.7	40.0	39.3
95	6131.0	26.1	70.5	75.0	202.9	108.1	45.0	23.9
45	6111.2	30.0	71.0	75.0	195.4	103.8	41.7	44.9
59	6107.1	27.2	70.0	75.0	186.8	89.6	42.3	12.1
104	6070.0	27.7	69.0	73.5	194.2	87.8	39.7	26.8
98	6021.3	26.8	72.5	76.0	171.7	79.8	38.0	30.5
92	6006.6	27.7	70.0	74.0	193.8	91.2	41.3	31.0
79	6004.7	28.9	68.0	72.5	181.7	92.3	40.3	31.0
74	5999.6	25.9	70.0	74.0	190.8	86.6	39.7	25.8
89	5980.3	28.2	67.0	70.5	198.1	103.3	42.0	22.7
49	5963.4	26.7	67.0	71.5	192.9	99.0	41.0	27.9
32	5960.2	27.6	68.0	72.5	182.5	85.1	44.7	27.3
119	5878.7	28.6	68.5	72.0	189.5	94.9	41.7	20.4
91	5795.4	26.6	69.5	73.0	172.2	86.4	38.7	34.9
62	5716.4	27.0	66.5	71.0	180.1	80.8	36.7	25.2
110	5713.4	28.1	72.5	77.5	179.4	80.8	43.7	23.6
58	5702.8	26.2	69.0	72.5	194.1	100.0	39.3	28.7
14	5698.5	24.4	67.0	70.5	163.5	78.4	39.0	29.7
24	5697.5	27.9	67.5	72.0	193.5	92.4	41.0	26.1
96	5688.9	28.3	67.5	71.0	205.4	101.2	43.7	22.8
84	5661.8	25.7	70.0	73.5	182.3	77.9	39.7	20.6
105	5616.2	29.0	69.0	73.5	183.3	87.3	42.0	26.5
19	5584.1	26.1	67.0	71.0	171.8	78.8	40.0	21.3
80	5578.1	30.8	72.0	76.0	177.8	88.4	41.7	30.9
99	5570.4	26.1	68.0	73.0	176.3	90.0	38.0	23.6
94	5557.8	25.8	70.5	74.5	190.0	88.7	39.0	33.7
76	5550.4	26.4	67.5	72.0	200.1	96.8	31.3	39.8
10	5505.1	27.1	72.5	77.0	178.4	91.3	40.7	31.9
17	5503.5	27.4	69.5	73.5	191.1	99.3	39.7	30.6
81	5460.4	28.3	69.0	75.0	185.1	88.3	39.0	17.8
5	5460.1	27.2	70.5	75.5	189.6	86.6	43.7	34.7
43	5429.7	26.4	68.0	72.0	162.6	82.2	43.7	25.2
66	5405.6	26.8	69.0	73.0	181.9	81.2	41.0	21.7
77	5398.7	26.9	71.0	75.0	161.1	76.6	38.7	27.2
37	5388.0	26.2	68.5	72.5	178.6	88.2	40.0	36.7
60	5366.3	27.7	69.5	74.5	179.7	79.4	40.7	26.9
44	5363.2	24.4	65.5	70.0	207.5	104.7	42.7	27.9
117	5358.3	26.7	66.5	71.5	195.1	100.3	40.3	19.3
55	5353.6	25.7	69.5	73.0	181.0	86.1	40.0	26.1
108	5337.1	25.1	67.5	71.5	179.4	97.0	38.0	30.3
106	5333.2	28.5	69.0	73.0	191.8	102.9	37.7	38.6
63	5311.3	27.9	70.0	74.0	179.9	93.1	38.7	36.8
1	5268.7	29.9	74.0	79.0	182.5	76.2	41.0	22.0
34	5253.9	26.7	67.5	72.5	194.9	96.0	38.0	37.1
42	5234.7	25.9	69.5	73.5	196.4	92.4	42.0	26.0
120	5195.9	28.1	71.5	76.0	183.5	101.7	39.0	24.4
64	5185.5	27.2	68.5	73.0	183.1	89.8	37.3	27.6
33	5170.4	28.2	72.0	76.0	175.3	78.7	42.0	17.6
9	5167.0	24.8	67.5	70.0	184.7	94.0	41.0	20.6

TABLE 4. cont'd.

109	5133.6	26.9	67.5	70.0	197.7	106.7	39.0	35.1
52	5098.4	25.2	69.5	74.0	180.9	89.7	37.3	31.0
71	5085.4	27.7	69.0	73.5	189.0	90.2	39.0	22.1
25	5085.0	29.0	70.0	73.0	176.3	96.3	40.0	25.2
30	5065.6	29.6	73.0	77.0	172.1	76.1	41.7	24.6
16	5057.0	28.1	70.5	74.0	198.5	106.4	39.3	25.2
114	5044.5	25.9	69.0	73.0	190.5	92.0	42.0	21.1
116	5043.9	26.5	69.0	72.5	196.4	98.0	40.3	36.1
70	5034.2	27.5	70.0	75.0	187.9	95.5	37.7	18.4
38	4988.2	25.9	67.0	71.0	186.7	97.3	40.7	45.2
115	4979.9	26.7	68.0	72.5	195.4	100.7	40.0	29.2
100	4971.6	26.3	72.0	76.0	179.8	87.6	38.0	27.5
35	4971.2	24.7	67.0	70.5	197.3	95.1	38.7	33.6
103	4966.9	29.3	68.5	72.5	170.5	82.5	40.7	20.6
118	4934.9	27.2	68.0	72.5	183.1	94.9	40.3	26.4
107	4924.8	27.0	68.5	73.0	180.8	87.2	35.7	28.8
87	4920.6	27.0	68.5	72.5	203.3	102.6	39.0	25.6
29	4904.3	26.9	68.0	72.5	184.9	98.8	40.0	26.4
67	4896.8	27.9	69.5	73.5	195.1	95.1	38.0	34.9
68	4883.9	26.4	70.5	75.5	180.8	89.6	43.0	31.3
11	4873.7	27.2	71.0	76.0	180.3	81.5	41.0	23.1
50	4873.7	27.7	72.5	77.0	183.5	89.2	41.0	14.0
102	4868.4	25.3	69.0	73.0	183.5	94.8	40.3	30.4
6	4852.2	25.7	67.5	72.5	186.7	103.7	40.3	30.7
83	4838.6	27.0	68.5	73.0	177.6	78.3	38.0	37.8
101	4834.0	27.9	74.5	77.5	195.5	100.8	37.7	25.3
65	4832.6	25.4	68.0	73.0	183.5	88.8	41.7	25.4
57	4810.4	27.4	67.0	70.0	204.2	104.0	38.7	32.2
27	4804.8	27.6	69.0	73.0	170.4	84.4	40.3	36.4
26	4794.4	24.8	67.5	72.0	184.5	95.5	41.0	24.8
46	4783.6	26.7	72.0	76.5	184.8	101.0	38.0	26.6
69	4769.4	28.8	69.0	72.5	197.3	105.7	40.0	14.8
75	4767.2	26.7	67.5	71.5	159.5	105.6	32.3	27.1
36	4765.1	27.9	69.0	72.5	189.3	89.2	37.0	37.6
113	4729.6	25.8	70.5	75.0	195.5	89.8	41.3	29.3
73	4716.2	26.7	69.0	73.5	159.5	85.0	38.7	23.4
3	4677.4	26.4	67.0	71.5	172.0	88.5	40.3	32.2
18	4670.1	29.2	71.5	76.0	200.1	101.3	36.3	22.0
7	4659.4	26.5	69.0	73.0	177.9	83.8	35.7	51.6
85	4640.8	26.9	68.5	71.5	193.3	99.4	37.0	21.9
82	4620.1	26.7	72.5	77.0	197.8	99.2	41.7	35.1
41	4574.3	30.1	74.0	78.5	184.1	89.0	38.3	25.5
53	4525.9	31.1	72.5	78.0	177.8	84.3	37.3	27.1
86	4518.0	28.4	70.0	75.0	198.2	107.0	37.7	43.5
8	4473.6	26.9	68.5	73.5	191.5	92.5	44.0	38.8
40	4417.1	27.2	72.5	78.0	180.4	84.1	32.0	24.8
20	4416.7	26.2	68.5	74.0	164.7	73.2	37.7	17.7
54	4384.5	26.8	71.5	75.0	196.1	92.1	37.7	23.1
13	4373.5	26.4	69.0	73.0	190.2	92.0	37.7	40.9
111	4317.4	26.9	71.0	75.5	188.2	93.7	39.7	30.2
47	4312.4	27.1	70.0	74.0	174.8	85.1	41.0	29.5
56	4304.4	25.7	70.5	75.0	197.9	94.8	35.0	33.6
48	4302.1	27.0	67.0	71.5	186.8	90.6	39.0	32.7
72	4251.5	28.2	70.5	74.5	191.2	88.9	36.7	24.6
61	4230.5	26.0	68.0	71.0	192.1	84.3	40.3	35.8
51	4206.4	27.4	71.0	75.0	193.3	90.4	32.0	22.4
23	4196.5	23.6	68.0	72.5	175.0	85.8	38.3	45.9
2	4154.6	28.6	71.0	75.5	177.6	94.7	37.3	21.9
112	4151.1	29.0	73.0	77.0	200.5	93.2	39.7	41.9

TABLE 4. cont'd.

12	4090.2	28.3	71.0	74.5	173.1	88.0	35.7	16.9
31	4056.7	27.4	69.5	73.5	197.9	89.2	38.7	21.9
121	4034.0	28.1	71.5	76.0	183.5	101.7	41.3	36.8
28	4025.2	26.2	68.5	73.0	198.7	95.6	37.7	42.7
78	3896.4	25.6	67.0	70.5	192.0	106.9	37.0	46.3
22	3781.2	26.9	70.0	73.5	162.2	74.3	30.3	46.1
15	3600.1	27.9	71.0	74.5	196.7	104.6	41.7	33.7
4	3567.0	26.1	69.0	74.0	195.7	100.8	40.0	34.1
21	3523.6	27.8	70.0	75.5	181.3	89.5	36.7	33.0
MEAN	5070.7	27.0	69.4	73.6	186.1	91.8	39.4	28.8
RANGE	6620.5	31.1	74.5	79.0	207.5	108.1	45.0	51.6
	3523.6	23.5	65.5	70.0	159.5	73.2	30.3	12.1
$LSD_{(0.05)}$	1321.7	2.59	3.93	4.29	23.52	20.56	5.62	19.24
$LSD_{(0.01)}$	1728.4	3.38	5.11	5.58	30.60	26.75	7.35	25.16
C.V.(%)	16.21	4.85	2.86	2.94	6.38	11.32	8.86	41.47

TABLE 5. MEAN VALUES OF EIGHT AGRONOMICAL CHARACTERISTICS OF ONE HUNDRED SELECTED GENOTYPES FOR EARLINESS FROM MICHIGAN SYNTHETIC #9 AT MSU FARM RESEARCH.

ENTRY NO.	GRAIN YIELD KG/HA	MOISTURE %	POLLEN SHED	SILK	PLANT HT cm	EAR HT cm	PLANT STAND	STALK LODG. %
94	6353.8	27.5	67.0	72.0	181.2	94.6	39.0	12.6
83	6017.5	25.0	68.0	71.0	189.9	88.4	40.0	17.7
8	5967.1	27.6	66.5	71.0	160.2	70.4	41.3	18.1
78	5695.3	24.8	67.0	71.0	161.6	73.9	41.0	16.3
77	5686.1	23.4	64.5	68.0	180.7	72.0	41.3	26.8
86	5628.8	24.5	68.0	71.5	164.2	69.0	39.3	23.6
5	5610.0	24.6	67.0	70.5	188.6	84.5	42.3	31.6
9	5593.0	26.3	68.5	72.5	198.2	96.0	41.0	14.1
35	5565.4	27.6	69.0	73.0	181.6	83.5	40.7	18.5
10	5565.1	25.6	70.0	73.5	176.4	78.8	38.3	21.2
49	5544.8	26.9	68.0	72.0	179.2	90.4	40.0	28.4
85	5518.0	26.1	67.5	70.5	196.2	94.5	41.7	35.4
60	5510.9	26.7	69.5	73.5	181.8	88.6	40.3	25.1
95	5453.1	24.4	69.5	73.0	173.8	71.3	40.3	22.3
70	5443.0	24.9	69.0	73.0	185.8	85.6	40.0	32.5
84	5398.2	27.6	68.0	73.0	186.7	83.6	42.7	31.4
90	5385.4	26.2	70.0	73.5	171.3	81.9	40.7	26.8
25	5375.3	27.6	69.0	72.5	171.0	84.2	41.3	21.7
99	5348.9	25.0	66.5	69.5	172.5	75.0	39.3	19.3
72	5338.9	25.2	69.0	73.0	192.6	85.5	38.0	13.9
93	5333.2	24.7	68.0	72.0	194.9	100.9	39.0	13.9
3	5326.8	25.1	66.0	69.5	168.9	75.5	40.7	24.1
89	5292.5	26.8	68.5	72.0	177.0	90.4	40.3	31.2
33	5231.5	22.3	68.5	71.5	181.1	91.3	40.3	27.7
27	5205.7	25.1	67.5	72.0	163.8	69.6	39.3	28.4
38	5178.0	26.6	69.0	73.0	184.0	91.6	38.0	26.3
17	5154.0	26.2	67.5	72.0	154.9	60.1	38.0	22.4
79	5134.3	26.5	71.5	75.5	159.2	76.0	39.7	30.7
68	5096.6	23.9	66.5	71.5	185.0	86.6	40.7	24.4
87	5086.6	26.5	67.5	71.5	186.5	92.5	36.3	34.3
30	5083.2	25.9	69.5	73.0	197.8	106.6	41.0	22.5
88	5059.3	25.2	66.5	70.0	186.7	88.7	40.7	35.0
53	5053.5	25.7	68.0	73.0	164.3	77.5	37.0	12.4
63	5053.3	24.3	66.0	71.0	183.3	73.8	39.3	29.3
81	5052.5	25.3	68.0	72.5	158.8	69.9	38.7	24.0
23	5035.4	24.0	69.0	72.5	169.0	91.8	38.3	29.1
56	5025.3	25.7	67.0	72.0	198.0	98.2	39.0	22.3
100	5013.6	25.0	66.5	69.5	172.5	75.0	38.7	18.0
96	5007.8	26.5	65.5	70.0	184.8	80.4	38.7	12.3
98	4997.1	25.6	69.0	72.5	175.1	85.6	42.3	20.5
67	4918.5	24.5	66.5	69.5	183.1	84.1	41.7	19.5
57	4913.6	26.7	69.5	73.0	175.0	85.4	42.7	25.6
47	4897.5	24.7	71.0	74.0	172.1	74.1	40.7	24.0
6	4891.8	27.2	69.0	73.0	158.2	70.0	39.7	32.2
54	4870.4	23.3	65.0	68.0	183.6	83.4	40.0	24.0
97	4861.4	27.1	68.0	73.5	179.3	87.7	41.3	16.5
26	4855.4	23.2	66.0	70.0	175.9	74.9	41.3	24.2
16	4834.7	26.5	67.5	72.0	189.4	99.1	40.7	31.0
37	4831.9	26.1	66.5	70.0	192.9	102.9	40.0	30.2
71	4825.8	25.3	68.0	71.0	167.1	81.4	40.3	30.2
11	4823.3	26.0	70.5	74.0	162.8	64.5	40.0	13.0
39	4814.0	23.8	67.0	71.5	177.0	82.5	42.0	15.3
2	4783.9	26.2	69.5	73.5	175.0	79.4	40.0	22.1

TABLE 5. cont'd.

91	4772.1	26.8	68.5	73.5	167.6	79.4	39.3	18.0
58	4770.4	27.1	67.0	71.5	189.1	92.5	41.3	20.4
13	4759.8	26.3	67.5	72.0	170.5	78.3	40.0	22.7
34	4753.6	28.4	69.0	73.0	176.0	89.1	38.3	31.4
46	4738.5	27.2	70.0	73.5	170.5	78.6	39.3	26.6
59	4723.5	24.2	64.0	67.5	174.9	71.5	35.7	11.4
75	4715.4	26.0	68.0	72.5	165.6	91.3	30.3	20.7
69	4680.5	25.4	68.5	73.0	178.6	73.3	42.3	26.2
1	4666.7	25.1	67.5	72.0	173.2	77.4	38.7	24.0
50	4629.6	27.5	68.5	72.5	169.6	75.5	39.3	34.0
45	4610.7	25.3	67.5	70.5	170.3	78.6	39.3	25.1
82	4601.5	25.9	68.5	71.5	195.8	92.9	36.7	30.1
76	4576.6	24.7	68.5	72.5	203.4	98.2	41.0	24.3
66	4545.6	25.2	68.0	73.5	183.6	91.2	41.0	23.0
24	4526.2	27.3	68.0	71.5	186.0	85.4	42.7	32.4
32	4492.6	23.6	67.0	70.5	181.8	86.4	41.0	25.9
18	4490.7	24.5	69.5	72.5	176.7	88.5	37.7	21.5
29	4482.5	25.9	66.0	69.5	179.6	80.4	41.3	23.9
73	4467.5	24.8	69.0	73.0	162.3	69.9	40.3	14.8
55	4458.7	26.2	68.5	72.0	184.8	92.0	40.0	38.4
42	4451.7	27.3	69.5	74.0	174.2	84.8	41.3	28.2
80	4418.6	24.1	69.5	73.5	184.1	85.3	40.3	17.7
14	4418.3	27.4	68.5	73.0	180.7	82.0	38.3	31.4
21	4400.2	25.7	71.0	75.0	173.5	83.0	39.3	26.4
15	4321.6	26.8	68.5	72.0	179.4	89.9	37.3	24.5
28	4311.6	26.1	70.5	74.5	182.5	88.5	38.3	28.9
43	4342.0	26.5	67.0	70.0	162.3	78.6	41.7	18.9
51	4316.3	27.3	70.0	74.5	171.4	80.9	41.7	15.5
20	4275.9	25.8	69.5	73.0	177.1	84.4	39.0	24.4
22	4226.5	25.5	67.0	72.0	198.9	85.2	41.7	22.2
36	4274.2	25.2	69.0	73.0	186.4	92.6	39.7	13.8
40	4236.2	27.0	71.5	75.5	161.5	77.2	38.7	27.5
44	4235.0	26.6	69.5	73.0	174.8	81.5	37.7	27.0
31	4141.3	25.0	68.0	72.0	170.6	80.2	41.3	34.3
74	4188.9	25.5	68.0	72.5	191.3	89.7	37.7	20.6
52	4030.8	26.5	67.0	71.5	173.1	66.6	40.3	30.4
61	4099.9	22.9	66.0	70.0	167.7	84.4	36.7	26.0
41	3931.2	25.4	68.0	72.5	189.9	93.0	40.0	26.2
64	3975.6	26.6	69.5	74.0	171.6	79.3	40.0	24.0
92	3938.8	26.3	67.5	72.0	172.2	82.8	38.7	10.9
4	3824.4	27.0	65.5	68.0	193.5	98.8	41.7	29.0
12	3822.9	25.8	69.5	73.0	174.5	84.0	33.7	17.1
65	3726.7	26.4	67.5	72.0	168.3	81.0	36.3	20.5
62	3684.9	26.4	70.5	74.0	168.2	77.5	37.7	16.1
7	3567.5	28.8	65.5	70.0	212.5	107.7	38.3	32.5
19	3490.7	24.7	68.5	73.0	172.3	85.0	34.3	48.1
48	3430.0	26.6	66.0	71.0	188.7	80.6	42.0	23.1
MEAN	4800.9	25.8	68.1	72.0	178.1	83.6	39.6	24.1
RANGE	6353.8	28.8	71.5	75.5	212.5	107.7	42.7	48.1
	3430.0	22.3	64.0	67.5	154.9	60.1	30.3	10.9
$LSD_{(0.05)}$	1267.7	2.71	3.14	3.17	21.60	18.70	5.71	14.77
$LSD_{(0.01)}$	1655.9	3.51	4.07	4.12	28.05	24.28	7.45	19.29
C.V.(%)	16.40	5.29	2.32	2.22	6.11	11.28	8.94	38.0

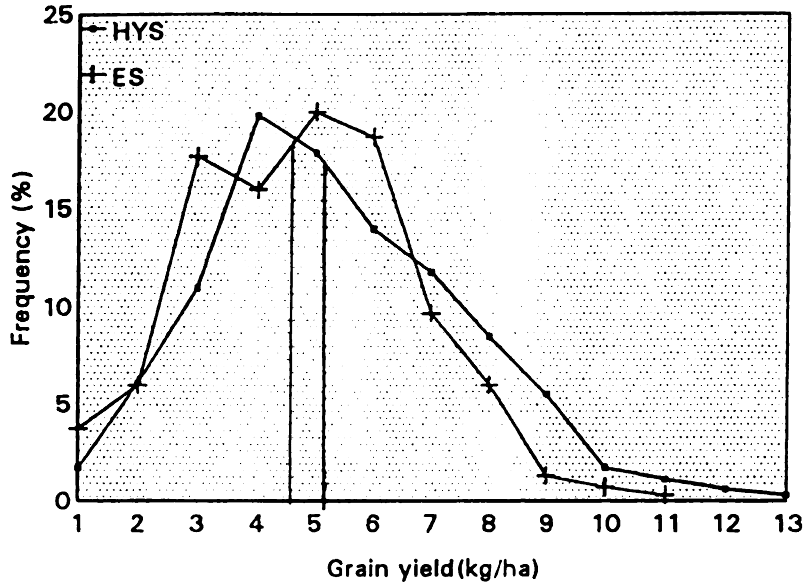

Figure 2. Grain yield distribution between early (ES) and high-yielding (HYS) genotypes at 546 g/plot class intervals.

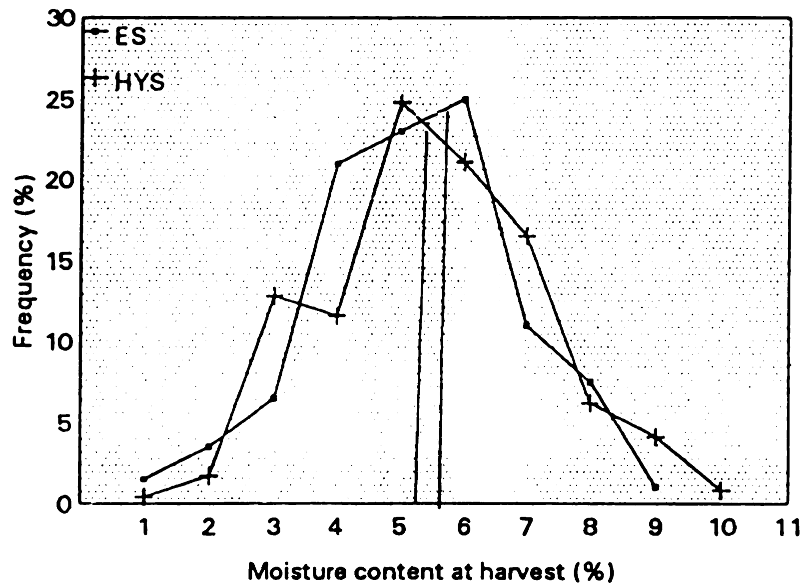

Figure 2a. Grain moisture content distribution between early (ES) and high-yielding (HYS) genotypes using 1.0 percent class intervals.

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This result indicate that HYS population is more variable and slightly higher yielding. Average grain yields were 5071 and 4801 kg/ha, for HYS and ES, respectively. Comparison of grain mean yields of the two trials indicated that ES was 94.6% that of HYS.

The distribution of grain weights measured in the field at harvest of progenies and their parents are presented in figures 3 and 4. The mean harvest grain weights of the progenator populations (C1) of both HYS and ES are higher than the mean harvest grain weights of their respective parents (C0). When dry weight comparisons were made the apparent higher yields disappeared. Mean dry grain yields selected of both populations were lower than the mean dry grain yield of their respective parents (figures 5 and 6). This demostrated that visual selection for harvest weight can not be the sole basis for selection. Thus, visual selection of superior plants using grain harvest weight isolated individuals with a higher moisture content and lower dry weight.

Mid pollen shed of the progenies and their parents are also shown in figures 7, 8, 9, and 10. The days to pollen shed of progenies (50% flowering) compared to either first day or last day of pollen shed of the parents indicate that a high frequency of the selected of plants shed their pollen earlier than their parents. Comparisons, made on the basis of the mean period for pollen shed among progenies with their parents show that the parents are later flowering by 2 and 4 days for

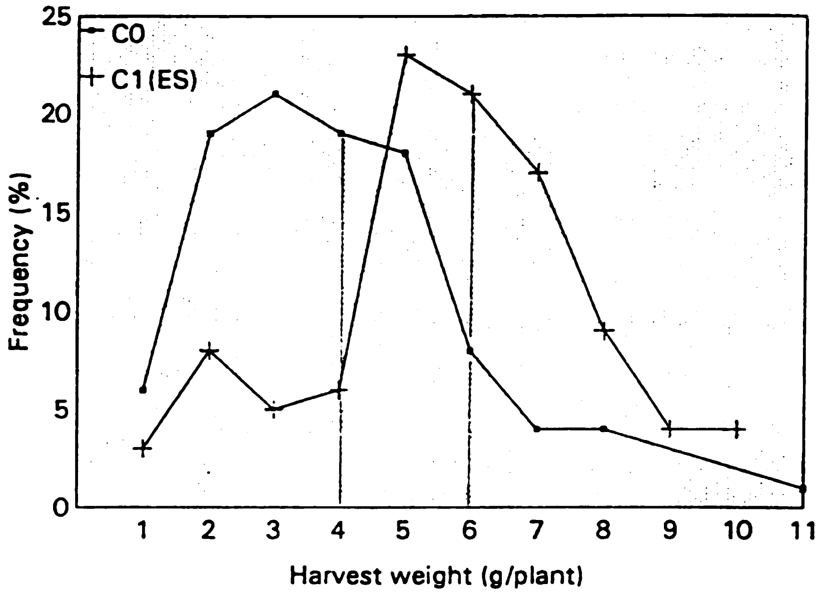

Figure 3. Harvest weight distribution between selected plants in the first cycle (C1) progenies compared to selected plants of the parental variety (CO), Mich. Syn. 9 at 13 g/plant class intervals.

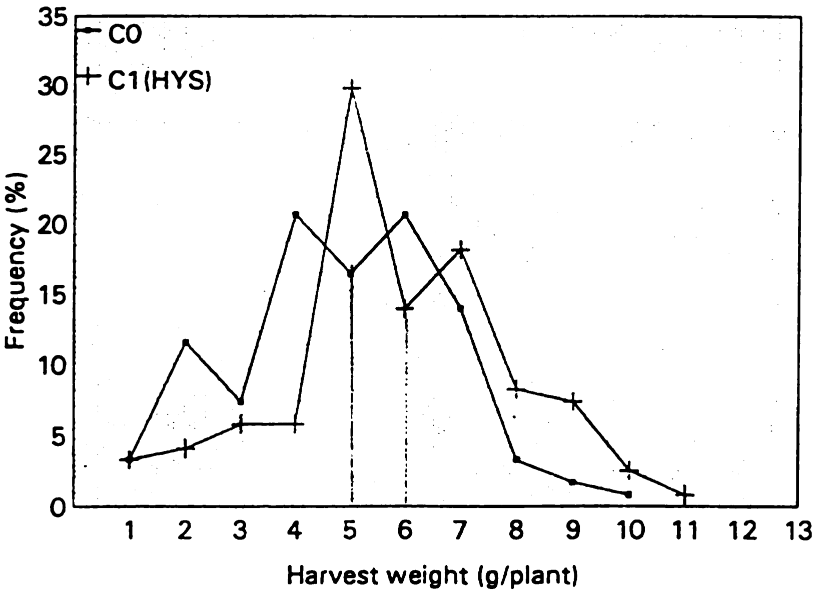

Figure 4. Harvest weight distribution between selected plants in the first cycle (C1) progenies compared to selected plants of the parental variety (CO), Mich. Syn. 9 at 13 g/plant class intervals.

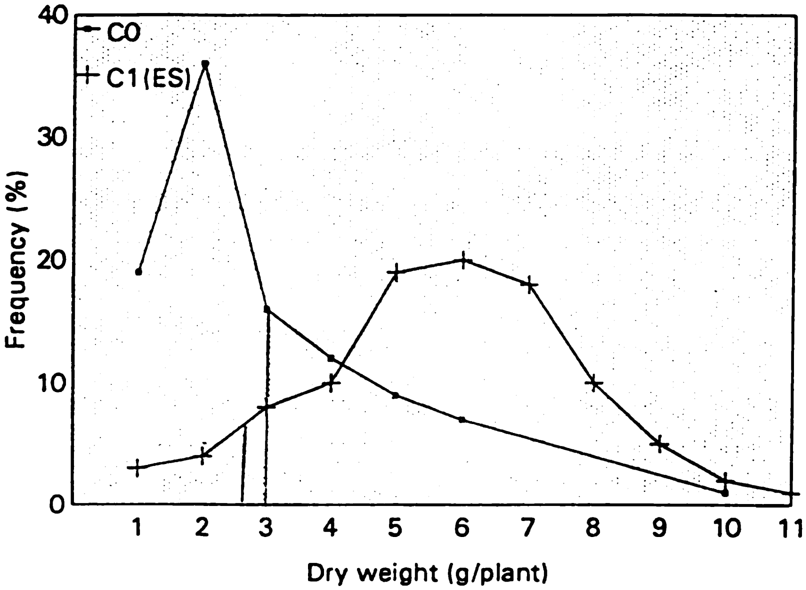

Figure 5. Dry weight distribution between selected plants in the first cycle (C1) progenies compared to selected plants of the parental variety (CO), Mich. Syn. 9 at 9 g/plant class intervals.

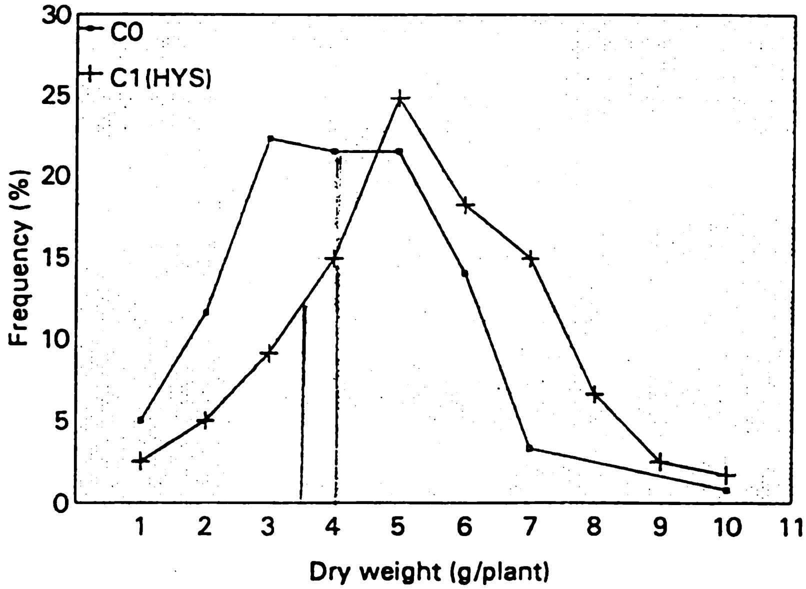

Figure 6. Dry weight distribution between selected plants in the first cycle (C1) progenies compared to selected plants of the parental variety(CO), Mich. Syn. 9 at g/plant class intervals.

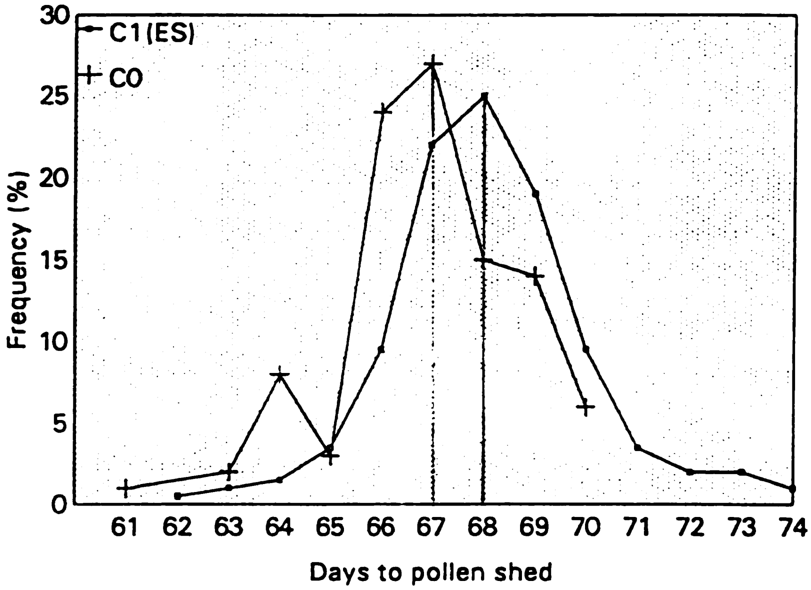

Figure 7. Pollen shed distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety(CO), Mich. Syn. 9 at 1 day class intervals.

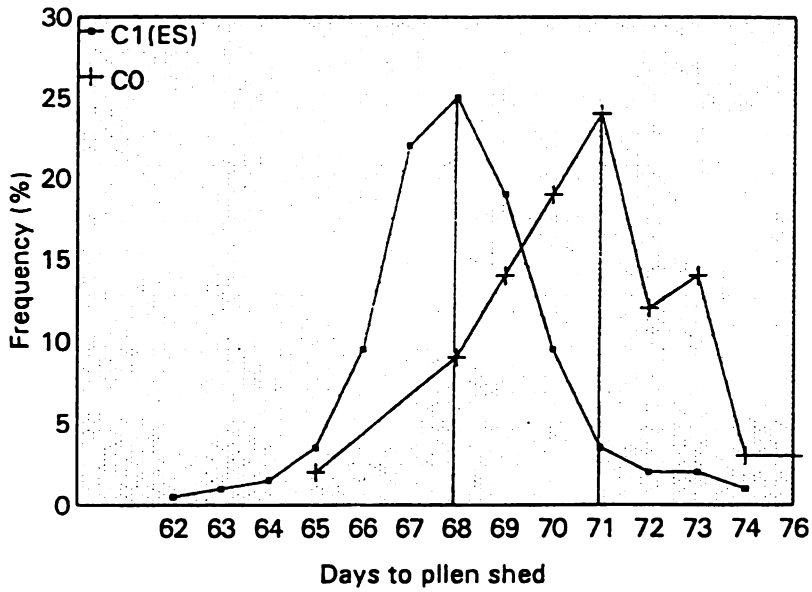

Figure 8. Pollen shed distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety(CO), Mich. Syn. 9 at 1 day class intervals.

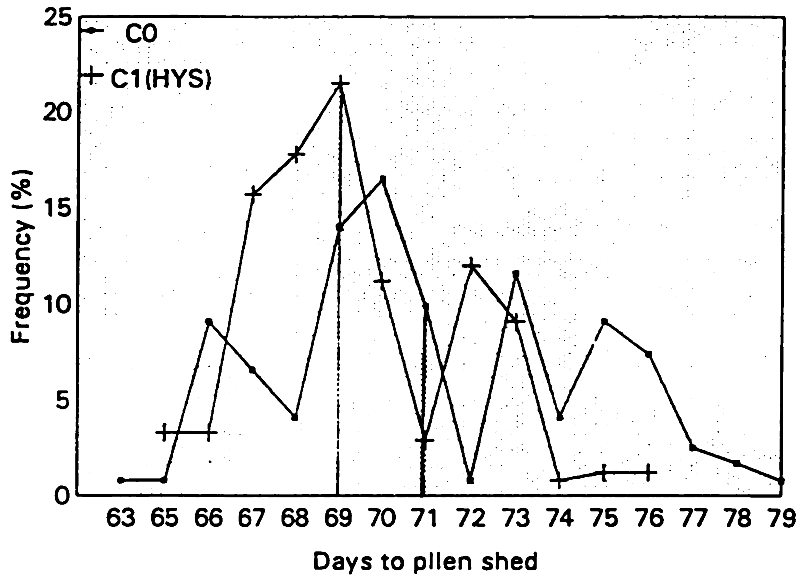

Figure 9. Pollen shed distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn. 9 at 1 day class intervals.

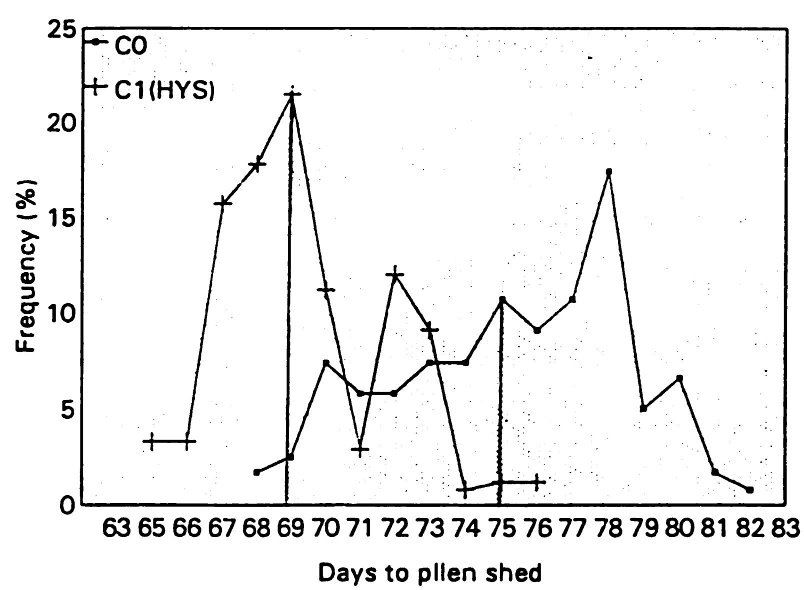

Figure 10. Pollen shed distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn. 9 at 1 day class intervals.

first and last days of pollen shed, respectively. In ES population, majority of the parents shed pollen earlier than their progenies in the case of first day pollen shed. The mean of pollen shed of parents were 67 days compared to 68 days in their progenies. This one day differnce which may be due to environment. Futhermore, in the case of last day to pollen compared to the progeny pollen shed (50% shedding), a high frequency of the plants showed 68 days for progenies and 71 days for the parents.

Silking date comparisons for both ES and HYS populations are presented in figures 11, 12, 13, and 14. In the case of HYS population, the mean of first day to silking for the parents concided with a high frequency of days to silk of the progenies (50% silking), most genotypes silk around 73 days. Comparison of their means, showed one day difference, which indicated that the progenies had flowered one day later. For last days to silk and days to silk (50% silking) most progenies flowered on day 73, but the parent showed late silking. However, there was a five days difference in the mean date to silking between the progengies and their parents. For ES population, the first day of silk started for parents to that progenies indicating the nonexistence of a relationship since most progenies fall outside of the upper tail of their parents. This result shows that first day to silk can not be a good measure for selection of earliness, while last day to silk and days to silk (50% silking) seem to provide some

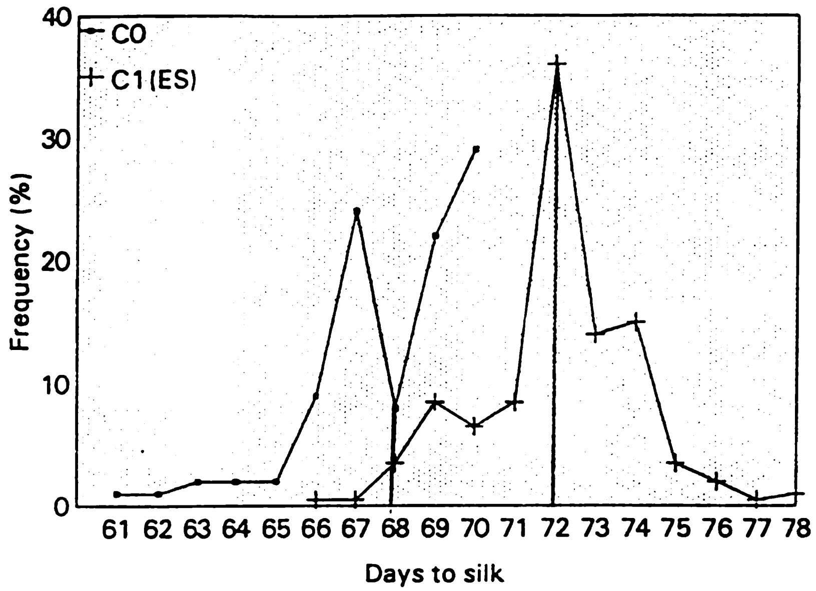

Figure 11. Silking dates distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn. 9 at 1day class intervals.

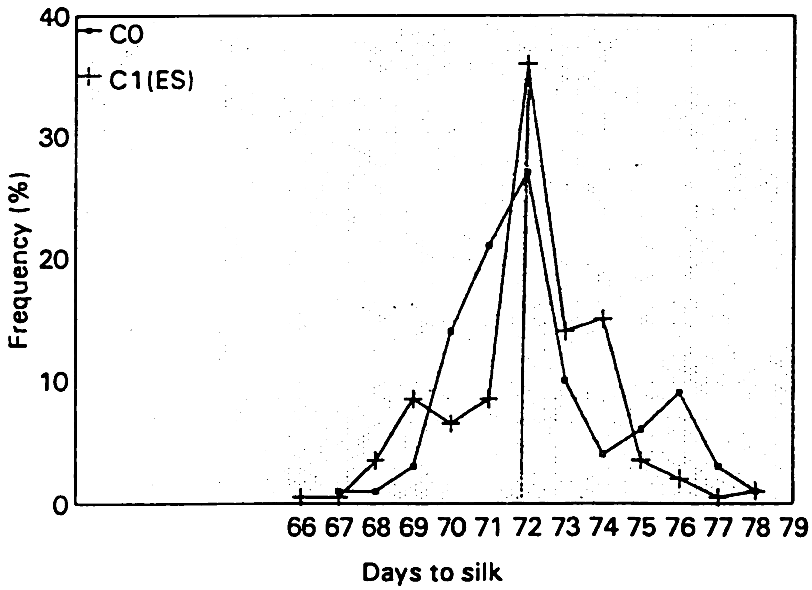

Figure 12. Silking dates distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn. 9 at 1 day class intervals.

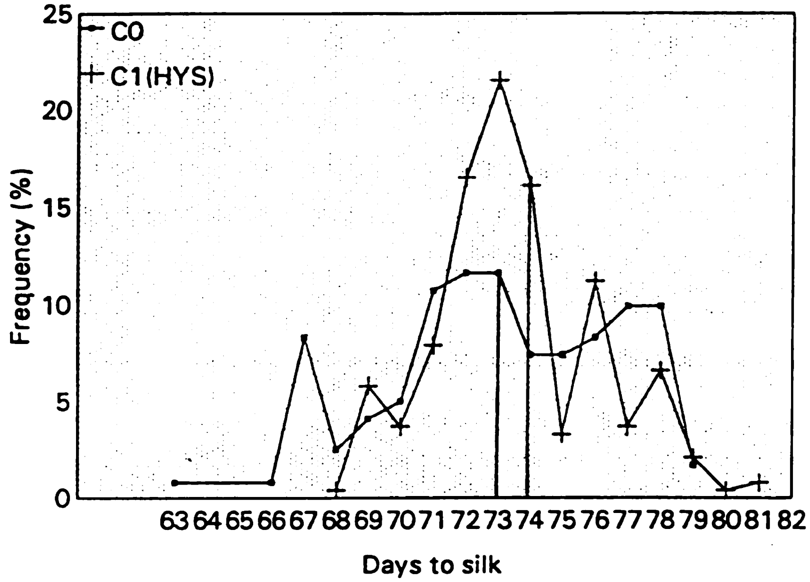

Figure 13. Silking dates distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn. 9 at 1 day class intervals.

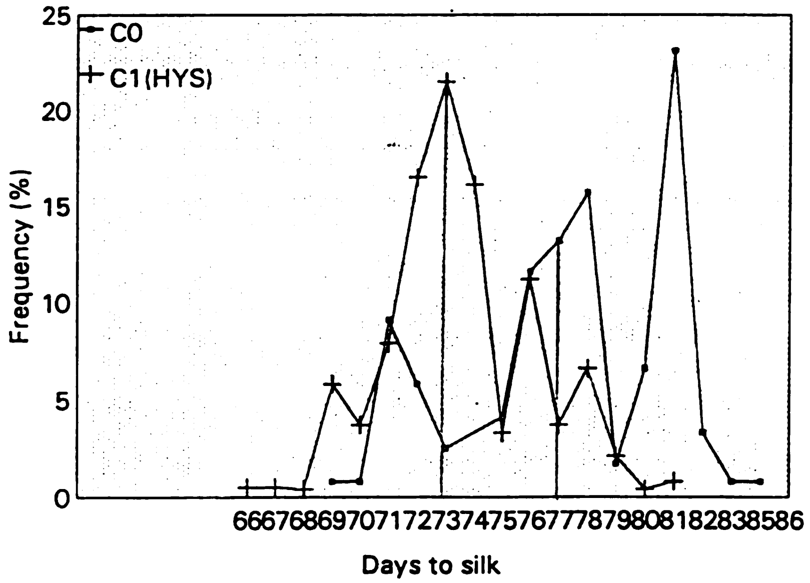

Figure 14. Silking dates distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn. 9 at 1 day class intervals.

information.

Grain moisture content distribution between ES and HYS is presented in figure 2a (p 43). This distribution indicated that ES genotypes have slightly lower moisture content than HYS genotypes.

Plant and ear height frequency distribution are presented in figures 15, 16, 17, and 18. The distributions show that in a single cycle of mass selection the mean plant and ear height of progenies are reduced. This reduction of heights may not be beneficial and not recommendable in the areas where Raccoon damages exists.

Stalk lodging of both ES and HYS are presented in figure 19. The distribution show that both trials show similar spread, but indicate that ES has lower stalk lodging.

Another trait which was also considered was plant stand distribution in figure 20. In this graph, the means of the two trials has almost the same mean.

Phenotypic correlations of all traits evaluated in those trials are presented in tables 6, 7, 8, and 9. There was considerable variation in the coefficients between all traits. In the result for HYS, there was a significant negative correlation between grain yield and plant stand, moisture content, pollen and silk. Only stalk lodging was not significant but showed positive correlation. For ES, the correlations were similar, but moisture content was not significant, while stalk lodging was significantly negative

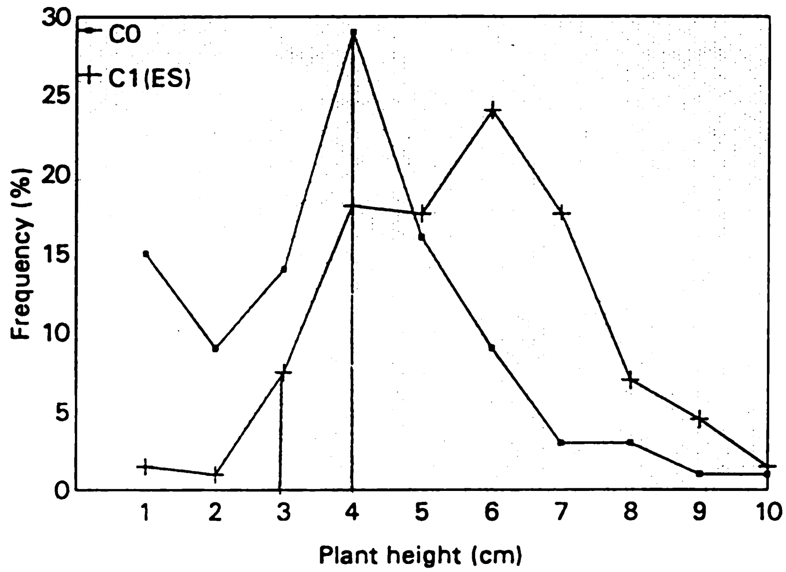

Figure 15. Plant height distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn.9 at 8 cm/plant class intervals.

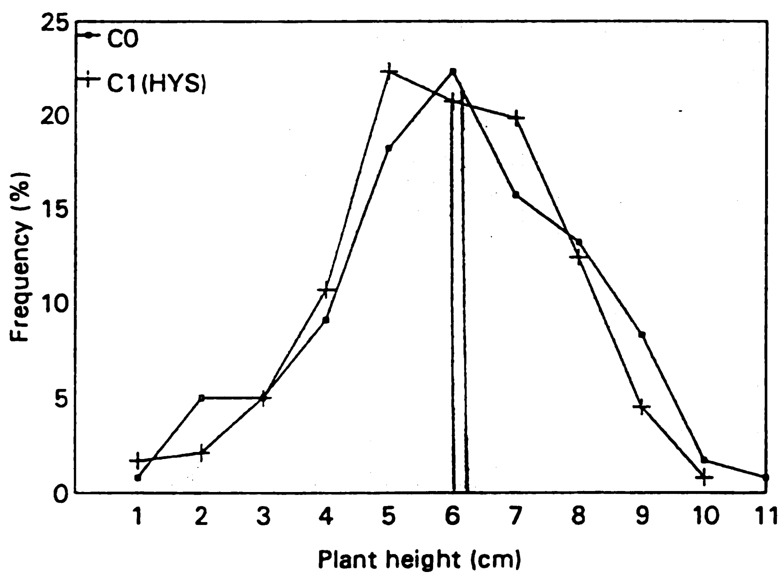

Figure 16. Plant height distribution between selected plants in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn. 9 at 8 cm/plant class intervals.

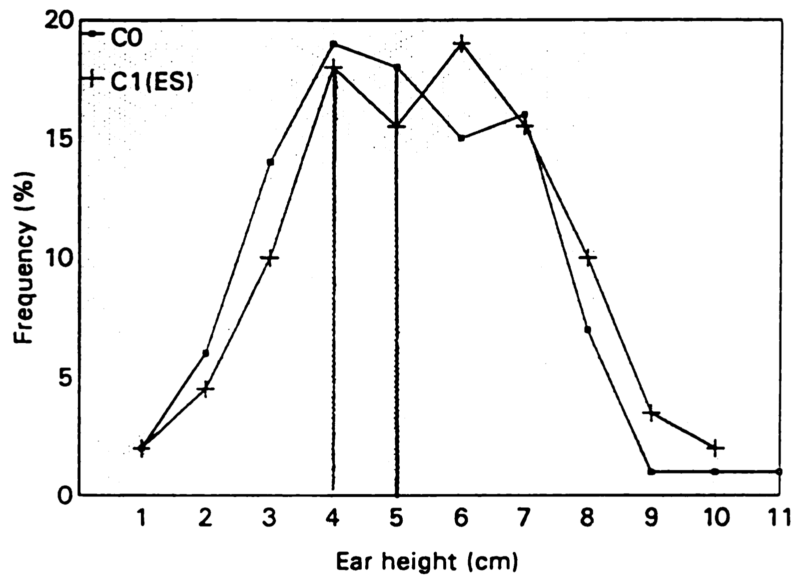

Figure 17. Ear height distribution between selected plants in the first cycle (C1) progenies compared to selected plants of the parental variety (CO), Mich. Syn. 9 at 6 cm/plant class intervals.

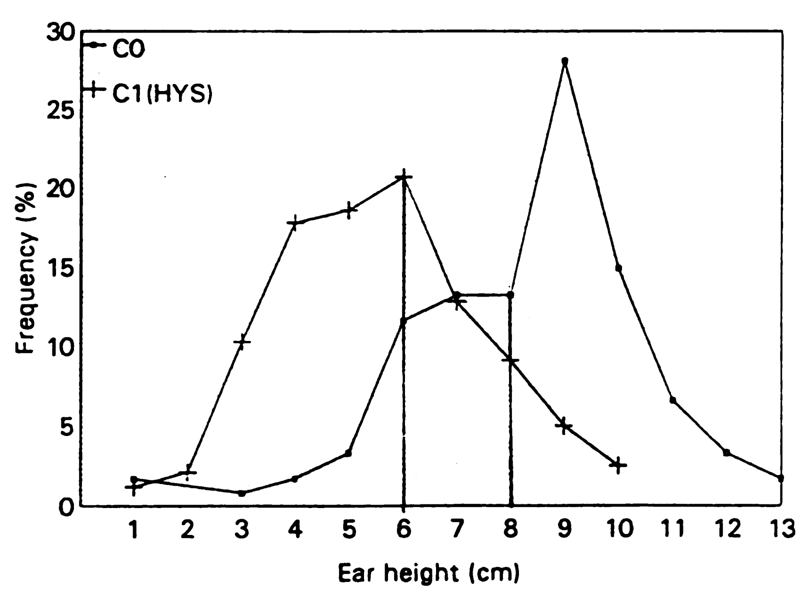

Figure 18. Ear height distribution between selected plant in the first cycle (C1) progenies compared to selected plants of parental variety (CO), Mich. Syn. 9 at 6 cm/plant class intervals.

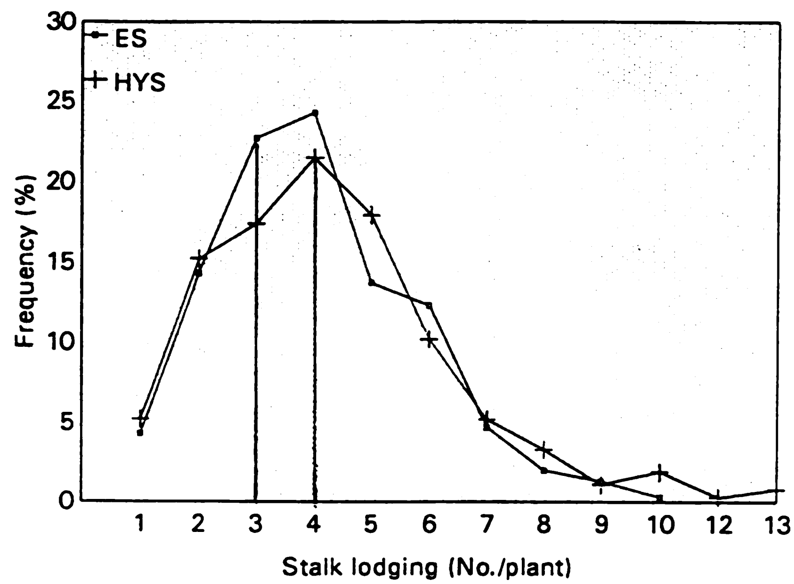

Figure 19. Stalk lodging distribution between early (ES) and high-yielding (HYS) genotypes at 6 plants class intervals.

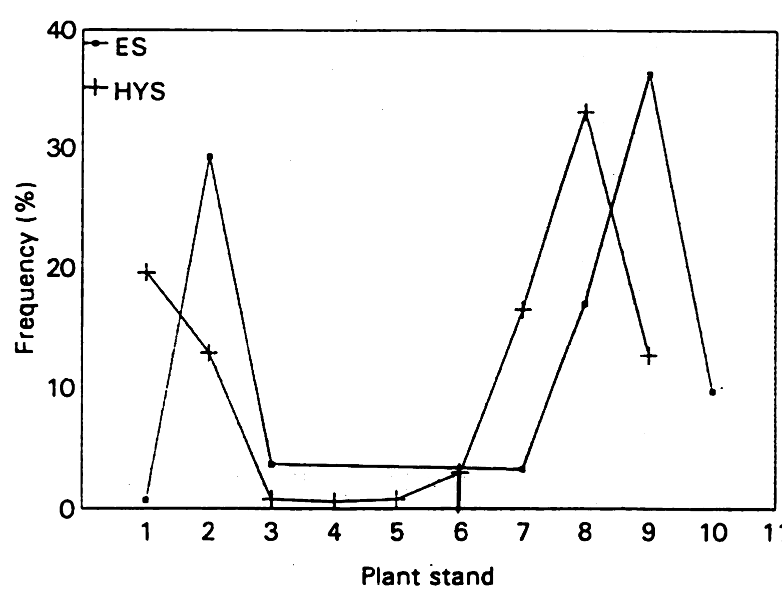

Figure 20. Plant stand distribution between early (ES) and high-yielding (HYS) genotypes at 5 plants class intervals.

correlated with grain yield.

In the case of the parents for both HYS and ES trials, the data produced a nonsignificant positive correlation between harvest weight and first day pollen shed, first day and last day silking. Only last day to pollen shed showed limited negative correlation.In addition, there was also small but negative correlation between dry weight and flowering dates. A significant positive correlation was obtained between plant and ear heights with the rest of the traits. In both parents, harvest weight and dry weight showed highly significant and positive correlation.

TABLE 6. CORRELATION COEFFICIENTS BETWEEN EIGHT TRAITS OF PRELIMINARY YIELD TRAIL FOR GENOTYPES SELECTED SPECIFICALLY FOR HIGH YIELD (HYS), YEAR 1990.

	Yield	Plant Stand	Moisture Content	Pollen Shed	Silking Date	Plant Ht	Ear Ht	Stalk Lodged
Yield	-	-0.524**	-0.132*	-0.449**	-0.476**	0.379**	0.378**	0.060ns
Stand		-	-0.035ns	-0.168**	-0.148*	0.162*	0.140*	-0.280**
Moisture			-	0.428**	0.405**	-0.002ns	-0.034ns	-0.046ns
Pollen				-	0.947**	-0.299**	-0.399**	-0.068ns
Silk					-	-0.331**	-0.447**	0.084ns
Plant height						-	0.798**	0.050ns
Ear height							-	0.128*
Stalk								-

*,** Indicate significance at 0.05 and 0.01 probability levels, respectively.

ns Indicate nonsignificance.

TABLE 7. CORRELATION COEFFICIENT BETWEEN EIGHT TRAITS OF PRELIMINARY YIELD TRAIL FOR GENOTYPES SELECTED SPECIFICALLY FOR EARLINESS (ES), YEAR 1990.

	Yield	Plant Stand	Moisture Content	Pollen Shed	Silking Date	Plant Ht	Ear Ht	Stalk Lodged
Yield	-	-0.465**	-0.029ns	-0.429**	-0.512**	0.412**	0.305**	-0.173**
Stand		-	-0.053ns	-0.056ns	-0.048ns	0.144*	0.173*	0.041ns
Moisture			-	0.207**	0.260**	0.004ns	0.102ns	-0.051ns
Pollen				-	0.890**	-0.296**	-0.155ns	-0.110ns
Silk					-	-0.325**	-0.197**	-0.120*
Plant height						-	0.788**	0.258**
Ear height							-	0.325**
Stalk								-

*,** Indicate significance at 0.05 and 0.01 probability levels, respectively.

ns Indicate nonsignificance.

TABLE 8. CORRELATION COEFFICIENTS BETWEEN EIGHT TRAITS OF THE SELECTED PARENTS FOR EARLINESS FROM THE POPULATION, MICHIGAN SYNTHETIC #9, YEAR 1989.

	FDP	LDP	FDS	LDS	PH	EH	HW	DW
FDP	-	0.842**	0.770**	0.676**	0.309**	0.441**	0.002ns	-0.123ns
LDP		-	0.696**	0.639**	0.259**	0.414**	-0.023ns	-0.111ns
FDS			-	0.777**	0.185**	0.363**	0.119ns	-0.059ns
LDS				-	0.081ns	0.236**	0.107ns	-0.110ns
PH					-	0.599**	0.246**	0.289**
EH						-	0.211**	0.145ns
HW							-	0.789**
DW								-

*,** Indicate significance at 0.05 and 0.01 probability levels, respectively.

ns Indicate nonsignificance.

FDP - first day pollen
LDP - last day pollen
FDS - first day silk
LDS - last day silk

PH - plant height
EH - ear height
HW - harvest weight
DW - dry weight

TABLE 9. CORRELATION COEFFICIENTS BETWEEN EIGHT TRAITS OF THE SELECTEED PARENTS FOR HIGH YIELD FROM THE ORIGINAL POPULATION, MICHIGAN SYNTHETIC #9, YEAR 1989.

	FDP	LDP	FDS	LDS	PH	EH	HW	DW
FDP	-	0.930**	0.901**	0.837**	0.363**	0.472**	-0.029ns	-0.273**
LDP		-	0.918**	0.922**	0.285**	0.379**	-0.026ns	-0.279**
FDS			-	0.936**	0.258**	0.312**	-0.057ns	-0.308**
LDS				-	0.194**	0.243**	-0.050ns	-0.301**
PH					-	0.655**	0.010ns	0.019ns
EH						-	0.090ns	-0.058ns
HW							-	0.763**
DW								-

*,** Indicate significance at 0.05 and 0.01 probability levels, respectively.

ns Indicate nonsignificance.

FDP - first day pollen
LDP - last day pollen
FDS - first day silk
LDS - last day silk

PH - plant height
EH - ear height
HW - harvest weight
DW - dry weight

DISCUSSION

Mass selection for yield, which consists simply of selection the individual plants with desirable characters based on their phenotypic performance, and propagate those selected plants *en masse* for next cycle. It is the least complex and least expensive procedure for improving corn populations. The effectiveness of mass selection depends on the genetic variability available in the population to be improved and heritability of the trait under selection.

Earlier reports showed that mass selection was a more effective method for improving traits with high heritability than those that have low heritability. It was concluded during the first quarter of this century that mass selection would not result in improving of traits with low heritable. More recent, studies conducted by Gardner (1961), Lonnquist (1966) and Lonnquist et al. (1966) have shown the effectiveness of mass selection for grain yield per se, a trait with obviously low heritability. Data presented by Hallauer and Sears (1969), however, did not show a continous and significant improvement in yield after six and five cycles of mass selection in two corn varieties.

In this thesis, mass selection was used to develop: (1) an early maturing population with reasonably high yield potential and (2) a high yielding population with medium maturity. The results indicate that those selected for yield

(HYS) yielded slightly more and flowered later than those selected for early maturity (ES). Usually early maturing plants produce less biomass and a reduction in grain yield at harvest. Chase (1964) studied the relationship between grain yield and silking date of a group of early hybrid having same grain moisture at harvest. He reported that an increase of approximately 56 pounds of dry grain per acre for each increase of one day in the interval between planting and silking. Another study by Baron (1982) comparing early European and Canadian hybrids reported a small loss in the whole plant yield occurred with a slight advancement in silking date. Troyer (1990) when selecting for earliness found a significant reduction in grain yield, time to flower, kernel moisture, plant and ear height, and silk delay, and increased significantly stalk damage. These reports are in agreement with the results we obtained, with the exception of stalk breakage which was less with ES than HYS selection.

It is recognized that selection for earlier flowering date cause reduction not only in grain yield, but whole plant size as well. Following the initiation of tasseling, the plant virtually ceases the vegetative growth phase. Thus, early induction of flowering results the reduction of leaves number and area, fewer nodes, and shorter plant size. As a result of selecting for earliness, the plant will end up with less photosynthetic capacity and lower grain yield potential. Hunter (1977) addressing the problems of growing corn and

sorghum in areas with short growing seasons suggests that a source (referring to photosynthesizing tissues such as green leaves, husk etc.) limitation exists in the short season regions, and that sink (grain size and filling period) limitation exists in longer season regions. Both Hunter (1977) and Tollenar (1977) agreed that source is often limiting to grain yield in a short season. However, Troyer and Brown (1976) noted in their paper that "earlier flowering increased grain yield among late flowering corns in the short seasons when a longer grain filling period is critical and decreased yield among early flowering corns when larger plant size is more important". They elaborated on this by contrasting relationships of flowering date with plant size and length of grain filling period.

It is clear that in short seasons, the source is a limiting factor, and as a result reduction in grain yield is expected. On the other hand, the grain filling period requires a continues supply of photosynthetic products in order to attain the desired grain yield potential. Gunn and Christensen (1965) observed that late maturing hybrids were characterized by longer grain filling period and larger kernels than their earlier counterparts. Corn genotypes differ in the rate of growth during early stages. Therefore, selecting genotypes that grow faster and bigger, and reach optimum size earlier, and also have longer grain filling period potentiality, would produce high grain yield in the short season. (Troyer et al.,

1972, 1976 and Troyer, 1990).

Plant and ear height are two morphological traits that influence the standibility of maize. Selection for earliness also affect the plant size. Daynard et al., (1977) reported that with earlier silking date, a decrease in plant size is expected. In this study, reduction of both plant and ear height were noted (figures 9, 10, 11 and 12). After one cycle of selection plant height was reduced by 2% in both ES and HYS, while ear height reductions were 5.7% and 7.8% for HYS and ES, respectively. This type of reduction in plant size may not be advantages where Raccoons damage the crop.

Stalk lodging is another trait that is closely related to plant and ear height. With selection for early maturity (ES) a significant positive association was recorded for stalk lodging with both plant and ear height. Selection for high yield (HYS) showed that stalk lodging was nonsignificant but positively associated with plant height, while it was significant and positively associated with ear height.

Grain moisture content is another measure for monitoring grain maturity. It is an accurate estimate when comparing maturity of different genotypes under various conditions. In this study, early flowering genotypes in ES populations showed less moisture content in the grain (25.8 vs 27.03%) than genotypes in HYS populations. Beil (1975) reported that the advancement of silking date of corn should allow kernels to fill to their maximum, while effectively lowering final

percent kernel moisture in short season climate. Moisture content in the grain had a significant positive association with flowering dates in both ES and HYS populations.

In general, the interrelationships of all traits evaluated in both preliminary trials (tables 5 and 6) show there is considerable variation in the coefficients among traits. There was a significantly negative correlation between grain yield and plant stand, pollen shed and silking date respectively. Grain moisture content and grain yield were negatively correlated in HYS populations, while that correlation was not significant in ES populations. Stalk lodging showed the opposite effect to that of grain moisture. Plant and ear height showed positive and significant association with grain yield in both trials.

As already indicated in earlier reports, selection for earliness reduces the grain yield potential. Modified mass selection proposed by Gardner (1961) increased the grain yield of Hays Golden, due presumably to additive genetic variance. Unfortunately, it is impossible to completely reconstruct the previous breeding and selection history of Michigan Synthetic #9. However, the relative plant to plant uniformity of the population leads to the postulation that the original materials combined to create the synthetic and subsequent selection had resulted in a high degree of genetic homogeneity. While the population may serve as an excellent source of early maturing inbred lines for use in specfic

hybrid combination, it may not be a population with a sufficiently broad genetic base from which a high yielding synthetic population is likely to be produced.

SUMMARY AND CONCLUSION

The selection response of Michigan Synthetic #9 to one cycle of mass selection for early maturity (ES) and high yielding populations (HYS) were evaluated. Data were recorded for pollen shed, silking date, plant height, ear height, moistutre content in the grain, plant stand, stalk lodging, and grain yield.

Results of analysis showed that mass selection was effective in achieving earliness, but selection of this trait reduced the grain yield potential. This reduction was 5.4% when compared to HYS trial, and it is associated with early flowering that causes an early cessation of the vegetative phase which also affect the whole plant size. In addition, selection practiced on field weight and plant appearance were not good evaluation criteria according to this study. The visual selection of superior appearing plants isolated those with high moisture content but lower total dry matter. Therefore, satisfactory results can only be expected when selection is practiced on actual dry weight.

Using germplasm with diverse genetic base, Troyer and Brown (1976) reported that early flowering increases grain yield among late flowering corns in a short season when a longer grain filling period is required. It decreased grain yield among early genotypes when a larger plant size is important.

Comparison between the ES ans HYS populations used in this study, the HYS population on average flowered one day later and was slightly higher yielding than ES population (figure 2). This finding is in an agreement with results of other investigators Troyer and Brown (1976), Troyer (1990), and Chase (1964).

Based on the data, plant and ear heights were reduced to a notable degree after one cycle of selection. Early induction of flowering decreased the whole plant size (Daynard,1977).

In general, the poor response of Michigan Synthetic #9 to mass selection for earliness and yield may have been due to restricted genetic base of the initial population. This selection of parental materials with a narrow genetic base had greatly decreased the chances of finding desirable segregants as defined in this study. Therefore, less genetic variation in the parents may have contributed to small response to mass selection for earliness and grain yield in Michigan Synthetic #9. Studies of genetic variance indicated that additive genetic variance should be available for the trait under selection in open pollinated corn varieties (Robinson et al., 1954, Lindsey et al., 1962). However, in this study it appears that the population may already have reached homogeneity and that further progress would be limited.

The evaluation of the effectiveness of mass selection for grain yield and earliness in Michigan Synthetic #9 had, however, the following limilations:

(1) Only one population, Michigan Synthetic #9 was tested.

(2) Only one cycles of selection was done. The additive genetic variance probably was not sufficient in C_1 to warrant mass selection as a precedure to further increase the frequency of desirable genes for grain yield. More cycles should be developed and compared to obtain conlusive results.

(3) The standard three replication yield did not provide sufficient precision for evaluation of the preliminary yield differences. In this study, both trials had three replicates each, with one of three replicate planted in an isolated field to maintain germplasm. Combining the data of the three replicates in the analysis provided an estimate of significance between genotypes. Increasing the number of replication in the trials would have provided increased precision in the measurement and detection of small difference in the experimental units.

(4) Success can not be expected by starting with materials that have a narrow genetic base. The chances of finding desirable segregants in a material such as Michigan Synthetic #9 will be very low. This narrow genetic base in the parents used to form population may have lead to a reduction in genetic variability especially for quantitative characters. As a result, improvement of the character may be difficult or impossible to acheive. This potential consequences of limited genetic variability will be difficult to overcome without introduction of new materials with broader genetic base.

(5) Parental control. In a stratified mass selection procedure, selection is practiced on the female parent. The superiority of selected parents is presumbly due to an increase in the frequencies of favorable yield influencing genes in the population. Generally, selection which increase the frequencies of favorable genes in the selected plants should enhance the chances of extracting genetically superior lines from population. However, this depends to great extent on the additive gene action which involves yield selected plants.

In the use of the equation for predicting genetic gain through selection, the value of parental control (c) should be one half when selected female plants are pollinated by random pollen which comes from both selected and unselected male plants in the population. Such a procedure will affect the gain from selection because the amount of recoverable additive genetic variance is influenced by parental control. Thus selecting fewer parents in the initial population will narrow the genetic variance of the population to be improved. As a result inbreeding will occur.

For instance, mass selection can be practiced to develop maize populations which may be useful in solving a bird damage problems in a sorghum growing areas of Somalia. To breed such a population certain criteria must be accomplished, such as tight husk cover, drought tolerance/resistance and finally reasonable grain yield potential.

Selection of a population source with wide genetic variability is the key factor in a base population, to find segregants of the desirable alleles for the trait of interest. In addition, consideration must be given to the heritability of the trait under selection in order to achieve the effectiveness of mass selection. Selecting useful alleles for all the desirable characteristics will increase the chances of creating high yielding genetic combination. As a consequence the plant breeder can point to an achievement of the stated goal, i.e. high yield capacity.

APPENDIX

The tables of the first year data

Table 1a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #1.

Variables	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	73.4	2.78	0.62
Pollen shed II	77.6	2.11	0.47
Silking date I	74.7	2.66	0.59
Silking date II	79.4	1.88	0.42
Plant height	165.6	21.32	4.77
Ear height	82.0	14.92	3.34
Field weight	208.5	39.91	8.92
Dry weight	157.3	24.31	5.44
Single cross			
Silking date I	78.6	0.89	0.40
Silking date II	85.2	1.48	0.66
Field weight	279.8	15.61	6.98
Dry weight	221.2	13.52	6.05

Table 2a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #2.

Variables	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	70.6	3.63	0.81
Pollen shed II	74.6	3.71	0.83
Silking date I	72.1	3.72	0.83
Silking date II	76.7	3.57	0.80
Plant height	182.1	15.37	3.44
Ear height	93.5	13.42	3.00
Field weight	211.5	34.58	7.73
Dry weight	159.8	27.71	6.20
Single cross			
Silking date I	77.3	1.53	0.88
Silking date II	84.0	1.73	1.00
Field weight	286.0	51.10	29.50
Dry weight	229.0	31.32	18.08

Table 3a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #3.

Variables	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	69.4	3.65	0.82
Pollen shed II	73.9	3.90	0.87
Silking date I	71.0	3.80	0.85
Silking date II	74.9	3.49	0.78
Plant height	187.7	15.23	3.41
Ear height	95.6	14.47	3.24
Field weight	220.2	39.62	8.86
Dry weight	168.0	25.58	5.72
Single cross			
Silking date I	74.2	1.10	0.49
Silking date II	82.0	1.00	0.45
Field weight	319.4	39.89	17.84
Dry weight	258.0	39.10	17.48

Table 4a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #4.

Variables	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	69.6	3.14	0.70
Pollen shed II	73.3	4.09	0.91
Silking date I	71.5	3.75	0.84
Silking date II	76.3	3.64	0.82
Plant height	176.6	19.98	4.47
Ear height	91.3	22.90	5.12
Field weight	227.4	34.02	7.61
Dry weight	168.9	19.77	4.42
Single cross			
Silking date I	78.0	1.41	0.63
Silking date II	84.8	2.05	0.92
Field weight	265.2	37.49	16.77
Dry weight	201.0	22.33	9.99

Table 5a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #5.

Variables	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	67.2	2.99	0.67
Pollen shed II	71.3	3.11	0.70
Silking date I	68.6	3.59	0.80
Silking date II	73.0	3.43	0.77
Plant height	170.7	16.57	3.70
Ear height	87.5	12.45	2.78
Field weight	203.3	41.69	9.32
Dry weight	157.1	29.21	6.53
Single cross			
Silking date I	75.6	1.82	0.81
Silking date II	82.6	0.89	0.40
Field weight	315.8	22.94	10.26
Dry weight	251.6	21.86	9.78

Table 6a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #6.

Variables	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	69.3	3.51	0.81
Pollen shed II	73.4	3.42	0.78
Silking date I	71.3	3.96	0.91
Silking date II	75.3	3.90	0.90
Plant height	173.2	14.45	3.32
Ear height	87.8	12.70	2.91
Field weight	216.4	32.31	7.41
Dry weight	164.8	20.07	4.60
Single cross			
Silking date I	76.2	0.84	0.37
Silking date II	82.8	0.45	0.20
Field weight	303.2	31.29	13.99
Dry weight	241.0	23.16	10.36

Table 7a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #7.

Variables	Mean	Standard Deviation	Standard Error	
<u>Michigan Synthetic #9</u>				
Pollen shed I	67.7	7.01	2.65	0.61
Pollen shed II	72.0	12.11	3.48	0.80
Silking date I	70.3	13.45	3.67	0.84
Silking date II	73.9	16.28	4.03	0.93
Plant height	171.4	409.58	20.24	4.64
Ear height	86.4	262.15	16.19	3.71
Field weight	184.2	1802.51	42.46	9.74
Dry weight	155.2	1044.73	32.32	7.42
<u>Single cross</u>				
Silking date I	75.8	0.70	0.84	0.37
Silking date II	82.4	0.30	0.55	0.25
Field weight	293.4	1732.30	41.62	18.61
Dry weight	237.6	1114.80	33.39	14.93

Table 8a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #8.

Variables	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	66.9	2.79	0.64
Pollen shed II	71.4	3.25	0.75
Silking date I	68.8	3.82	0.88
Silking date II	73.4	3.53	0.81
Plant height	169.0	19.37	4.44
Ear height	82.5	12.10	2.78
Field weight	192.6	49.14	11.27
Dry weight	161.6	37.92	8.70
Single cross			
Silking date I	74.8	1.48	0.66
Silking date II	81.8	0.84	0.37
Field weight	334.0	22.44	10.04
Dry weight	265.6	24.51	10.96

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Table 9a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #9.

Variables	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	68.2	2.41	0.55
Pollen shed II	72.1	2.64	0.60
Silking date I	69.5	2.55	0.58
Silking date II	74.0	2.77	0.64
Plant height	181.5	15.23	3.49
Ear height	90.2	12.79	2.93
Field weight	209.3	35.18	8.07
Dry weight	174.4	27.60	6.33
Single cross			
Silking date I	75.4	1.52	0.68
Silking date II	82.4	1.52	0.68
Field weight	321.0	30.44	13.61
Dry weight	259.8	22.02	9.85

Table 10a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #10

Variables	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	67.5	2.01	0.46
Pollen shed II	71.9	2.53	0.58
Silking date I	69.3	3.16	0.73
Silking date II	73.6	2.91	0.67
Plant height	187.9	13.07	3.00
Ear height	94.8	10.86	2.49
Field weight	215.0	40.65	9.33
Dry weight	177.5	28.64	6.57
<u>Single cross</u>			
Silking date I	75.6	1.67	0.75
Silking date II	81.6	1.14	0.51
Field weight	312.2	43.72	19.55
Dry weight	244.8	36.15	16.17

Table 11a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #11.

Variables	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	68.8	3.30	0.74
Pollen shed II	73.0	3.22	0.72
Silking date I	70.1	3.42	0.77
Silking date II	74.4	3.33	0.74
Plant height	196.8	17.07	3.82
Ear height	99.1	10.85	2.43
Field weight	223.6	32.17	7.19
Dry weight	183.2	21.67	4.85
<u>Single cross</u>			
Silking date I	76.8	1.92	0.86
Silking date II	82.2	2.17	0.97
Field weight	246.2	25.23	11.29
Dry weight	196.0	19.39	8.67

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Table 12a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #12.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	75.3	3.10	0.69
Pollen shed II	79.4	2.78	0.62
Silking date I	76.6	2.91	0.65
Silking date II	81.1	2.87	0.64
Plant height	190.5	16.51	3.69
Ear height	91.8	14.75	3.30
Field weight	195.5	43.04	9.62
Dry weight	154.3	35.61	7.96
Single cross			
Silking date I	80.2	2.17	0.97
Silking date II	86.4	2.61	1.17
Field weight	274.6	26.47	11.84
Dry weight	204.0	29.31	13.11

Table 13a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #13.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	75.0	2.60	0.58
Pollen shed II	78.7	2.08	0.47
Silking date I	76.0	2.59	0.58
Silking date II	80.1	2.09	0.47
Plant height	184.8	19.42	4.34
Ear height	91.4	17.14	3.83
Field weight	184.2	48.43	10.83
Dry weight	155.3	37.98	8.49
<u>Single cross</u>			
Silking date I	79.6	0.89	0.40
Silking date II	86.2	2.17	0.97
Field weight	259.8	42.99	19.23
Dry weight	192.8	36.21	16.19

Table 14a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #14.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	70.8	3.17	0.71
Pollen shed II	75.5	2.65	0.59
Silking date I	73.4	3.03	0.68
Silking date II	77.6	2.98	0.67
Plant height	190.2	19.60	4.38
Ear height	97.4	18.92	4.23
Field weight	195.8	32.67	7.31
Dry weight	164.1	24.50	5.48
Single cross			
Silking date I	76.4	2.88	1.29
Silking date II	83.0	3.54	1.58
Field weight	271.6	67.13	30.02
Dry weight	208.2	57.38	25.66

Table 15a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #15.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	70.4	2.52	0.56
Pollen shed II	74.5	2.61	0.58
Silking date I	72.2	2.78	0.61
Silking date II	76.5	2.86	0.64
Plant height	191.7	14.14	3.16
Ear height	97.9	12.17	2.72
Field weight	185.4	30.36	6.79
Dry weight	160.8	25.65	5.74
<u>Single cross</u>			
Silking date I	75.2	1.64	0.74
Silking date II	81.6	1.14	0.51
Field weight	312.2	39.09	17.48
Dry weight	248.4	33.84	15.14

Table
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Pollen

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Table 16a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #16.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	68.5	2.20	0.50
Pollen shed II	72.9	2.37	0.54
Silking date I	71.0	2.69	0.62
Silking date II	75.2	2.89	0.66
Plant height	181.5	16.06	3.68
Ear height	90.8	12.24	2.81
Field weight	206.5	43.81	10.05
Dry weight	176.9	34.21	7.85
Single cross			
Silking date I	74.8	1.10	0.49
Silking date II	82.0	1.41	0.63
Field weight	348.8	30.24	13.53
Dry weight	284.0	24.34	10.89

Table
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Silkin
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Field
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Table 17a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #17.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	69.1	2.83	0.63
Pollen shed II	73.6	2.72	0.61
Silking date I	71.0	3.43	0.77
Silking date II	75.4	3.73	0.83
Plant height	178.1	14.76	3.30
Ear height	87.5	10.14	2.27
Field weight	194.5	39.92	8.93
Dry weight	164.9	29.53	6.60
<u>Single cross</u>			
Silking date I	73.4	0.55	0.25
Silking date II	80.4	0.55	0.25
Field weight	285.4	34.13	15.26
Dry weight	228.6	27.64	12.36

Table 1
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Table 18a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #18.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	67.8	2.10	0.47
Pollen shed II	71.7	2.85	0.64
Silking date I	70.3	2.54	0.57
Silking date II	74.3	2.85	0.64
Plant height	173.3	15.08	3.37
Ear height	86.7	9.58	2.14
Field weight	184.9	37.83	8.46
Dry weight	155.9	27.31	6.11
<u>Single cross</u>			
Silking date I	74.0	1.00	0.45
Silking date II	80.4	1.34	0.60
Field weight	344.0	25.67	11.48
Dry weight	277.4	24.08	10.77

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Dry w
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Silki
Silki
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Table 19a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #19a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	68.8	2.33	0.52
Pollen shed II	73.0	2.92	0.65
Silking date I	71.1	2.95	0.66
Silking date II	75.2	2.76	0.62
Plant height	175.4	17.46	3.90
Ear height	87.9	10.40	2.33
Field weight	188.4	43.88	9.81
Dry weight	156.7	36.94	8.26
Single cross			
Silking date I	75.8	2.17	0.97
Silking date II	82.8	1.48	0.66
Field weight	308.2	24.91	11.14
Dry weight	244.4	28.18	12.60

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Table 20a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #20a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	69.6	2.43	0.56
Pollen shed II	73.4	2.78	0.64
Silking date I	71.6	2.89	0.66
Silking date II	75.5	3.24	0.74
Plant height	189.0	8.92	2.05
Ear height	95.4	13.13	3.01
Field weight	192.3	28.93	6.64
Dry weight	163.3	22.22	5.10
<u>Single cross</u>			
Silking date I	75.4	2.61	1.17
Silking date II	82.6	3.13	1.40
Field weight	295.0	44.97	20.11
Dry weight	226.6	32.65	14.60

Table 21a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #21a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	70.1	1.96	0.45
Pollen shed II	74.6	2.78	0.64
Silking date I	72.2	2.93	0.67
Silking date II	76.6	3.44	0.79
Plant height	186.3	15.16	3.48
Ear height	95.3	12.53	2.88
Field weight	200.1	41.90	9.61
Dry weight	167.4	35.02	8.03
Single cross			
Silking date I	75.0	0.71	0.32
Silking date II	81.2	1.10	0.49
Field weight	329.4	28.66	12.82
Dry weight	254.6	33.15	14.82

Table 22a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #22a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	71.3	3.21	0.72
Pollen shed II	75.8	3.19	0.71
Silking date I	72.9	3.46	0.77
Silking date II	77.8	3.00	0.67
Plant height	185.4	14.25	3.19
Ear height	97.1	12.74	2.85
Field weight	173.5	55.11	12.32
Dry weight	143.8	45.38	10.15
<u>Single cross</u>			
Silking date I	76.4	1.34	0.60
Silking date II	82.2	1.10	0.49
Field weight	288.3	57.26	28.63
Dry weight	232.5	53.88	26.94

Table 23a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #23a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	71.8	2.51	0.56
Pollen shed II	76.5	2.69	0.60
Silking date I	73.5	2.48	0.56
Silking date II	78.4	2.98	0.67
Plant height	188.8	13.81	3.09
Ear height	95.6	13.04	2.92
Field weight	192.1	36.88	8.25
Dry weight	163.0	28.29	6.49
Single cross			
Silking date I	77.6	1.34	0.60
Silking date II	83.0	2.55	1.14
Field weight	229.0	47.33	21.17
Dry weight	180.8	36.34	16.25

Table 24a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #24a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	75.7	1.84	0.41
Pollen shed II	79.1	1.10	0.25
Silking date I	77.5	1.54	0.34
Silking date II	81.3	1.48	0.33
Plant height	193.7	11.55	2.58
Ear height	93.3	10.32	2.31
Field weight	182.0	46.69	10.44
Dry weight	150.0	35.62	7.97
<u>Single cross</u>			
Silking date I	79.4	0.50	0.25
Silking date II	86.6	2.30	1.03
Field weight	269.8	42.23	18.89
Dry weight	194.0	25.89	11.58

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Silki

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Field

Dry w

Sing

Silk

Silk

Fiel

Dry

Table 25a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #25a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	75.1	3.36	0.77
Pollen shed II	78.9	2.38	0.55
Silking date I	77.3	2.75	0.63
Silking date II	81.6	3.45	0.79
Plant height	187.2	19.45	4.46
Ear height	96.1	13.78	3.16
Field weight	162.3	41.99	9.63
Dry weight	134.4	34.75	7.97
Single cross			
Silking date I	79.0	0.82	0.41
Silking date II	85.3	2.06	1.03
Field weight	208.3	38.11	19.05
Dry weight	153.0	31.21	15.60

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Table 26a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #26a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	72.8	2.75	0.65
Pollen shed II	76.9	2.45	0.58
Silking date I	74.5	2.36	0.56
Silking date II	78.5	1.65	0.39
Plant height	192.7	11.19	2.64
Ear height	97.9	10.22	2.41
Field weight	162.9	52.85	12.46
Dry weight	134.0	42.24	9.96
<u>Single cross</u>			
Silking date I	78.8	0.45	0.20
Silking date II	85.0	1.41	0.63
Field weight	258.8	18.02	8.06
Dry weight	198.4	9.34	4.18

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Table 27a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #27a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	72.2	2.97	0.68
Pollen shed II	76.9	2.42	0.55
Silking date I	75.1	2.74	0.63
Silking date II	78.9	2.51	0.58
Plant height	178.5	21.63	4.96
Ear height	91.6	17.99	4.13
Field weight	156.8	38.95	8.94
Dry weight	129.7	32.95	7.56
<u>Single cross</u>			
Silking date I	76.0	0.71	0.32
Silking date II	81.4	1.14	0.51
Field weight	251.0	22.52	11.26
Dry weight	191.5	14.11	7.05

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Table 28a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #28a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	72.2	2.93	0.67
Pollen shed II	76.3	3.00	0.69
Silking date I	74.7	3.09	0.71
Silking date II	79.2	2.89	0.66
Plant height	185.6	14.90	3.42
Ear height	97.8	9.21	2.11
Field weight	151.3	40.82	9.36
Dry weight	125.9	31.73	7.28
Single cross			
Silking date I	77.6	1.52	0.68
Silking date II	83.6	1.34	0.60
Field weight	249.8	36.86	16.49
Dry weight	192.8	24.83	11.11

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Table 29a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #29a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	70.6	1.91	0.43
Pollen shed II	75.9	2.21	0.49
Silking date I	74.6	3.15	0.71
Silking date II	79.4	3.90	0.87
Plant height	182.0	13.34	2.98
Ear height	91.0	12.68	2.84
Field weight	152.0	36.58	8.18
Dry weight	131.2	32.93	7.36
Single cross			
Silking date I	78.2	1.10	0.49
Silking date II	83.8	1.64	0.74
Field weight	256.0	48.97	21.90
Dry weight	206.8	31.21	15.61

Table 30a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #30a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	71.2	2.91	0.67
Pollen shed II	75.3	3.35	0.77
Silking date I	73.5	3.03	0.69
Silking date II	77.7	2.83	0.65
Plant height	191.5	19.95	4.58
Ear height	104.2	26.04	5.97
Field weight	179.3	47.47	10.89
Dry weight	148.4	32.97	7.56
Single cross			
Silking date I	76.5		
Silking date II	83.5		
Field weight	272.0		
Dry weight	211.5		

Table 31a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #31a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	70.0	2.92	0.65
Pollen shed II	74.6	3.02	0.68
Silking date I	72.3	3.28	0.73
Silking date II	76.7	3.15	0.70
Plant height	189.0	17.25	3.86
Ear height	94.1	17.81	3.98
Field weight	209.1	43.59	9.75
Dry weight	171.2	29.01	6.49
Single cross			
Silking date I	76.0	2.65	1.53
Silking date II	83.0	1.00	0.53
Field weight	305.7	33.01	19.06
Dry weight	260.0		

Table 32a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #32a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	71.2	2.91	0.67
Pollen shed II	75.3	2.96	0.68
Silking date I	73.5	3.20	0.74
Silking date II	77.8	3.33	0.76
Plant height	188.2	11.87	2.72
Ear height	95.9	12.26	2.81
Field weight	188.2	33.91	7.78
Dry weight	158.0	27.03	6.20
<u>Single cross</u>			
Silking date I	77.5	1.73	0.87
Silking date II	84.5	1.73	0.87
Field weight	281.0	35.17	17.58
Dry weight	218.5	30.53	15.27

Table 33a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #33a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	70.3	2.49	0.56
Pollen shed II	75.2	3.05	0.68
Silking date I	73.6	2.91	0.65
Silking date II	78.0	2.87	0.64
Plant height	187.8	8.60	1.92
Ear height	88.9	10.76	2.41
Field weight	180.2	27.95	6.25
Dry weight	153.3	23.61	5.28
Single cross			
Silking date I	78.4	0.89	0.40
Silking date II	85.2	2.49	1.11
Field weight	266.8	27.23	12.18
Dry weight	205.8	22.22	9.94

Table 34a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #34a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	71.4	3.20	0.72
Pollen shed II	76.1	2.96	0.66
Silking date I	74.0	3.23	0.72
Silking date II	78.8	3.68	0.82
Plant height	186.1	13.89	3.11
Ear height	94.4	12.49	2.79
Field weight	174.5	29.64	6.63
Dry weight	146.0	22.13	4.95
Single cross			
Silking date I	76.0	1.23	0.55
Silking date II	82.6	1.34	0.60
Field weight	286.4	24.58	10.99
Dry weight	230.8	11.21	5.01

Table 35a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #35a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	74.3	3.29	0.74
Pollen shed II	78.5	2.59	0.58
Silking date I	76.4	3.28	0.73
Silking date II	80.8	3.14	0.70
Plant height	186.3	14.01	3.13
Ear height	130.5	14.49	3.24
Field weight	187.8	44.61	9.98
Dry weight	147.9	31.05	6.94
<u>Single cross</u>			
Silking date I	77.8	0.84	0.37
Silking date II	83.4	1.52	0.68
Field weight	261.2	19.64	8.78
Dry weight	202.2	14.82	6.63

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Table 36a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #36a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	75.9	2.23	0.50
Pollen shed II	79.5	1.82	0.41
Silking date I	77.1	1.86	0.42
Silking date II	81.5	1.67	0.37
Plant height	193.2	11.16	2.50
Ear height	99.9	14.88	3.33
Field weight	165.7	29.55	6.61
Dry weight	138.6	19.68	4.40
Single cross			
Silking date I	78.4	2.19	0.98
Silking date II	84.8	3.35	1.50
Field weight	280.2	27.37	12.24
Dry weight	212.0	19.12	8.55

Table 37a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #37a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	75.0	2.58	0.58
Pollen shed II	79.1	1.37	0.31
Silking date I	77.5	2.72	0.61
Silking date II	81.6	2.68	0.60
Plant height	193.4	21.67	4.85
Ear height	101.1	17.43	3.90
Field weight	145.0	63.46	14.19
Dry weight	112.2	47.80	10.69
<u>Single cross</u>			
Silking date I	78.8	0.45	0.20
Silking date II	85.0	1.23	0.55
Field weight	265.4	35.09	15.69
Dry weight	203.6	24.17	10.81

Table 38a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #38a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	73.9	3.64	0.81
Pollen shed II	78.4	2.89	0.65
Silking date I	76.7	3.42	0.77
Silking date II	81.3	2.92	0.65
Plant height	182.6	20.42	4.57
Ear height	93.3	15.19	3.40
Field weight	166.3	48.52	10.85
Dry weight	129.9	37.76	8.44
<u>Single cross</u>			
Silking date I	78.0	2.00	0.89
Silking date II	82.8	2.05	0.92
Field weight	242.2	15.09	6.75
Dry weight	186.8	12.13	5.43

Table 39a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #39a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	72.9	3.08	0.69
Pollen shed II	77.0	2.93	0.66
Silking date I	75.2	3.02	0.68
Silking date II	79.6	2.01	0.45
Plant height	192.8	19.36	4.33
Ear height	102.8	16.71	3.74
Field weight	188.0	30.07	6.72
Dry weight	145.6	21.57	4.82
Single cross			
Silking date I	77.4	2.07	0.93
Silking date II	82.6	1.52	0.68
Field weight	275.4	17.87	7.99
Dry weight	218.2	19.79	8.85

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Table 40a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #40a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	71.1	2.37	0.53
Pollen shed II	75.4	2.46	0.55
Silking date I	73.4	2.74	0.61
Silking date II	78.4	2.83	0.63
Plant height	188.9	13.36	2.99
Ear height	94.4	16.77	3.75
Field weight	187.6	36.09	8.07
Dry weight	159.3	28.32	6.33
Single cross			
Silking date I	77.8	1.10	0.49
Silking date II	83.4	0.89	0.40
Field weight	289.0	41.00	20.50
Dry weight	225.5	42.85	21.43

Table 41a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #41a.

Variable	Mean	Standard Deviation	Standard Error
Michigan Synthetic #9			
Pollen shed I	70.4	3.57	0.80
Pollen shed II	74.6	3.05	0.68
Silking date I	72.4	3.23	0.72
Silking date II	77.2	3.25	0.73
Plant height	184.9	14.74	3.38
Ear height	93.7	14.61	3.35
Field weight	200.4	33.96	7.59
Dry weight	169.5	25.77	5.76
Single cross			
Silking date I	76.4	1.14	0.51
Silking date II	83.0	0.71	0.32
Field weight	317.6	28.40	12.70
Dry weight	244.6	21.51	9.62

V

M

Po

Po

Si

Si

P

E

F

D

S

S

S

I

I

Table 42a: Presents the mean, standard deviation and error of eight characters measured in Michigan Synthetic #9 and four characters measured in the single cross as control in 1989 for plot #42a.

Variable	Mean	Standard Deviation	Standard Error
<u>Michigan Synthetic #9</u>			
Pollen shed I	70.5	3.55	0.79
Pollen shed II	75.4	3.68	0.82
Silking date I	73.5	4.25	0.95
Silking date II	77.7	4.55	1.02
Plant height	177.1	20.59	4.60
Ear height	89.8	17.67	3.95
Field weight	188.9	42.66	9.54
Dry weight	155.2	34.15	7.64
<u>Single cross</u>			
Silking date I	76.2	1.48	0.66
Silking date II	82.6	0.89	0.40
Field weight	302.8	24.79	11.09
Dry weight	241.6	20.38	9.11

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