INDICATORS OF STRESS IN PARTICULAR CORN (*Zea mays* L.) GENOTYPES UNDER FIELD CONDITIONS

by

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B. Sc. (Agric.) Kansas State University, 1978

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1980

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ACKNOWLEDGEMENTS

The Author would like to express his thanks and great appreciation to:

(i) The Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and the Ministry of Agriculture, Government of Tanzania for the financial support throughout his study,

(ii) Professors Ed Kanemasu and Clyde Wassom for their inspiration, guidance and advice during the study,

(iii) ET (Evapotranspiration) Lab staff, students, and workers whose help in many ways made his study and preparation of this thesis possible.

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CHAPTER I

INTRODUCTION

Introduction

Corn (Zea mays L.), also correctly referred to as maize in other lands, is often grown in areas which are subject to such environmental stresses as heat and drought that can substantially reduce yields. Yet, due to its long known culture, divergent genotypes, and a psychological feeling about its yield potential, corn is and will probably continue to be grown in areas with less than ideal environmental conditions. This is particularly so in the developing countries where corn forms the basic part of the human diet.

Promisingly enough, there seems to be a considerable variability in the way certain corn genotypes respond and perform under stress conditions. For instance, certain corn genotypes are relatively stable in overall performance, and consequently, yield better than other genotypes under moisture and heat stress. Such genotypes, if they can be identified and incorporated into improved materials, may make great contribution toward increasing corn grain production to meet the ever-increasing food and feed demand. Thus, a practical procedure of identifying such corn genotypes from corn populations will be a valuable tool to corn breeders and growers as well.

The study reported here was initiated to:

(1) compare leaf water potential, leaf temperature and stomatal diffusive resistance among particular corn genotypes under soil moisture stress and well-watered conditions;

(2) to observe ear filling rates among the corn genotypes;

(3) to assess the possibility of utilizing leaf water potential, stomatal diffusive resistance and leaf temperature as useful indicators in selecting drought resistant corn genotypes under field conditions.

Literature Review

The literature on drought and heat stress is replete with reports from a variety of researchers. For example, Russell (1959) reviewed the reports on soil-plant water relations and concluded that a better understanding of plant-water deficits and their influence on growth, development, and yield is very essential for successful crop production both on dry land and irrigated areas. Hyne and Bruson (1940), studying heat and drought tolerance in corn, observed in many instances that corn hybrids have shown less effect under adverse drought and heat stress than their respective inbred lines. They also pointed out that drought resistance in corn is a complex character influenced by many genes.

Usually, plant growth is controlled directly by plant-water deficits and indirectly by soil-water deficits. The plant-water deficit that develops in any particular situation is a result of complex and interrelated combination of soil, plant, and atmospheric factors which interact to influence the rate of water absorption, water use and water movements in plants (Begg et al., 1976). Generally, water stress in plants would be more evident under drought; drought being a period when water deficiency either acute or chronic is very likely to adversely affect plant's growth and development (Frankel, 1971). Although the term stress is more specifically used in physics than in biological sciences, plant physiologists use the term stress in a broad sense to refer to any environmental factor capable of inducing a potential injurious strain in a living organism (Levitt, 1972). Samson et al. (1978) pointed out that drought resistance in crop plants can be expressed as:

(1) avoidance of plant tissue to water deficit by having efficient water uptake or reduced water loss;

(2) tolerance for tissue water deficit without permanent tissue damage; and

(3) ability to maintain adequate internal water during drought stress.

In this context, therefore, drought tolerance would refer to the extent to which plant function is maintained during water deficit.

In order to be able to evaluate different cultivars for drought and heat tolerance or resistance, one needs to observe and interpret the plant's response to heat and drought stress. A practical procedure of measuring and quantifying such indicators of stress would be extremely beneficial in evaluating and screening plant genetic materials.

Several workers (Sullivan, 1971; Levitt, 1973; and Kozlowski, 1976) have indicated that measuring drought stress is complex because of the complexity of many factors involved, including biochemical and physio-chemical processes of the plant.

Kramer (1969) suggested that, depending on the degree of plant water deficit and its duration, one could distinguish between incipient, temporary and permanent wilting. However, this is purely descriptive and does not quantify the stress.

Clark and Hiler (1973) suggested that knowledge of the symptoms both displayed externally and those which can be determined quantitatively by simple practical procedure will be valuable for effective and efficient water use and management. They also emphasized that a combination of both soil and plant-water status will be a better indicator of stress than either one taken singly. The water status in the plant reflects an integrated effect of the atmospheric demand, soil water potential and the plant rooting characteristics. Boyer (1969, 1970a) indicated that low leaf-water potential induces stomatal closure in light, resulting in increased canopy temperature, elevating above air temperature. Therefore, leaf-water potential, stomatal diffusive resistance and leaf-canopy temperature can be viewed as possible signals of drought and heat stress.

Hurd (1971) suggested that parameters of drought stress, such as water potential of plant-tissue, photosynthetic rates, and yield tests could be employed in breeding for drought resistance. Sanchez-Diaz and Kramer (1971) also stated that plant-tissue water potential could play an increasing role in screening for drought resistance. Williams et al. (1967) indicated that the ultimate test of drought is a yield comparison conducted under typical drought conditions. Under natural conditions, however, one might not have the drought conditions at the time when best desired. With no control over timing, intensity, or duration of drought, results from yield comparisons are likely to be inconsistent from test to test and from year to year. They argued that, yield comparison as a screening technique would be useful in eliminating poor yielding cultivars, thereby permitting large numbers of promising lines to be grown in the yield tests.

Larson (1971) pointed out that certain plant cultivars may resist drought stress due to their ability to maintain a high internal-water content, which would usually be reflected as high water potential (more positive). The cultivars that show low internal water content may also survive drought stress. This is believed to be due to certain protoplasmic properties that can tolerate low-internal water content. Larson (1971) referred to this kind of resistance as tolerance or hardiness, and such tolerant genotypes exhibit the ability to recover and grow when soil moisture is replenished. Begg (1973) pointed out that leaf-water potential in corn varied over considerable range throughout the day; and this was in response with the declining soil moisture. At low soil moisture, the leaf-water potential declined to more negative values.

As a result of reduced leaf-water potential beyond a certain threshold, increased leaf diffusive resistance results (Begg and Turner, 1976). Sanchez-Diaz and Kramer (1971) also mentioned that when the rate of water uptake is less than that transpired, an internal water deficit occurs, resulting into loss of turgor in the guard cells, causing the stomata to close. Since changes in turgor relations of the guard cells influence stomatal movement, stomatal conductance may also be considered as a good indicator of leaf-water status (Turner, 1973). Studies by Neumann et al., (1973), Turner and Begg (1975), relating stomatal resistance and leaf-water potential of field crops like corn, sorghum, sunflower, and tobacco, pointed out that there is no unique value of leaf-water potentials for stomatal closure. However, Turner (1974b) indicated that leaf-water potential for stomatal closure varies with the position of the leaf, crop cultivar and environmental factors like air and leaf canopy temperature, relative humidity, wind, carbon dioxide concentration, and growth conditions such as cycles of stress, severity and duration. Henzell et al. (1975) compared the stomatal response to soil moisture depletion in 23 sorghum genotypes and reported a marked diversity in response. Blum (1974) also observed variation in stomatal conductance in 14 sorghum genotypes grown under field conditions when the soil and leaf water deficits developed. Turner (1974) stated that there is a range of high leaf-water potential over which potential has little influence on stomatal resistance. Kanemasu and Tanner (1968) have suggested that there is effectively an on-off response in which stomata close almost completely once a critical potential is reached.

Burrows and Milthorpe (1976) also agree with the suggestion of an on-off system in response to water deficits. Turner and Begg (1973) concluded that the critical leaf-water potential for corn was around -17 bars. They also pointed out that the stomata on the adaxial epidermis may close at a higher leaf-water potential than the abaxial epidermis. It suffices to generalize that most of the reports in the literature tend to reveal that as drought predominates, there is an increased stomatal resistance in response to a decline in leaf-water potential and this will consequently result into increased plant temperature.

Gates (1964) stated that the energy load of the leaf is dissipated by three major mechanisms namely reradiation, sensible heat, and latent heat transfer. When one considers the amount of latent heat required to evaporate one gram of water, it becomes evident that transpiration plays an inportant role in heat dissipation in plants. Gates (1968) showed that the flow of sensible heat is either toward or away from vegetative surface depending on whether the surface is cooler or warmer than air. With the recent development of advanced infrared thermometry, leaf-canopy temperature can be remotely measured under field conditions. The emitted thermal radiation from all plant surfaces in the field-of-view gives an integrated temperature measurement which is an important indicator of the plant response to the environmental factors such as solar radiation, air temperature, air movements and water availability (Gates, 1964). Turner (1963) also indicated that plant temperature is useful in relating plant and its surrounding environment; and leaf temperature could also be useful in detecting moisture stress differences among plant genotypes.

CHAPTER I

Chapter 1

Comparisons of Plant Water Status Among Corn (*Zea mays* L.) Hybrids and Their Inbred Parents

Abstract:

Practical means of identifying and quantifying the differential response of corn genotypes to environmental factors, such as heat and drought stress, will be valuable in screening corn genotypes. A study was therefore initiated in which six corn genotypes Mo17 x B73, A619 x A632, including their respective inbred parents Mo17, B73, A619, and A632 were compared relative to their leaf-water potential, stomatal diffusive resistance, and canopy temperatures under irrigated (IRR) and non-irrigated (NON-IRR) conditions. Soil moisture measurements, leaf area, and ear filling rates were also taken. Leaf-water potential and canopy temperature data showed that the hybrids had cooler canopy temperatures and higher leaf-water potentials than the inbreds. The seasonal trends of leaf-water potentials were similar to those of available soil moisture depletion. The stomatal diffusive resistance data did not show a consistent trend for particular corn genotypes. The changes in ear weight were more pronounced on the IRR compared to NON-IRR conditions. The hybrids showed higher ear dry weight accumulation than their inbred parents. This was also maintained in the final yield components, kernel weight and harvested grain yield.

Introduction

Genotypic variation to environmental stress factors like drought and heat stress has been noticed in many field crops (Blum, 1974; Boyer, 1970; Dedio, 1975; Samson et al., 1978). Hyne and Burson (1940) observed that corn hybrids showed less effect under adverse drought and temperature stress than their inbred parents. Since the response of plants to drought and temperature stress involves genotype-environment interactions, one needs to know, identify, and measure the differential response displayed by the plant genotypes so as to be able to distinguish the susceptible genotypes from the resistant or the tolerant ones.

Plant growth and development is influenced by water uptake and supply from the soil, water expenditure by the plant which is largely controlled by the transpirational resistance of the canopy and atmospheric demand. Plant water status will, therefore, depend on soil moisture conditions, the atmospheric water demand, and plant characteristics. As the soil moisture becomes severely depleted without recharge, soil moisture tension increases, resistance of water movement through the rhizosphere increases, and water absorption tends to lag behind transpiration. This will result in reduced leaf-water potential, stomatal conductance, and transpirational cooling which leads to elevated leaf canopy temperature (Boyer 1969, 1970a; Gates 1968). Plants response in terms of leaf-water potential, canopy temperature, and stomatal diffusive resistance can be useful indicators of stress under field conditions.

We conducted a study with the objectives to compare measurable indicators of stress (leaf-water potential, stomatal diffusive resistance, and canopy temperature) among particular corn genotypes.

Materials and Methods

During the summer of 1978, we conducted an experiment in which two corn (*Zea mays* L.) hybrids namely Mo17 x B73 and A619 x A632 and their respective inbred parents,--Mo17, B73, A619 and A632 were planted. These corn materials were planted on 15 May at Ashland Agronomy Research Farm, Evapotranspiration Site (14 km SW of Manhattan) in a split block design with six replications, half of the block receiving irrigation and half without irrigation. The intra- and inter-row plant spacing was approximately 30 cm and 75 cm respectively, with rows 5m in length; thus, the approximate plant population was 44,444 plants per hectare. Full emergence was observed on 25 May and harvesting was done on 5 September. Routine observations such as development stages, leaf area, ear dry weight, and soil-water status were taken weekly. Estimates of canopy temperature, leaf-water potential and stomatal diffusive resistance were made at various stages of growth as weather and stress conditions permitted. Irrigation was applied on 16 June, 3 July, 10 July, 25 July and 14 August. Stomatal resistance measurements were made with a diffusion porometer (Delta T-Devices) on the exposed upper leaf and ear leaf of plants from the two center rows of all six entries on the irrigated and non-irrigated block. Two porometer readings were made on each side of the leaf and the average leaf resistance (R_s) was calculated using the formula:

$$\frac{1}{R_s} = \frac{1}{R_{ad}} + \frac{1}{R_{ab}} \quad \text{where} \qquad [1]$$

R_{ad} is the adaxial surface resistance and R_{ab} is the abaxial surface resistance. The leaf-water potentials were estimated from the upper exposed leaves of each treatment with a pressure chamber method (Scholander et al., 1965). Leaf area (green leaves only) from the corn plant samples were measured using an optical meter (LiCor Instrument Corp). Canopy temperatures were measured on clear sunny days at mid-afternoon hours using an infrared thermometer (Barnes, PRT-5) which viewed primarily vegetation. Soil water content was measured weekly using neutron probe (Troxler, model 380) from 15 to 150 cm depth in soil profile, at 15 cm intervals. Gravimetric soil samples were taken on 12 random plots (six from irrigated block and six from non-irrigated block) to determine the water content in the top 15 cm soil layer. Water use (ET) was estimated from soil-water content measurements and precipitation.

Results and Discussion

The trends of available soil moisture and rainfall (cm) received during the growing season for hybrid Mo17 x B73 is shown on Fig. 1.0. Early in the growing season when the crop water demand was low, the available soil water percentage on both irrigated and non-irrigated block were similar. As the active vegetative growth proceeded (Fig. 1.1 and Appendix A1), the percentage of available water began to deplete at a rapid rate on both the irrigated and the non-irrigated block. Obviously, the irrigated block had a higher available water content throughout the growing season because of irrigation. During flowering (Fig. 1.1), the percentage of available water on the non-irrigated block dropped to less than 50%. Russell (1959) pointed out that depletion of available soil water reserves before grain filling without recharge either through irrigation or rainfall can result in reduced yields or crop failure.

Seasonal trends of leaf-water potentials appear in Figs. 1.2 to 1.4. Some apparent differences were observed among the corn genotypes, in particular inbred Mo17 (Fig. 1.2). In the afternoon (pm), the difference in leaf-water potential between the Mo17 (IRR) and Mo17 (NON-IRR) was -3.0 bars on 27 July and 8 August, -3.3 and -3.6 bars on 21 August. Inbred A619 (IRR) maintained slightly higher leaf-water potential than inbred A632 (IRR), and inbred B73 also showed a general tendency to have higher leaf-water potential than inbred Mo17. In general, the leaf-water potentials were higher (less negative) early in the season, followed by a general decrease, except after an irrigation or rainfall. The morning (am) leaf-water potentials were higher than the afternoon (pm) values in both the moisture

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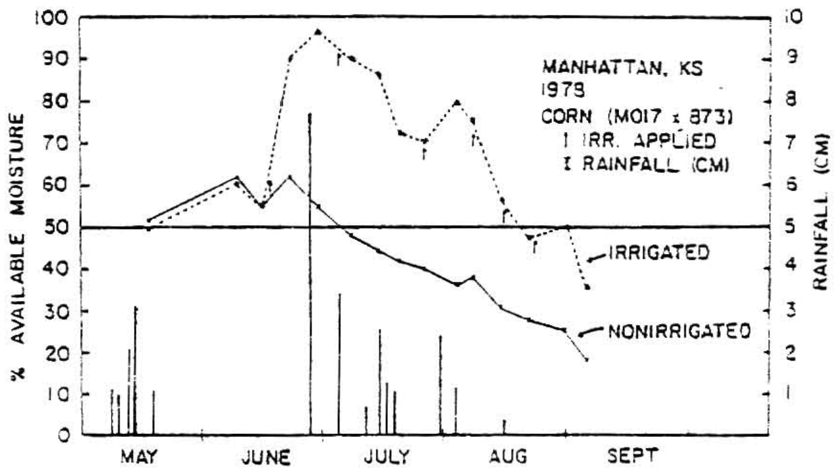

Fig. 1.0. Trends of percentage available moisture and rainfall (cm) received during corn growing season. (summer, 1978)

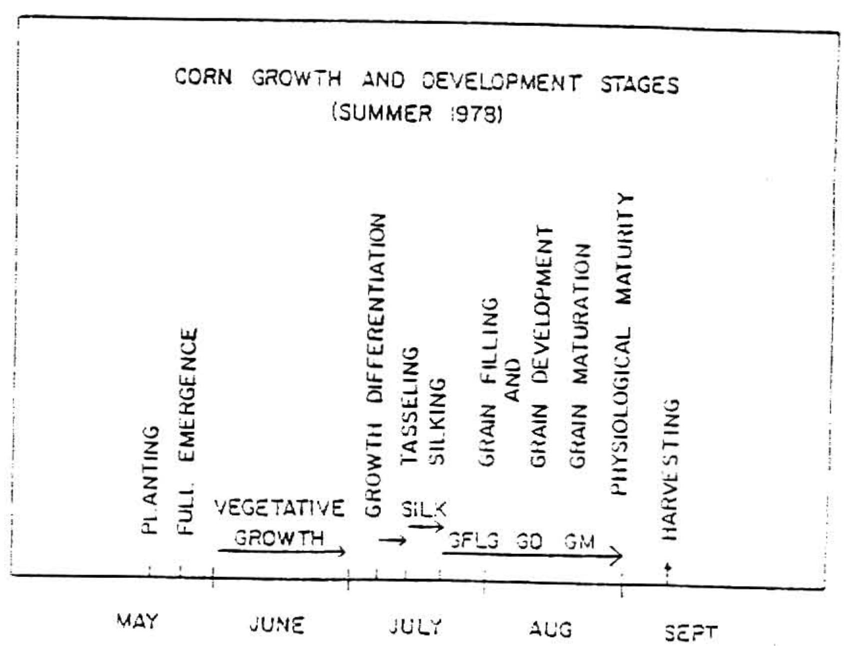

Fig. 1.1. The main growth and development stages of the corn genotypes. (summer, 1978)

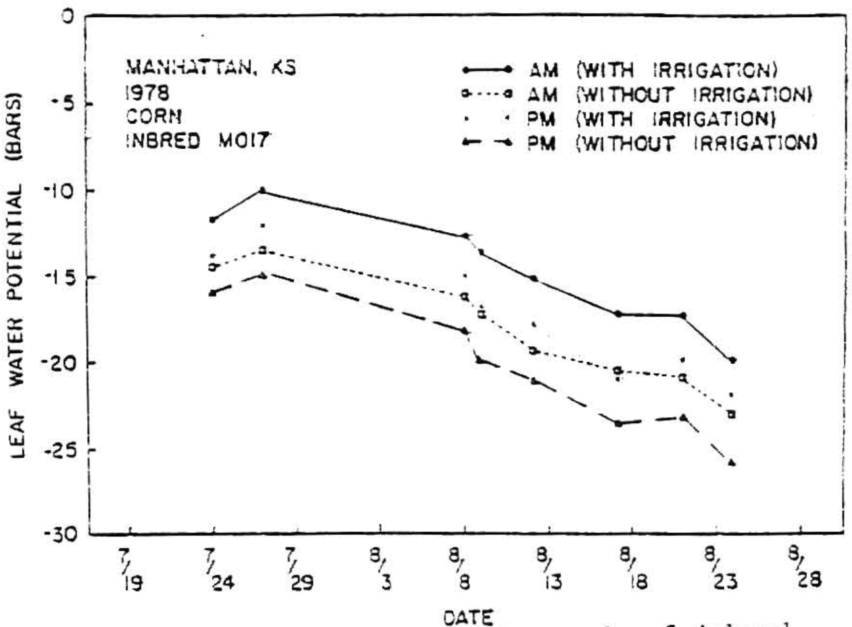

Fig. 1.2. Leaf-water potential trends of inbred Mo17. (summer, 1978)

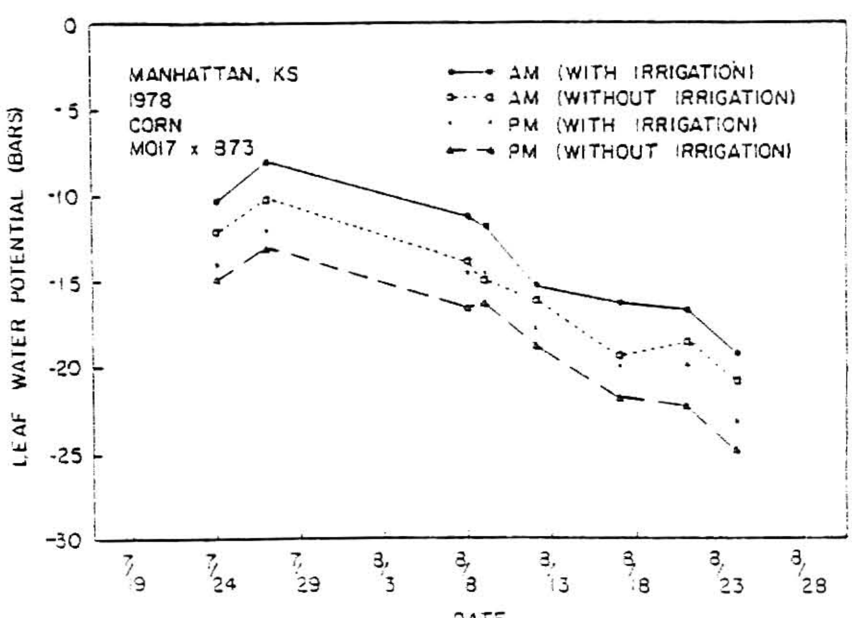

Fig. 1.3. Leaf-water potential trends of Mo17 x B73. (summer, 1978)

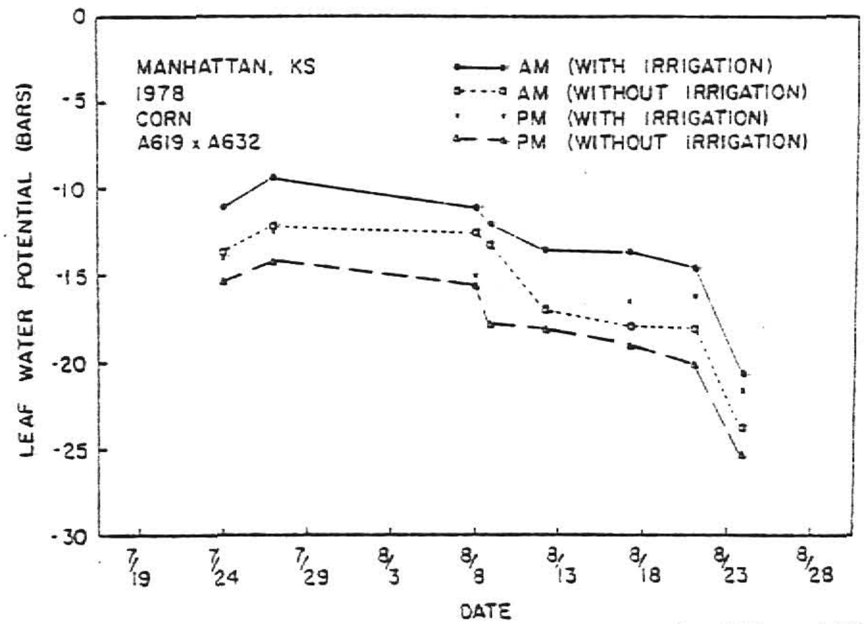

Fig. 1.4. Leaf-water potential trends of A619 x A632. (summer, 1978)

conditions, indicating higher turgor during the morning hours, the nearly parallel lines of IRR and NON-IRR, treatments indicate little temporal change in osmotic potential for the stress treatment. The hybrids consistently showed higher leaf-water potential than the inbred parents both under IRR and NON-IRR, again pointing out the superior ability of the hybrids to extract soil moisture and maintain high plant water content. As presented in Figs. 1.5 and 1.6 the soil water extraction pattern for the hybrids and inbred parents in the upper 60 cm of the soil profile was similar. The hybrids were more effective than the inbred parents in extracting the soil water from deep in the profile. Although there were some trend differences in leaf-water potential among the inbreds parents, the overall leaf-water potential trends observed were similar to those of Turner and Begg (1973).

Although several workers (Hiechel, 1971; Neumann et al., 1973; Turner, 1969; and Kanemasu et al., 1973) were able to observe trends with stomatal diffusive resistance values among varietal genotypes, stomatal resistance data (Table 1.0) do not show clear and consistent trends upon which one can associate the stomatal behavior of particular corn genotypes under the varying field conditions. There was, however, a general tendency for the corn genotypes to show low resistance values early in the growing season. Stomatal resistance values were also lower on the IRR than on the NON-IRR conditions. For example, on 8 and 17 August, the hybrids had lower stomatal resistance values than the inbreds; but this was not consistent enough to warrant one to conclude that the hybrids in our study exhibited lower stomatal resistance than the inbreds. Hagan et al., (1959) pointed out that the observed plant responses are integrated effects of plant growth and environmental effects, some of the responses become more detectable than others. In our case, the stomatal resistance values as

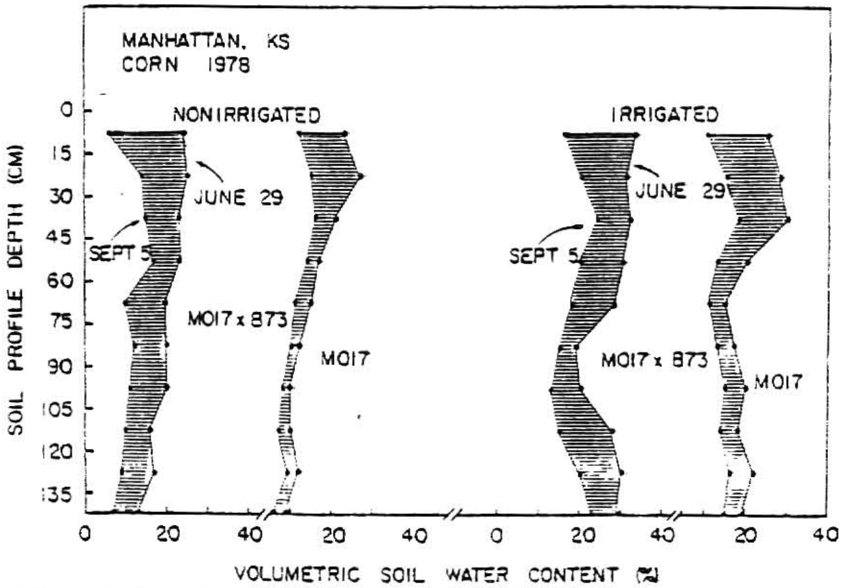

Fig. 1.5. Available moisture depletion pattern of Mo17 x B73 and inbred Mo17 under irrigated and non-irrigated conditions. (summer, 1978)

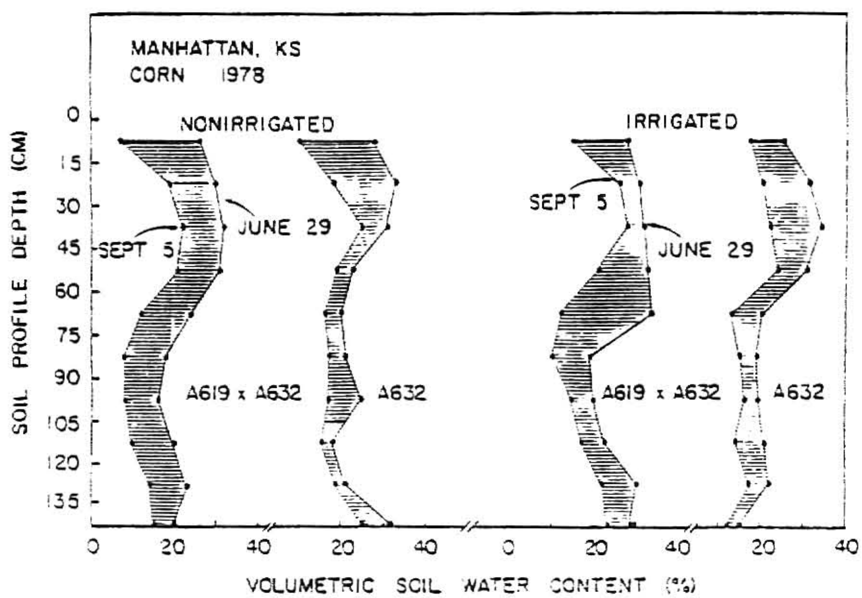

Fig. 1.6. Available moisture depletion pattern of A619 x A632 and inbred A632 under irrigated and non-irrigated conditions. (summer, 1978)

Table 1.0. Stomatal resistance values (sec cm^{-1}) of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1978)

Entry	Rs (sec cm^{-1}) NON-IRR	Rs (sec cm^{-1}) IRR
Date: 7/24 1500 hours CDT		
Mo17 x B73	4.2	2.6
B73	3.6	3.0
Mo17	3.8	2.9
A632	3.9	2.5
A619	4.5	3.1
A619 x A632	4.3	3.4
Date: 8/8 1400 hours CDT		
Mo17 x B73	3.2	2.7
B73	5.3	3.9
Mo17	5.0	3.7
A632	3.5	3.2
A619	4.1	3.3
A619 x A632	5.6	4.2
Date: 8/17 1400 hours CDT		
Mo17 x B73	4.9	3.6
B73	8.6	5.8
Mo17	7.4	7.0
A632	10.8	9.4
A619	8.2	5.1
A619 x A632	7.4	4.8

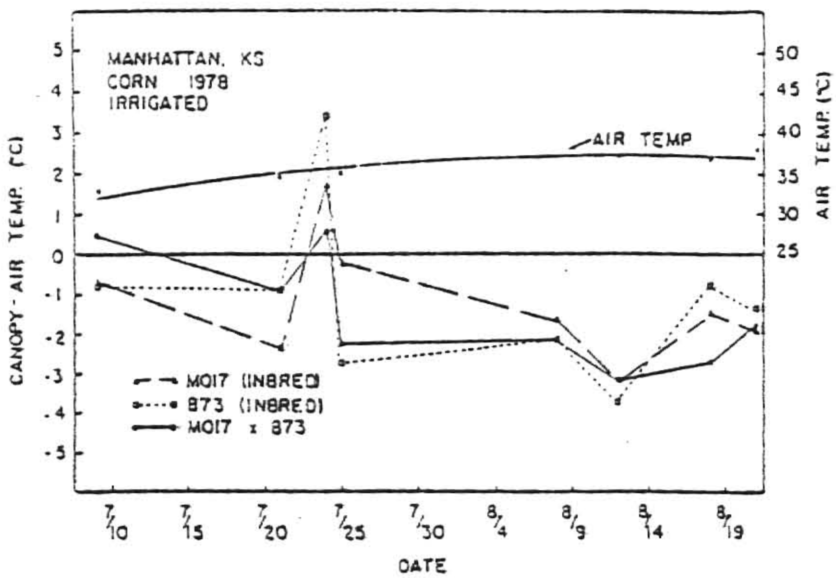

Fig. 1.7. Canopy-air temperature (ΔT) trends of Mo17 x B73 and its inbred parents under irrigated conditions. (summer, 1978)

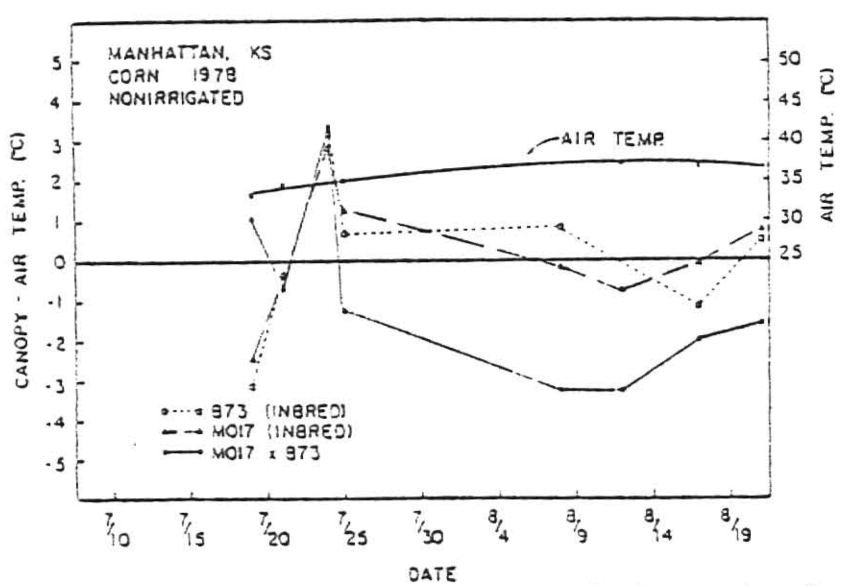

Fig. 1.8. Canopy-air temperature (ΔT) trends of Mo17 x B73 and its inbred parents under non-irrigated conditions. (summer, 1978)

estimated by diffusive porometer did not enable us to clearly distinguish among the corn genotypes. This implies that the estimation of stomatal resistance by the diffusive porometer was not as sensitive as the leaf-water potential. This might have been due to sampling error, poor porometer sensitivity and some complications by such environmental factors as light intensity, relative humidity and carbon dioxide concentration.

The canopy-air temperature values (ΔT) appear in Figs. 1.7 and 1.8 and Appendix A1. The irrigated plots appeared to have cooler canopy temperatures than the non-irrigated. This is presumably due to partial stomatal closure on water stress (NON-IRR) plots. Under non-irrigated condition, the hybrids' canopy appeared cooler than the inbreds, indicating a lower transpirational resistance which is consistent with the water use data (Table 1.1).

The total water use (ET) and water use efficiency (WUE) expressed as a ratio of grain yield (kg/ha) to the amount of water used (cm) appear on Table 1.1. Both the inbreds and hybrids showed increased total water use under irrigated condition (IRR). Hybrid A619 x A632 and Mo17 x B73 used about the same amount of water, 55.4 cm and 53.8 cm, respectively, under irrigation, which was about 14.2 cm higher than the non-irrigated block. In all cases, the hybrids used more water than the inbreds.

Observations on the ear dry weight (EDWT) taken approximately on weekly intervals, starting two weeks after silking (WAS), are shown in Table 1.2 and Figs. 1.9 and 1.10. Under IRR and NON-IRR conditions, the hybrids A619 x A632 and Mo17 x B73, showed significant difference in EDWT throughout the sampling periods. At 4WAS (a period of rapid grain filling), all corn genotypes showed significant trends in dry ear weight (Table 1.2). The changes in EDWT under IRR were about twice those under NON-IRR condi-

Table 1.1. Cumulative water use (cm), water use efficiency (WUE) (kg/ha/cm) under irrigated (IRR) non-irrigated (NON-IRR) conditions. (summer, 1978)

Entry	Water use (cm)		(WUE kg/ha/cm)	
	NON-IRR	IRR	NON-IRR	IRR
A632	37.6	50.7	27.4	41.7
A619	36.2	49.8	50.2	53.1
A619 x A632	40.4	53.8	78.6	106.8
Mo17	35.1	51.4	51.5	51.7
B73	35.3	48.3	56.3	61.3
Mo17 x B73	40.4	55.4	99.8	128.2

tions. This emphasizes the importance of having favorable environmental conditions (e.g. adequate moisture and nutrients supply and also favorable temperature) to allow photosynthesis, translocation and portitioning of the photosynthates to take place unrestricted and without interference, so as to enable the genetic potential to be expressed. Inbred B73 showed no substantial gain in EDWT at 2WAS, 5WAS, and 6WAS, whereas inbred A632 and A619 showed no significant gain in EDWT at 4WAS. This could be possibly due to low genetic ability for these genotypes to make full use of the favorable moisture supply in the case of IRR condition. Later in the grain filling, the leaf area indices (LAI) of these corn genotypes (Figs. 1.11 and 1.12 and Table A1.2) were considerably reduced as a result of rapid senescence of the lower leaves. This not only resulted in a decrease in the photosynthetic organ of the corn plants (source strength) but reduced leaf area duration and, consequently, the photosynthetic capacity and the dry matter (DM) accumulation in the ears. The hybrids on the other hand, attained and maintained higher LAI and longer leaf duration than the inbreds and, hence, their improved capacity to photosynthesize and accumulate higher DM in the ears than the inbreds, which was subsequently reflected in high grain yield.

Results for kernel weight (KWT), that is weight (gm/1000 kernels), and grain yield (GYLD), weight kg/ha of shelled grain, both adjusted to 15.5% moisture content appear on Table 1.3. As anticipated, the corn genotypes IRR conditions performed better in terms of KWT and GYLD than those under NON-IRR conditions (Table 1.3). The GYLD for inbred A632 under IRR did not differ significantly from that under non-irrigated conditions. This was in part due to less than optimum stand as a result of poor emergence. However, inbred A632 showed a significant difference in KWT when the two moisture conditions were compared. This is in support of positive response

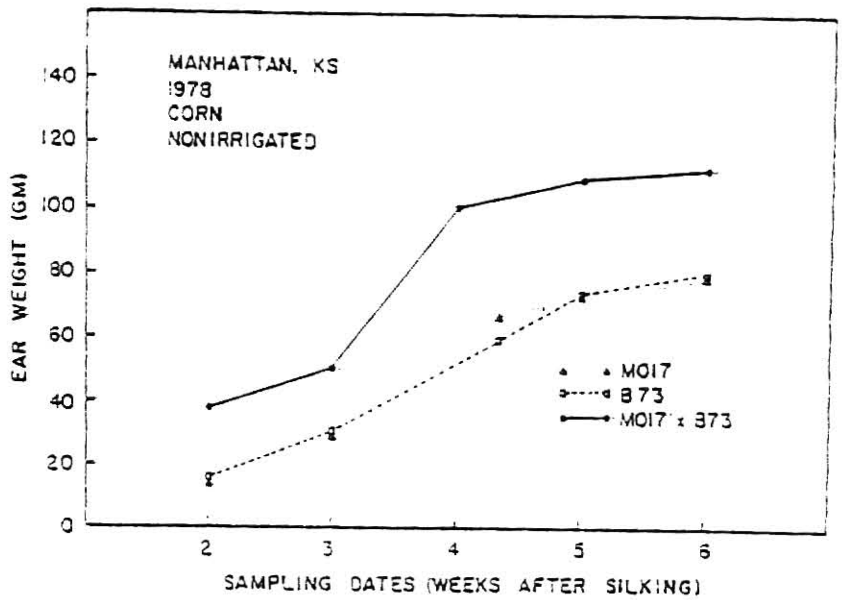

Fig. 1.9. Trends in dry ear weights of A619 x A632 and its inbred parents under non-irrigated condition. (summer, 1978)

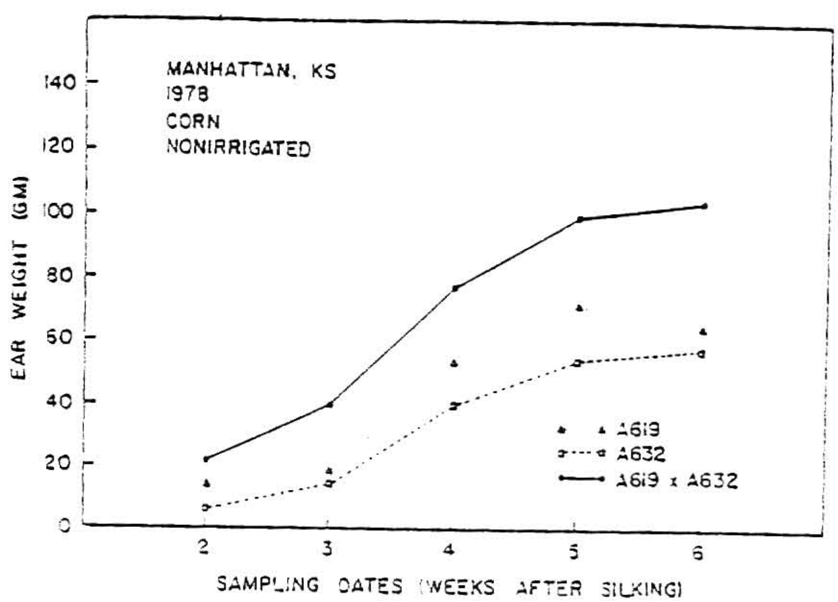

Fig. 1.10. Trends in dry ear weights of Mo17 x B73 and its inbred parents under non-irrigated condition. (summer, 1978)

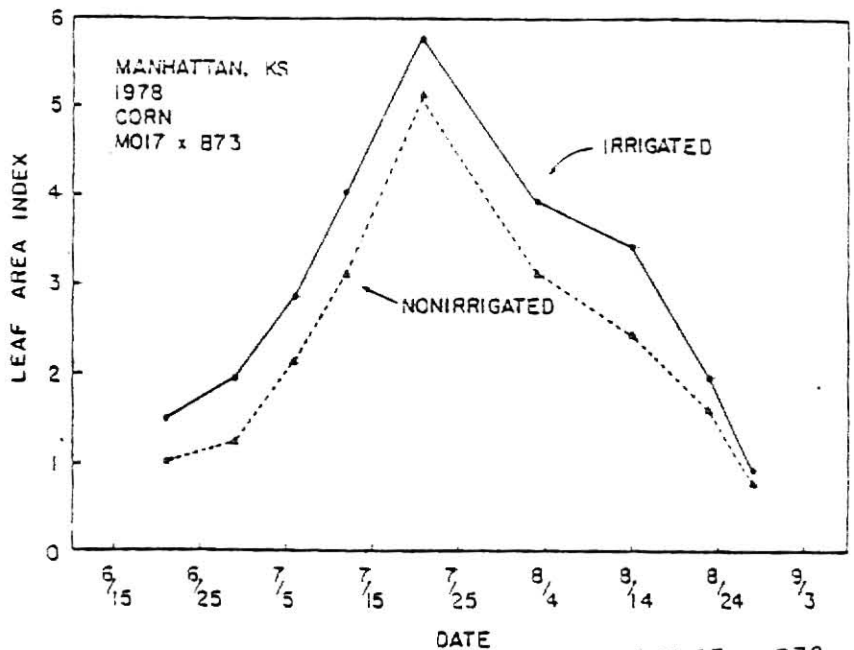

Fig. 1.11. Leaf area index trends of Mo17 x B73 under irrigated and non-irrigated conditions. (summer, 1978)

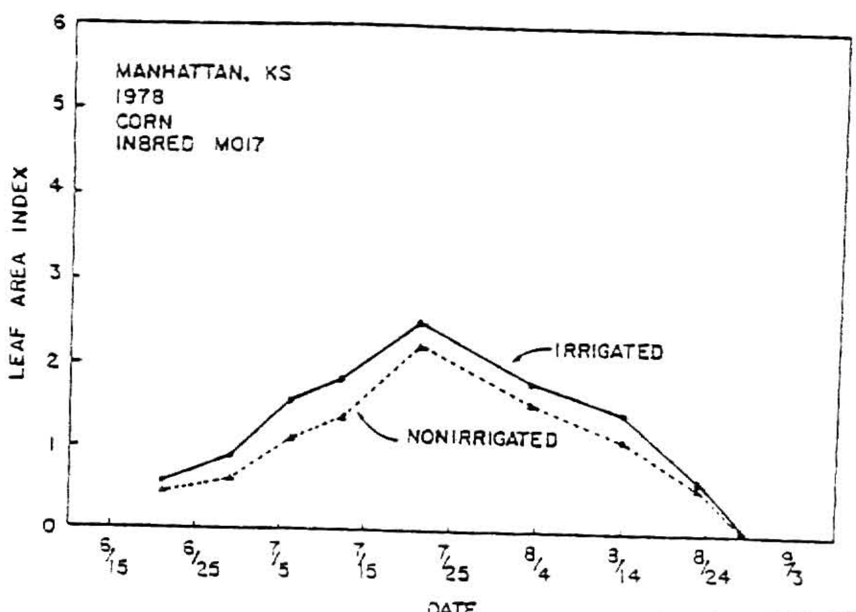

Fig. 1.12. Leaf area index trends of inbred Mo17 under irrigated and non-irrigated conditions. (summer, 1978)

Table 1.2. Trends in dry ear weight (gm) of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1978)
WAS = Weeks After Silking T = Sampling Time

Entry	T_1 2WAS NON-IRR	T_1 2WAS IRR	T_2 3WAS NON-IRR	T_2 3WAS IRR	T_3 4WAS NON-IRR	T_3 4WAS IRR	T_4 5WAS NON-IRR	T_4 5WAS IRR	T_5 6WAS NON-IRR	T_5 6WAS IRR
A632	8.86*a[†]	16.03*d	14.92*f	39.57*j	40.39m	56.54q	51.86*u	79.53*w	57.56*z	86.65*c
A619	11.96*a[§]	18.71*d	18.56*f	42.52*j	52.54m	63.12q	71.04*u	96.17*w	65.35*z	98.30*c
Mo17	13.72a	17.25d	28.71*gf	52.30*j	64.40mn	72.70q	73.60u	81.24w	77.24z	84.70c
B73	16.52ab	23.50d	31.04*gh	70.52*k	60.43*mn	87.53*qr	75.92u	92.60w	80.60za	96.15c
A619 x A632	21.13*ab	31.60*d	39.60*gh	72.70*k	78.73*mno	112.70*s	99.45v	120.50*x	102.60*b	126.20*d
Mo17 x B73	38.21*e	52.90*e	49.62*e	92.58*l	102.17*p	120.73*s	110.73*s	143.90*y	113.35*b	151.15*e

† Means with * sign (compared horizontally across) differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

§ Mean values sharing the same letter(s) vertically down the column) do not differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

Table 1.3. Kernel weight (KWT) and grain yield (GYLD) (at 15.5% MC) of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1978)

	KWT (gm/1000 kernels)			GYLD (kg/ha)	
Entry	NON-IRR	IRR	Entry	NON-IRR	IRR
A632	202.34*a†	252.83*c	A632	1394.98f	2057.05h
Mo17	211.65*a§	249.73*c	A619	1689.60*f	2611.51*h
B73	235.48*b	252.09*c	B73	1908.73*f	2745.27*h
A619	240.30b	246.89c	Mo17	1923.67*f	2597.15*h
A619 x A632	243.36*b	265.37*c	A619 x A632	2945.37*g	4233.72*i
Mo17 x B73	252.09*b	271.65*ce	Mo17 x B73	3563.55*g	6393.31*j

† Means with * sign (compared horizontally across) differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

§ Mean values sharing the same letter(s) (vertically down the column) do not differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

as a result of favorable moisture supply during grain filling which enhances nutrients translocation and accumulation, resulting in well-filled kernels and, hence, the significant difference in KWT. Inbred A619 showed significant difference in GYLD between the two moisture conditions, however, it did not show a similar response in terms of KWT. When the corn genotypes are compared separately under the two moisture conditions, the performance of the inbreds did not differ significantly between or among each other. However, the two hybrids ranked as superior performers and significantly outyielded the inbreds, Mo17 x B73 performed best in both KWT and GYLD. These results are in agreement with those reported by Tanaka and Yamaguchi (1972) who concluded that there is obviously varietal difference in performance and yielding ability among corn genotypes, hybrids yielding better than their respective inbreds.

Conclusion

The results from this study indicate the existance of genetic differences among corn genotypes in terms of their responses and performance under such environmental conditions like heat and moisture stress. Leaf-water potential and canopy temperature measurements as indicators of stress were more sensitive in distinguishing the corn genotypes than stomatal diffusive resistance. Generally, the hybrids showed higher leaf-water potential, cooler canopy temperatures than the inbreds, thus indicating superior ability to withstand moisture stress. Canopy temperature and leaf-water potentials may therefore be a potential screening indicator for drought resistance.

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CHAPTER II

Chapter II

Comparison of Canopy Temperature and Water Use of Seven Corn (*Zea mays* L.) Genotypes

Abstract:

To isolate plant genotypes that can withstand environmental factors such as heat and drought stress, it is desirable to describe and measure characteristics of plants for possible resistance to heat and drought. A field study was conducted in which seven corn genotypes, Kansas White Synthetic KW(SYN), hybrids Mo17 x B73, A619 x A632 and their respective inbreds (Mo17, B73, A619, A632) were compared in terms of their canopy-air temperature differential (ΔT) under irrigation (IRR) and without irrigation (NON-IRR). Measurements on canopy and air temperatures, soil moisture, leaf area, leaf-water potential, stomatal diffusive resistance and ear dry weights were measured. The results indicated that the canopy temperatures were sensitive enough to distinguish among the corn genotypes both under IRR and NON-IRR conditions. For instance on 22 August, 1300 CDT, KW(SYN) indicated a canopy temperature of about $3^{o}C$ cooler than inbred Mo17 and, the two hybrids and the KW(SYN) were consistently cooler than the inbreds. Neither the leaf-water potential nor the stomatal resistance values showed a consistent trend or variation which could clearly be associated with or distinguish between the genotypes. KW(SYN) and two hybrids Mo17 x B73 and A619 x A632 showed higher WUE than the inbreds and this was also reflected in their ear dry weight trends, kernel weights and grain yields.

Introduction

Search for plant genotypes that can withstand high temperature and water stress is being intensified in several of the field crops (Kilen and Andrew, 1969; Kinbancher, 1969; and Aron, 1972). Corn (Zea mays L.) is extensively grown in areas where high temperature and water deficits are likely to occur and cause considerable yield reduction (Aron 1972, Gupta, 1975). It is unfortunate that corn is grown and also flowers during the warmest season of the year, when extremes of high temperatures intensified by moisture deficit will adversely affect pollination, fertilization, grain setting and development resulting in shrivelled kernels and, consequently, reduced grain yields (Denmead and Shaw, 1960). In several instances, however, certain corn genotypes have been observed to withstand considerable heat and drought stress and yield better than others under the same stress conditions. Practical procedure of isolating such genotypes from populations, followed by further genetic improvement, will be very valuable in stabilizing corn grain production in marginal areas to satisfy the growing world grain demand. The study reported here was conducted with the objective of comparing the canopy-air temperature (ΔT) and water use of the corn genotypes.

Materials and Methods

In summer 1979, an experiment was conducted in which two corn hybrids (Mo17 x B73 and A619 x A632), their respective parent inbreds (Mo17, B73, A619, A632), and KW(SYN) corn materials, a total of seven entries, were planted. These were planted on 18 May at Ashland Agronomy Research Farm, Evapotranspiration Field Research Site (14 km SW of Manhattan, KS) in a split-block design with eight replications, half the block receiving irrigation and the remaining half without irrigation. The spacing between plants was approximately 30 cm and 75 cm between rows 5 m in length, thus, the approximate plant population was 44,444 plants per hectare. Full emergence was observed on 29 May and harvesting was done on 21 September. Irrigation was applied on 16 June, 3 July, 25 July, 8 August and 14 August. Weekly observations and measurements such as leaf area, ear dry weights, growth stage and soil water content were taken. Canopy temperature, leaf-water potential and stomatal diffusive resistance measurements were taken at various stages of growth as weather conditions permitted. Stomatal resistance measurements were estimated with a diffusive porometer (Delta T-Devices) on the exposed upper and ear leaf of plants from the two center rows of all seven entries on the irrigated (IRR) and non-irrigated (NON-IRR) block. Two porometer readings were made on each side of the leaf and the average leaf stomatal resistance (Rs) was calculated using the formula,

$$\frac{1}{Rs} = \frac{1}{R_{ad}} + \frac{1}{R_{ab}} , \qquad [1]$$

where R_{ad} is the adaxial surface resistance and R_{ab} is the abaxial surface resistance. Leaf-water potentials were estimated from the upper exposed leaves of each treatment with a pressure chamber method (Scholander et. al., 1965). Leaf area (green leaf only) was estimated in the field by measuring the length and maximum width of all green leaves on a corn plant, using the formula, plant leaf area = Σ(leaf length x maximum width).75.

Canopy temperatures were measured on clear sunny days at 0900, 1000, 1300, 1400 and 1600 CDT, using an infrared thermometer (Telatemp Model 42) which is capable of measuring the leaf canopy and the air temperature concurrently. Soil water content was measured weekly using neutron probe (Troxler, Model 380) from 15 to 150 cm in the soil profile at 15 cm intervals. Gravimetric soil samples were taken on 14 random plots, seven from irrigated block and seven from non-irrigated block, to determine the water content in the top 15 cm. Water use (ET) was estimated from the soil moisture measurements and precipitation.

Results and Discussion

Presented in Figs. 2.0 to 2.2b (also Appendix A2) are the hourly trends of the canopy-air temperature (ΔT) for the seven corn genotypes under IRR and NON-IRR conditions. From these trends it is evident that the canopy temperatures were generally cooler than air temperature, indicating low transpirational cooling resistance. For instance, on 22 August 1300 CDT the canopy temperature of (IRR) KW(SYN) was about 5°C cooler than the air temperature. The KW(SYN), which was genetically more diversed than the other corn genotypes, showed a general tendency of having cooler canopy temperature than the rest of the corn materials. The two hybrids (Mo17 x B73 and A619 x A632) consistently showed cooler canopy temperature than the inbred parents (Figs. 2.0 and 2.1), thus, indicating a lower transpirational cooling resistance than the inbred parents. This is in agreement with the total water use by the respective corn genotypes as summarized in Table 2.0. Usually, plant temperature is an integrated result of all the energy absorption and dissipation mechanisms acting singly or in combination with the crop environment. As the internal-plant water content declines, and water uptake lags behind evapotranspirational demand, transpirational cooling is reduced due to stomatal closure (partial or complete closure).

Shown in Fig. 2.2a and 2.2b are the ΔT values on several sampling dates taken at 1300 CDT, the canopy temperatures were cooler than the air temperature. The ΔT values were more negative for IRR than NON-IRR conditions. Linacre (1964) indicated that there is a tendency for the difference between canopy and air temperature (ΔT) to be positive during cool weather and negative during hot weather. Our ΔT trends are in general agreement

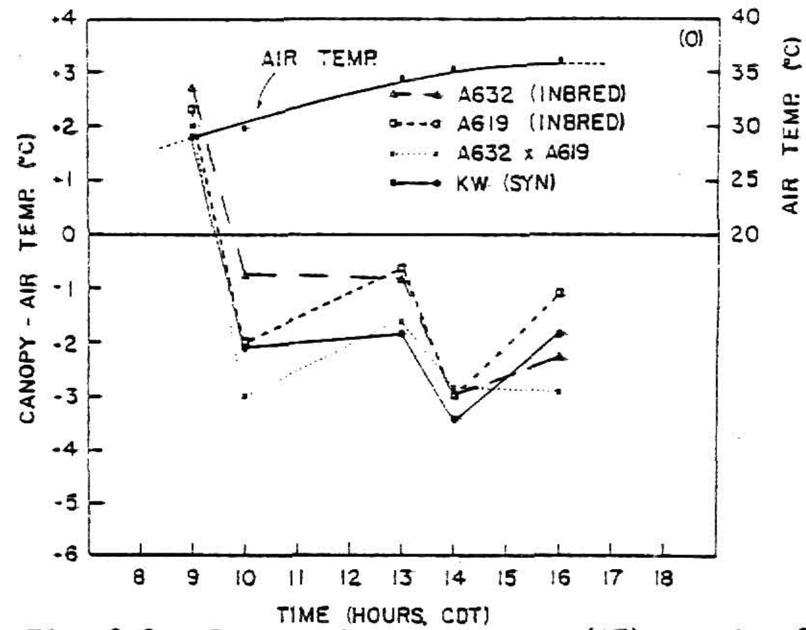

Fig. 2.0. Canopy-air temperature (ΔT) trends of the KW(SYN), A619 x A632, its inbred parents A619 and A632, NON-IRR, 8 August, 1979.

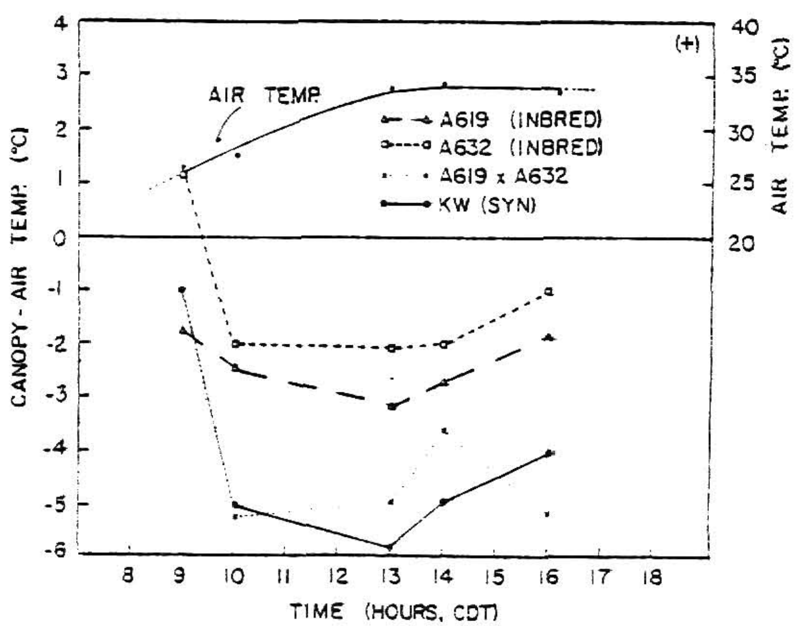

Fig. 2.1. Canopy-air temperature (ΔT) trends of the KW(SYN), A619 x A632, its inbred parents A619 and A632, IRR, 22 August, 1979.

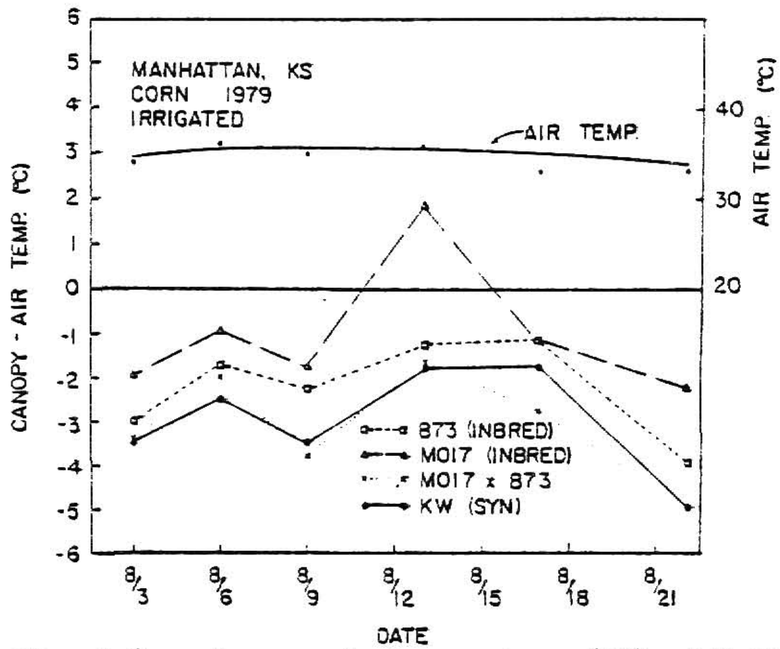

Fig. 2.2a. Canopy-air temperature (ΔT) of Mo17 x B73, its inbred parents and KW(SYN) taken at 1300 CDT on various dates, under irrigated condition. (summer, 1979)

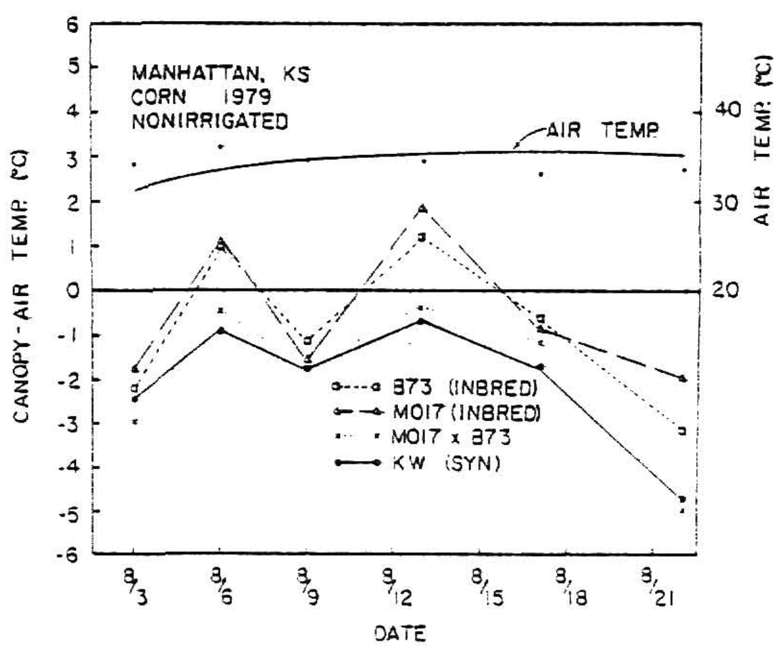

Fig. 2.2b. Canopy-air temperature (ΔT) of Mo17 x B73, its inbred parents and KW(SYN) taken 1300 CDT on various dates, under non-irrigated condition. (summer, 1979)

with Linacre's suggestion.

Fig. 2.3a and 2.3b (also Appendix A2) shows the seasonal trends of leaf-water potential for IRR A619 x A632 and its respective inbred parents. In contrast to the trends in leaf-water potentials we observed in summer 1978 (Chapter I), the 1979 trends had less distinct variation among the corn genotypes, and generally the two hybrids showed higher leaf-water potential than the inbreds in both summers. Similar to 1978, the 1979 stomatal resistance values showed no consistent trend (Appendix A2) to which one can associate or generalize about the corn genotypes. However, the resistances were lower in 1979 than in 1978; this being in part due to improved rainfall and available soil moisture distribution in 1979 corn growing season (Appendix A2).

The cumulative water use (cm) and water use efficiency (WUE = grain yield/water use) of the individual corn genotypes are summarized in Table 2.0. It is evident that the KW(SYN), the two hybrids and their inbred parents used more water under IRR than under NON-IRR conditions. KW(SYN), A619 x A632 and Mo17 x B73 used more water than the inbreds, indicating their greater ability to make use of favorable available soil moisture than the inbreds, and this was also reflected in their water use efficiency. For instance, Mo17 x B73 indicated about three times higher WUE value than its respective inbred parents--Mo17 and B73. The WUE values for A619 x A632 and KW(SYN) were about the same, but still higher (about twice) than that of any inbred. This is in agreement with the grain yield values of the corn genotypes (Table 2.3). However, when the WUE for the two moisture conditions are compared for an individual corn genotype the values are similar.

Relative yield expressed as, yield from NON-IRR condition/yield from

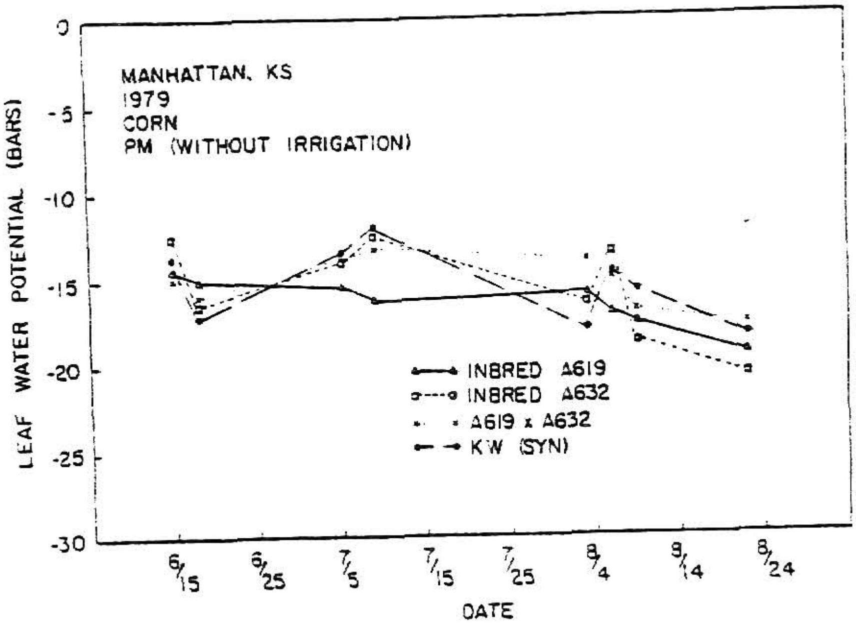

Fig. 2.3a. Leaf-water potential trends of A619 x A632, its inbred parents and KW(SYN), pm values under non-irrigated condition. (summer, 1979)

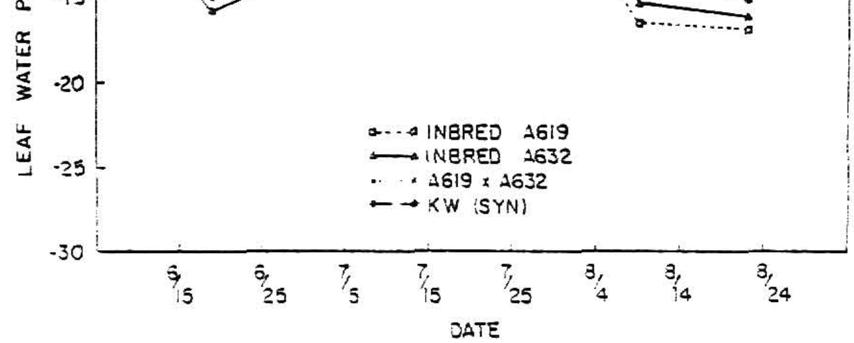

Fig. 2.3b. Leaf-water potential trends of A619 x A632, its inbred parents and KW(SYN), pm values under irrigated condition. (summer, 1979)

Table 2.0. Consumptive water use values (cm) and water use efficiency (WUE) (grain yield/water use) for the corn genotypes, under irrigated (IRR) and non-irrigated (NON-IRR) conditions and *potential evapotranspiration. (summer 1978, 1979)

	Summer 1978					Summer 1979			
	Water use (cm)		WUE (gm/kg water use)			Water use (cm)		WUE (gm/kg water use)	
Entry	NON-IRR	IRR	NON-IRR	IRR	Entry	NON-IRR	IRR	NON-IRR	IRR
A619	36.2	49.8	.50	.53	A619	41.2	47.6	.52	.64
A632	37.6	50.7	.27	.42	A632	41.0	49.3	.50	.80
A619 x A632	40.4	53.8	.79	1.10	A619 x A632	40.3	50.6	1.10	1.30
Mo17	35.1	50.4	.51	.51	Mo17	38.0	48.6	.49	.51
B73	35.3	48.3	.56	.61	B73	38.3	48.0	.54	.68
Mo17 x B73	40.4	55.4	.99	1.29	Mo17 x B73	41.0	52.5	1.71	1.80
-	-	-	-	-	KW(SYN)	46.2	53.3	1.10	1.20

* Potential evapotranspiration (PET) (as estimated by Priestley - Taylor method) (25 May to 20 August, 1978) = 60.6 cm

* Potential evapotranspiration (PET) (as estimated by Priestley - Taylor method) (25 May to 20 August, 1979) = 50.3 cm

IRR condition referred to as actual yield/maximum yield in this text, and relative evapotranspiration, actual evapotranspiration/potential evapotranspiration (AET/PET), appear in Table 2.1. The corn genotypes, which had significant differences in grain yield between IRR and NON-IRR conditions, showed smaller actual maximum/yield ratios in 1978 than in 1979. This is due to improved available moisture distribution during grain filling and lower PET in 1979 compared to 1978 (Table 2.0 and Appendix A2). In 1979 corn growing season the AET/PET and actual yield/ maximum yield ratios were comparatively higher than in 1978 (Table 2.1), indicating both increased water use efficiency and higher grain yield than in 1978. The KW(SYN), Mo17 x B73, and A619 x A632 showed higher relative ET and grain yield ratios than any of the corn genotypes and this was also reflected in their ear dry weights, kernel weights and grain yield.

Daynard et al. (1971) pointed out that the rate and duration of grain filling period are important in relation to final grain yield. Therefore, ear dry weights (EDWT) were taken approximately on weekly intervals, starting one week after silking (WAS) (Table 2.2). At sampling period T_4 (4WAS), nearly all corn genotypes showed significant differences in EDWT between IRR and NON-IRR and among the corn genotypes. Inbred Mo17 showed no such significant difference in EDWT; and this was probably due to poor genetic ability of this inbred to exploit its environment. In nearly all sampling periods except T_1 (1WAS), T_5 (5WAS), T_6 (6WAS), T_7 (7WAS), the KW(SYN), Mo17 x B73 and A619 x A632 showed significant differences in EDWT compared to the inbreds, and between IRR and NON-IRR conditions, again illustrating their improved ability to photosynthesize, translocate and accumulate their photosynthate into the sink (ear). The high EDWT trends (Fig. 2.4 and 2.5) of the KW(SYN) and the two hybrids

Table 2.1. *Relative evapotranspiration (AET/PET) and grain yield (AYLD/Max YLD) of the corn genotypes (1978, 1979) growing seasons

	1978				1979		
	AET/PET		AYLD/Max YLD		AET/PET		AYLD/Max YLD
Entry	NON-IRR	IRR		Entry	NON-IRR	IRR	
A619	.60	.82	.69	A619	.82	.95	.71
A632	.74	.83	.49	A632	.81	.98	.52
A619 x A632	.66	.88	.55	A619 x A632	.80	1.00	.70
Mo17	.57	.83	.70	Mo17	.76	.96	.76
B73	.58	.80	.67	B73	.76	.95	.62
Mo17 x B73	.66	.91	.56	Mo17 X B73	.82	1.04	.72
				KW(SYN)	.92	1.05	.75

* Relative evapotranspiration expressed as Actual evapotranspiration/Potential evapotranspiration.

* Relative yield expressed as Yield from NON-IRR/Yield from IRR.

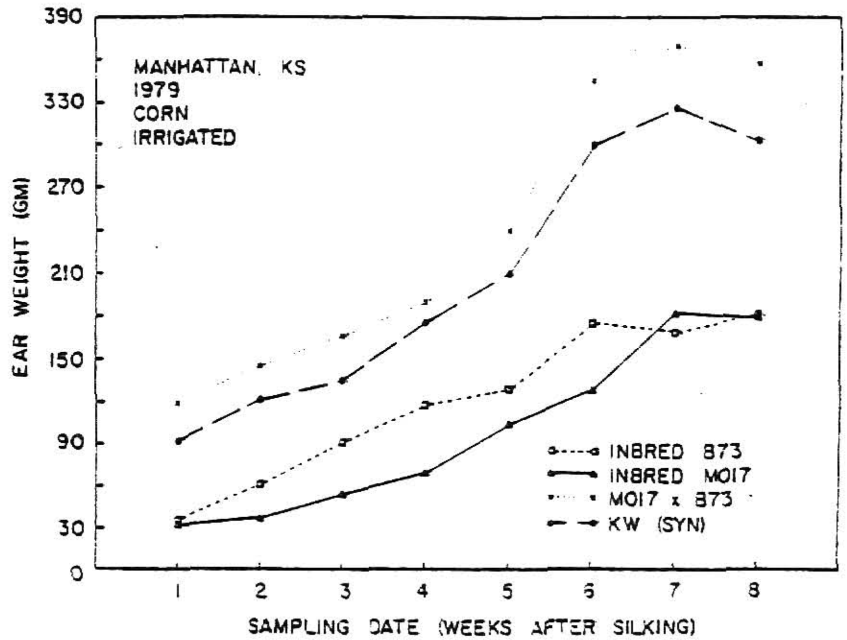

Fig. 2.4. Trends in ear dry weights of Mo17 x B73, its inbred parents and KW(SYN) under irrigated condition. (summer, 1979)

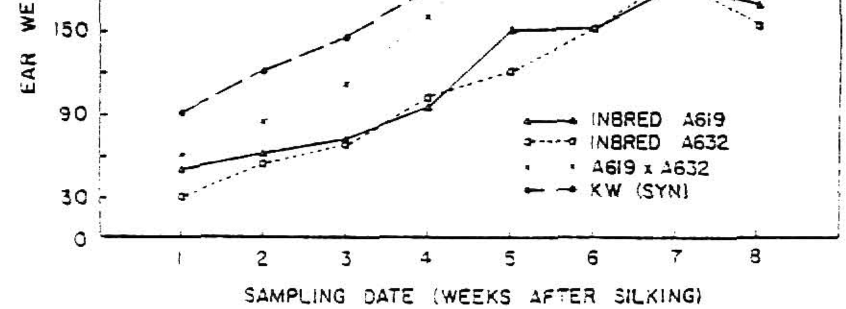

Fig. 2.5. Trends in ear dry weights of A619 x A632, its inbred parents and KW(SYN) under irrigated condition. (summer, 1979)

are also consistent with their higher leaf area indices (LAI) compared to the inbreds (Figs. 2.6 and 2.7). The KW(SYN) and hybrids maintained their LAI for a longer duration than the inbreds, thus enabling greater photosynthate and dry matter (DM) production (other factors being the same). The KW(SYN) and hybrids Mo17 x B73, A619 x A632 which possessed superior genetic ability to exploit and make efficient use of available environmental resources, showed larger kernel weight (KWT) than any of the inbreds (Table 2.4). When compared among themselves, neither KW(SYN) nor the two hybrids showed a significant difference in KWT. This suggests that under the conditions of our study they had about the same ability in translocating and accumulating photosynthates in their kernels. With an exception of inbred A632, inbreds A619, B73 and Mo17 showed no significant difference in KWT among themselves. Although there were some differences in KWT among genotypes when the two moisture conditions are considered, these differences (except for Mo17 x B73 and inbreds Mo17 and A632) were not statistically different. This could be, in part, due to favorable moisture supply during grain filling. Tollenaar and Daynard (1978) pointed out that cereal plants have the potential to mediate and adjust their grain yield to the prevailing environment in terms of kernel number and kernel size (KWT). Thus, under favorable environmental conditions, corn may set more kernels which are likely to be smaller than those formed under less favorable conditions.

In analyzing the kernels within an ear into a bottom portion (BKWT), middle portion (MKWT), and upper portion (UKWT) (Table 2.5), BKWT in all genotypes was consistently much greater than MKWT and UKWT. This is in agreement with the findings of Poneleit and Egli (1979), who pointed out that there are variations in kernel development on the ear, the bottom

Table 2.2. Trends in ear dry weight EDWT (gm) of the corn genotypes under irrigated (IRR and non-irrigated (NON-IRR) conditions. (summer, 1979) WAS - Weeks After Silking T - Sampling Time

	T_1			T_2			T_3			T_4	
	1WAS			2WAS			3WAS			4WAS	
Entry	NON-IRR	IRR	Entry	NON-IRR	IRR	Entry	NON-IRR	IRR	Entry	NON-IRR	IRR
Mo17	19.43a	30.45e	A632	29.41i	38.55m	A632	34.2r	51.64u	A632	47.50*a	70.29*d
A632	20.80a[§]	29.65e	Mo17	34.70i	51.78m	B73	49.63*r	70.20*u	B73	65.10*a	102.42*e
A619	27.90*a[†]	47.10*e	B73	37.65i	59.14m	Mo17	50.45*r	73.92*uv	Mo17	80.24a	98.24e
B73	28.05a	34.80e	A619	43.54i	60.15mn	A619	67.30*rs	89.47*uv	A619	91.08*ab	115.94*e
A619 x A632	44.28ab	59.25ef	A619 x A632	60.72*j	82.76*o	A619 x A632	78.85*re	112.62*w	A619 x A632	110.96*ab	159.60*f
KW(SYN)	63.56c	90.45g	KW(SYN)	86.31*k	120.64*r	KW(SYN)	100.20*t	144.50*x	KW(SYN)	127.82*ab	176.40*f
Mo17 x B73	84.52*d	116.18*h	Mo17 x B73	106.08*l	143.02*q	Mo17 x B73	119.30*t	165.60*y	Mo17 x B73	152.54*c	190.00*g

§ Mean values sharing the same letter(s) (vertically down the column) do not differ significantly at 0.05 probability level as determined by Duncan's multiple-range test).

† Means with * sign (compared horizontally across) differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

Table 2.2. (cont'd). Trends in ear dry weight EDWT (gm) of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1979) WAS - Weeks After Silking T - Sampling Time

	T_5			T_6			T_7			T_8	
	5WAS			6WAS			7WAS			8WAS	
Entry	NON-IRR	IRR	Entry	NON-IRR	IRR	Entry	NON-IRR	IRR	Entry	NON-IRR	IRR
A632	72.51*h[§]	107.50*l	A632	101.25o	131.40q	B73	137.20t	185.20w	B73	123.40y	178.50a
B73	87.68*h[†]	121.35*l	B73	105.75o	150.60q	Mo17	150.36t	191.35w	A619	125.07y	152.95a
A619	121.16i	149.80lm	A619	136.42o	150.20q	A632	151.90t	182.37w	A632	127.40y	165.70a
Mo17	127.40i	140.19lm	Mo17	143.19o	172.70q	A619	159.25t	168.17w	Mo17	130.18y	180.60a
A619 x A632	134.48*i	211.38*n	KW(SYN)	190.20*p	291.80*qr	A619 x A632	187.75t	239.51w	A619 x A632	162.53y	224.50a
KW(SYN)	168.73*j	210.60*n	A619 x A632	191.10p	224.20s	KW(SYN)	204.31*t	327.80*x	KW(SYN)	194.24z	308.34b
Mo17 x B73	215.20k	240.28n	Mo17 x B73	232.13*p	346.55*s	Mo17 x B73	241.50*tv	374.47*x	Mo17 x B73	223.97z	358.18b

§ Mean values sharing the same letter(s) (vertically down the column) do not differ significantly at 0.05 probability level as determined by Duncan's multiple-range (test).

† Means with * sign (compared horizontally across) differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

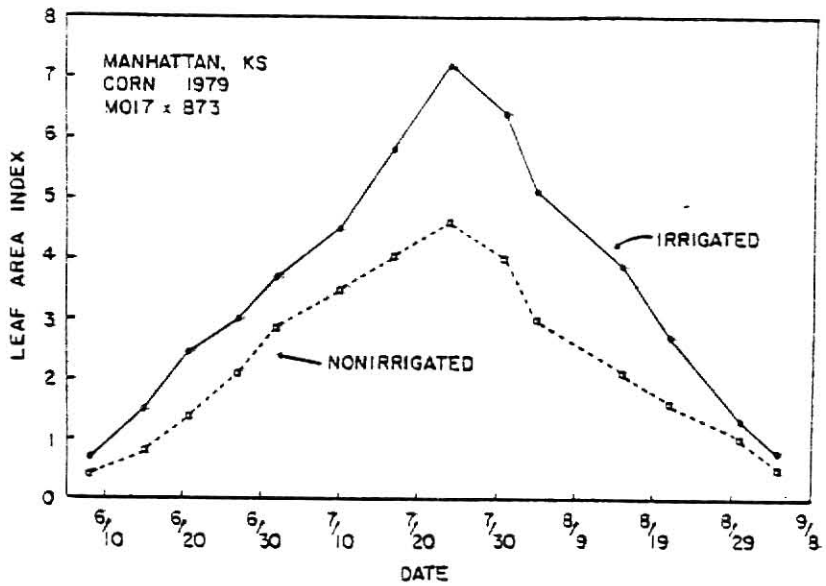

Fig. 2.6. Leaf area index trends of Mo17 x B73 under irrigated and non-irrigated conditions. (summer, 1979)

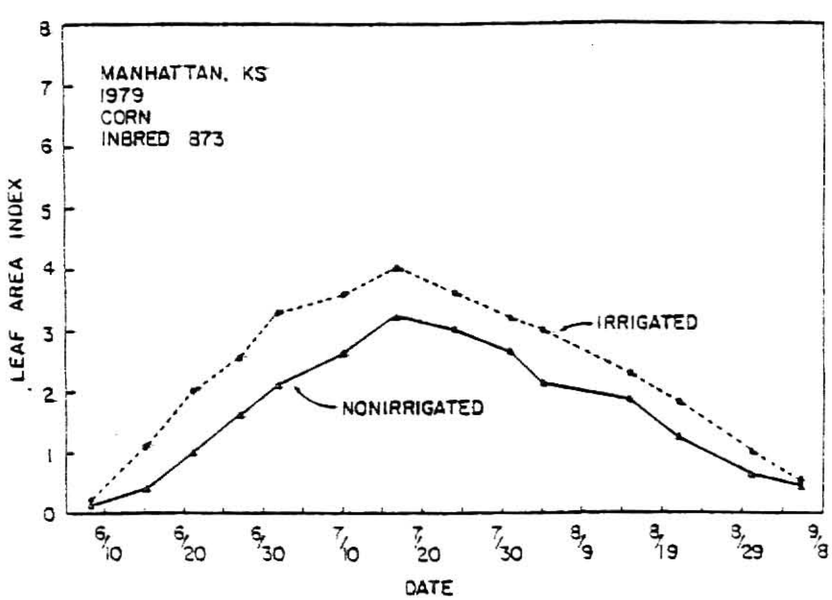

Fig. 2.7. Leaf area index trends of inbred B73 under irrigated and non-irrigated conditions. (summer, 1979)

Table 2.3. Mean grain yields (kg/ha) and kernel weight (g/1000 kernels) at 15.5% moisture content of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1979)

Entry	Grain Yield (kg/ha)		Entry	Kernel Weight (g/1000 kernels)	
	NON-IRR	IRR		NON-IRR	IRR
Mo17 x B73	7771.70*a†	9335.68*e	KW(SYN)	319.80a	327.32d
KW(SYN)	5765.04*b§	6432.19*f	A619 x A632	319.28a	309.60e
A619 x A632	5463.35*b	5907.77*g	Mo17 x B73	313.02*a	335.76*f
B73	2185.33*c	2700.52*h	B73	256.42b	243.60g
A619	2097.80*c	2822.06*h	Mo17	255.45*b	285.41*h
Mo17	2035.42c	2470.00h	A619	252.74b	260.73i
A632	1448.30*d	2369.10*h	A632	231.51*b	268.92*i

† Means with * sign (compared horizontally across) differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

§ Mean values sharing the same letter(s) (vertically down the column) do not differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

Table 2.4. Base, middle and upper mean kernel weight (gm/1000 kernels) of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1979) BKWT - Base Kernel Weight MKWT - Middle Kernel Weight UKWT - Upper Kernel Weight

Entry	NON-IRR	IRR	Entry	NON-IRR	IRR	Entry	NON-IRR	IRR
Mo17 x B73	405.54i[§]	406.97k	Mo17 x B73	339.59n	347.12s	Mo17 x B73	238.70a	245.45e
KW(SYN)	400.88i	403.88k	KW(SYN)	318.99o	320.50s	KW(SYN)	216.55b	222.52f
A619 x A632	388.42i	297.37k	A619 x A632	270.68p	293.79t	A619 x A632	204.76b	205.65f
A619	350.51j	322.32l	Mo17	252.69q	268.81t	A619	146.82*c	187.26*g
Mo17	325.94j	337.32l	B73	246.72n	249.30t	Mo17	146.69*c	173.50*g
A632	302.16*j[†]	327.40*m	A619	231.78r	239.50t	B73	144.65*c	171.86*g
B73	320.34j	321.16m	A632	225.62r	234.93t	A632	162.09d	163.54gh

§ Mean values sharing the same letter(s) (vertically down the column) do not differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

† Means with * sign (compared horizontally across) differ significantly at 0.05 probability level as determined by Duncan's multiple-range test.

kernels being formed first and the tip kernels formed last. Assuming the rate of kernel growth being approximately the same at various locations in the ear (Duncan et al., 1965), the bottom kernels will have a longer duration of grain filling. In a simplified version, the grain yield can be expressed as the product of average grain production (dry weight increment per unit time) and the duration of grain filling (Daynard et al., 1971). The early formed kernels (bottom kernels) will have a better chance than the middle or upper kernels to utilize the available environmental resources early in the grain filling before they become limiting--particularly under heat and moisture stress. This will result into sound, well-filled bottom kernels (Table 2.4). The KW(SYN) showed comparatively higher BKWT, MDWT and UKWT values than the inbreds. The UKWT of inbreds were statistically different between IRR and NON-IRR which indicates a source limitation during grain filling. The hybrids and KW(SYN) had higher UDWT than the inbred parents under both IRR and NON-IRR conditions.

The results of the grain yield (GYLD) appear on Table 2.3. To our expectations the corn genotypes ranked themselves in terms of the overall grain yield, Mo17 x B73 had the highest grain yield, followed by KW(SYN) and A619 x A632 and then the hybrids. With the exception of inbred Mo17, the corn genotypes showed a significant difference in GYLD between IRR and NON-IRR conditions. This suggests the stability of grain yield of Mo17 to water deficit. The corn genotypes under IRR made use of the available soil moisture and set more kernels, subsequently, this was reflected in greater grain yield, hence, the significant difference in GYLD between IRR and NON-IRR conditions.

Conclusion

In our study, the canopy temperature measurements were sensitive enough to distinguish the genotypes apart both under NON-IRR and IRR conditions. The two hybrids (Mo17 x B73, A619 x A632) and the KW(SYN) showed cooler canopy temperatures than the inbreds, illustrating their improved ability to transpire and, presumably, photosynthesize at a greater rate than the inbreds. The stomatal diffusive resistance and leaf-water potential data did not show a clear or consistent variation to distinguish among the genotypes. Nevertheless, the leaf-water potentials were higher, and the stomatal resistance were lower on IRR than on the NON-IRR conditions. The KW(SYN) and the two hybrids showed higher water use efficiency in terms of their ear dry weights and grain yield. Although field testing for drought tolerance is complicated by genotype - environment interactions, measurements of canopy temperature is relatively easy to take and; when supplemented by other environmental measurements like soil moisture, air temperature, relative humidity, and solar radiation, canopy temperature may prove useful in field screening of corn genotypes.

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APPENDIX A1

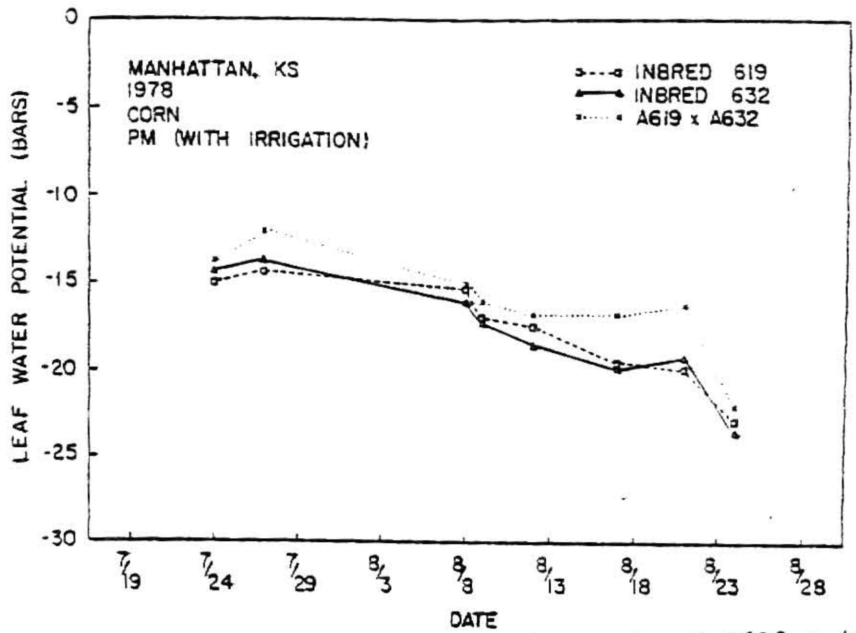

Fig. A1.0. Leaf-water potential trends of A619 x A632 and its inbred parents, pm values under irrigated condition. (summer, 1978)

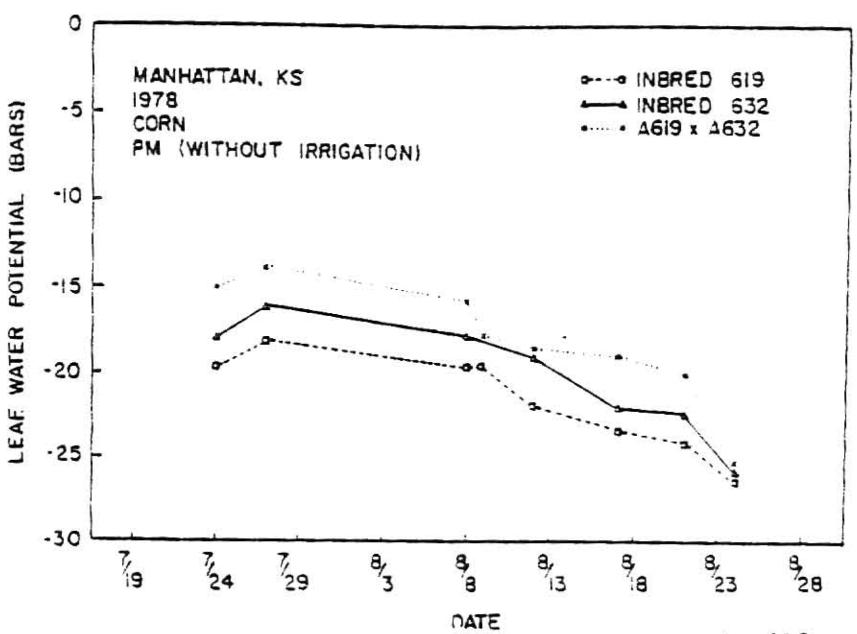

Fig. A1.1. Leaf-water potential trends of A619 x A632 and its inbred parents, pm values under non-irrigated condition. (summer, 1978)

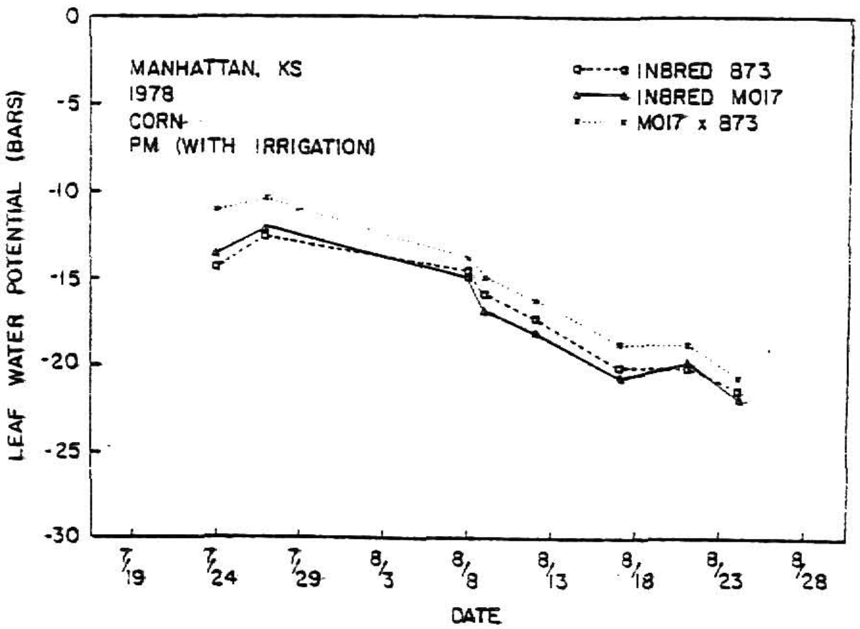

Fig. A1.2. Leaf-water potential trends of Mo17 x B73 and its inbred parents, pm values under irrigated condition. (summer, 1978)

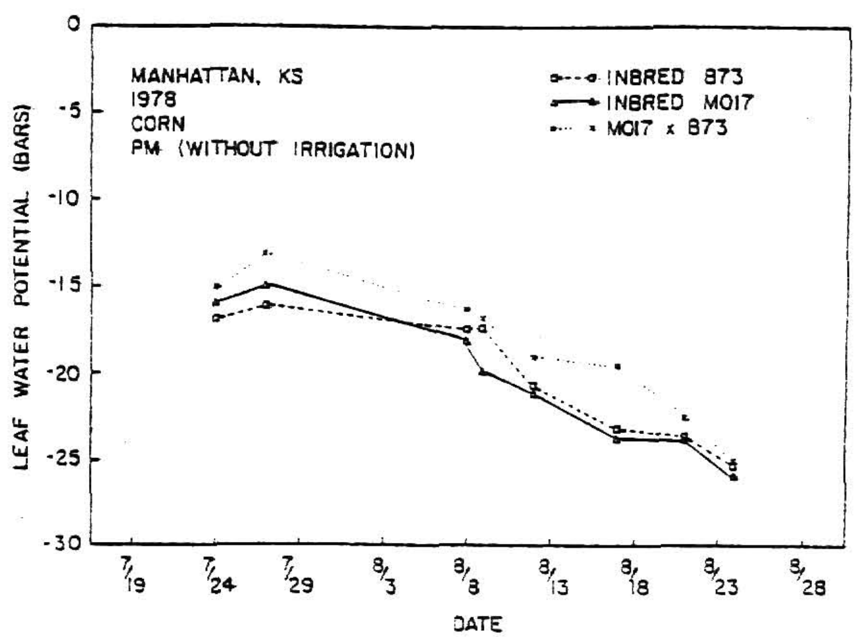

Fig. A1.3. Leaf-water potential trends of Mo17 x B73 and its inbred parents, pm values under non-irrigated condition. (summer, 1978)

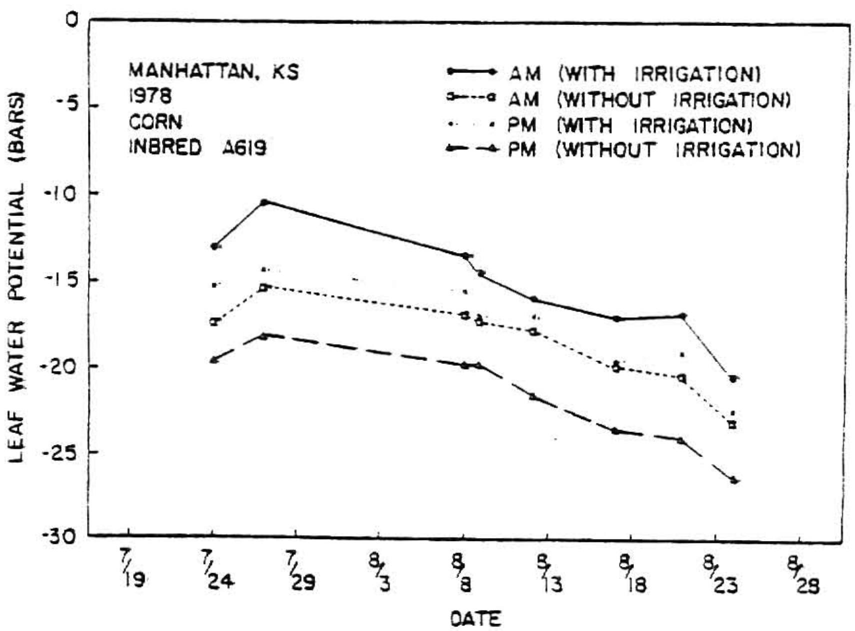

Fig. A1.4. Leaf-water potential trends of inbred A619 under irrigated and non-irrigated conditions. (summer, 1978)

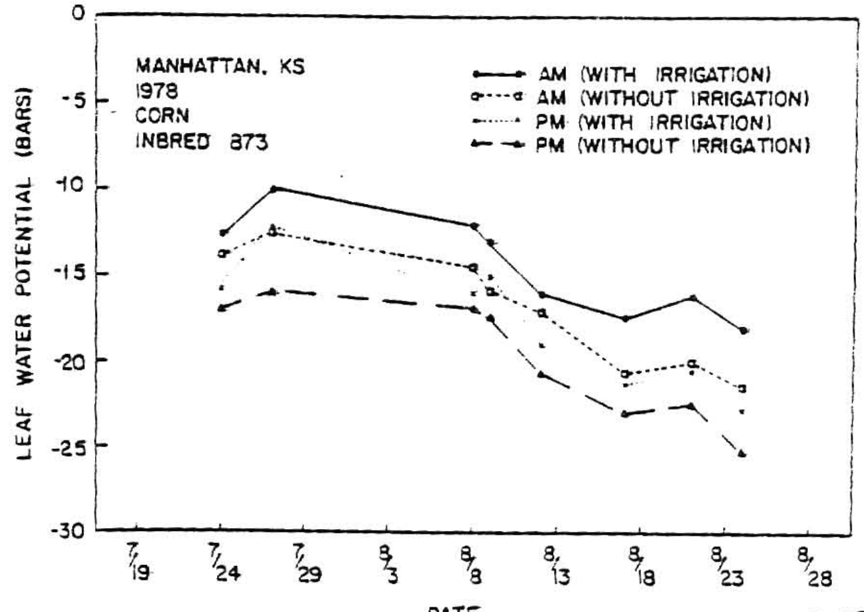

Fig. A1.5. Leaf-water potential trends of inbred B73 under irrigated and non-irrigated conditions. (summer, 1978)

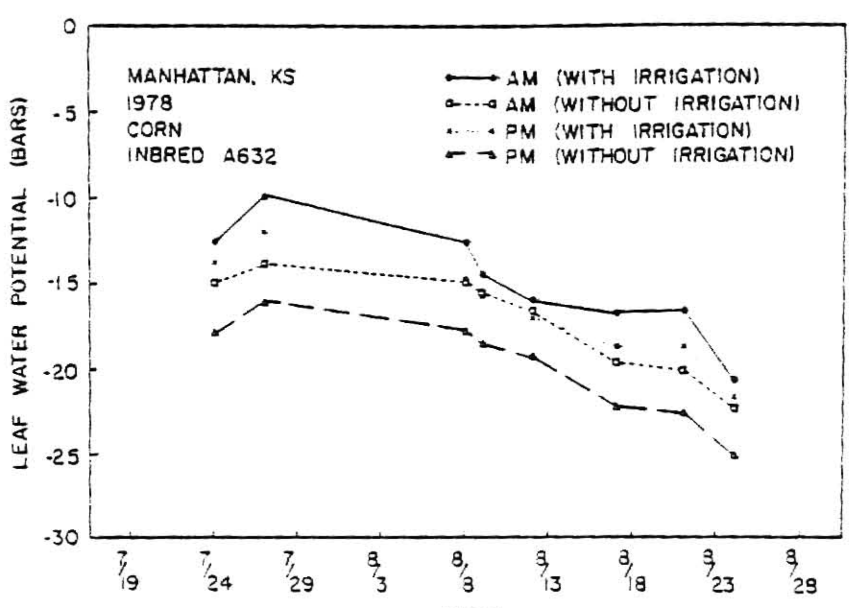

Fig. A1.6. Leaf-water potential trends of inbred A632 under irrigated and non-irrigated conditions. (summer, 1978)

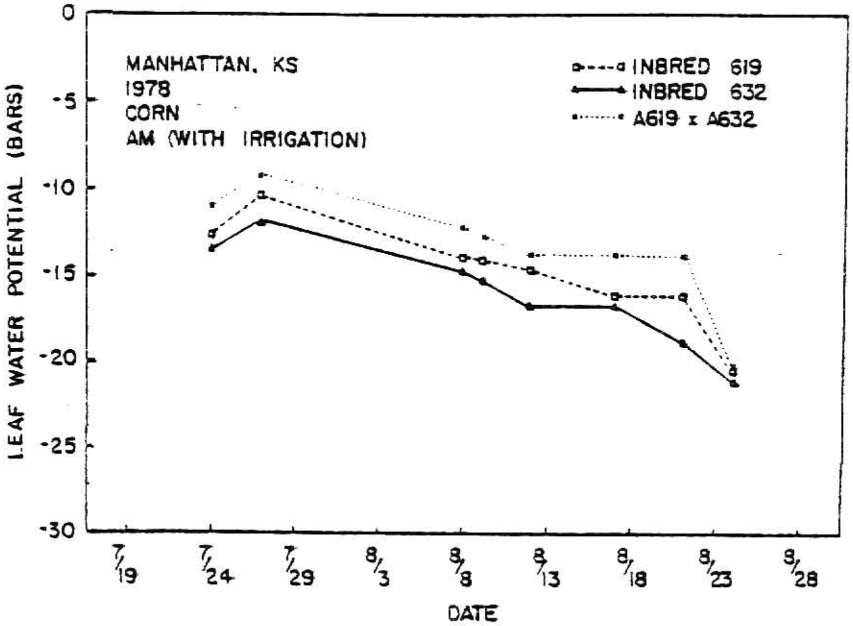

Fig. A1.7. Leaf-water potential trends of A619 x A632 and its inbred parents under irrigated condition. (summer, 1978)

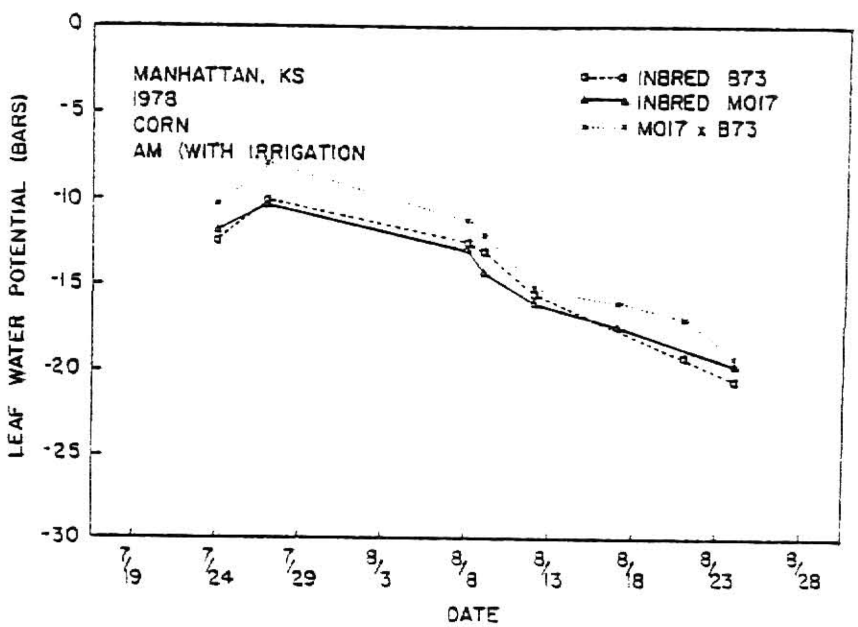

Fig. A1.8. Leaf-water potential trends of Mo17 x B73 and its inbred parents under irrigated condition. (summer, 1978)

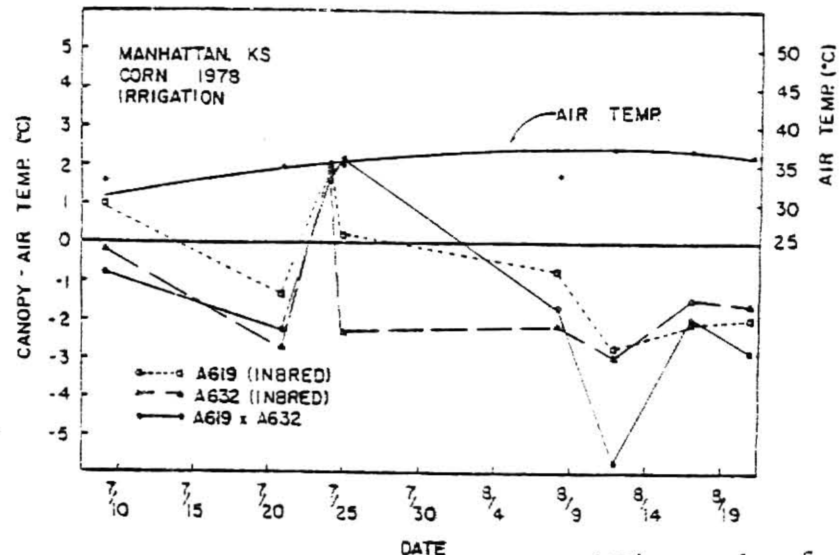

Fig. A1.9. Canopy-air temperature (ΔT) trends of A619 x A632 and its inbred parents under irrigated condition. (summer, 1978)

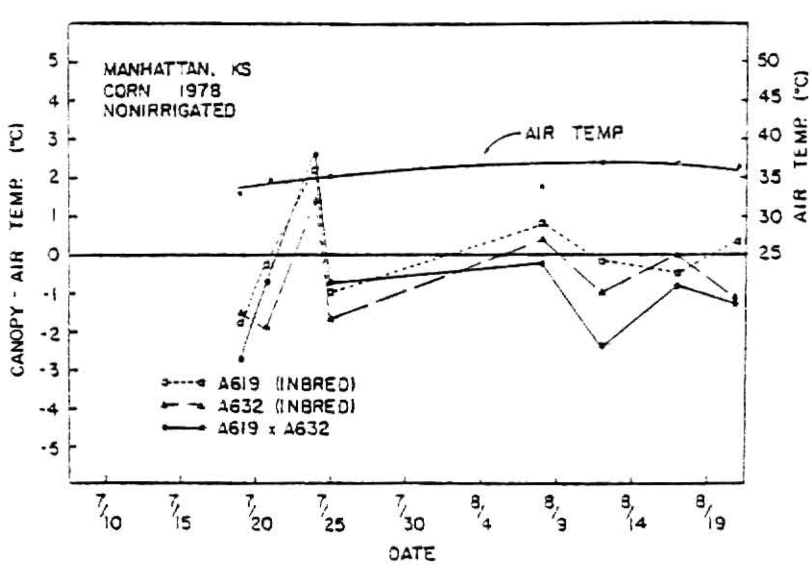

Fig. A1.10. Canopy-air temperature (ΔT) trends of A619 x A632 and its inbred parents under non-irrigated condition. (summer, 1978)

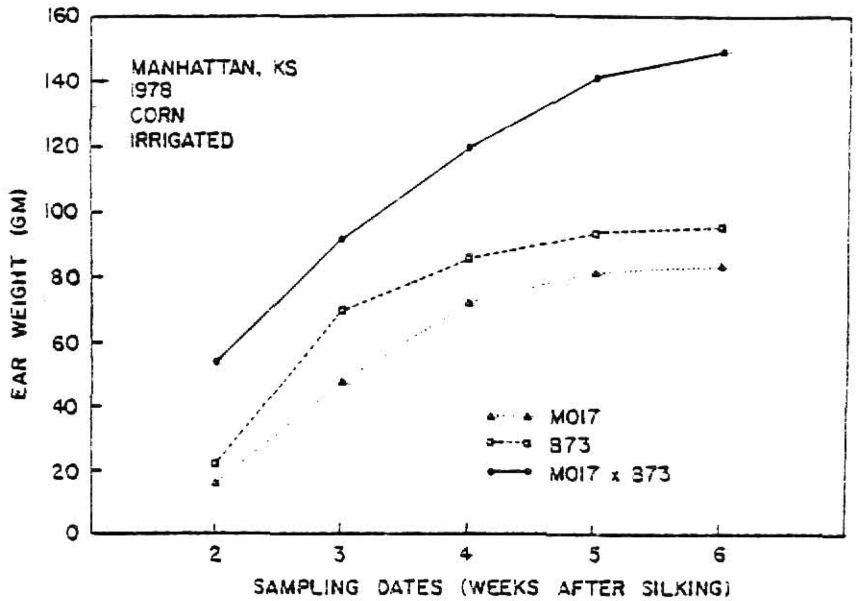

Fig. A1.11. Trends in dry ear weights of Mo17 x B73 and its inbred parents under irrigated condition. (summer, 1978)

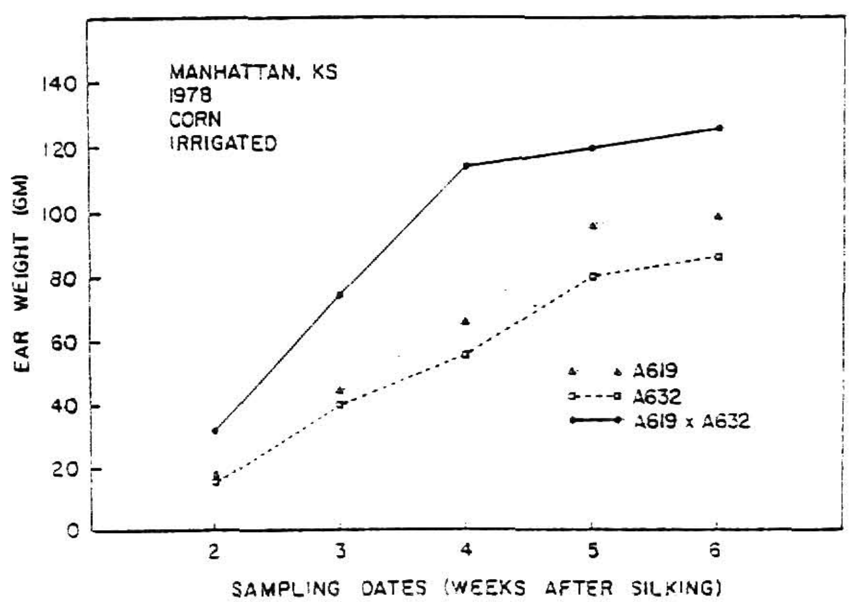

Fig. A1.12. Trends in dry ear weights of A619 x A632 and its inbred parents under irrigated condition. (summer, 1978)

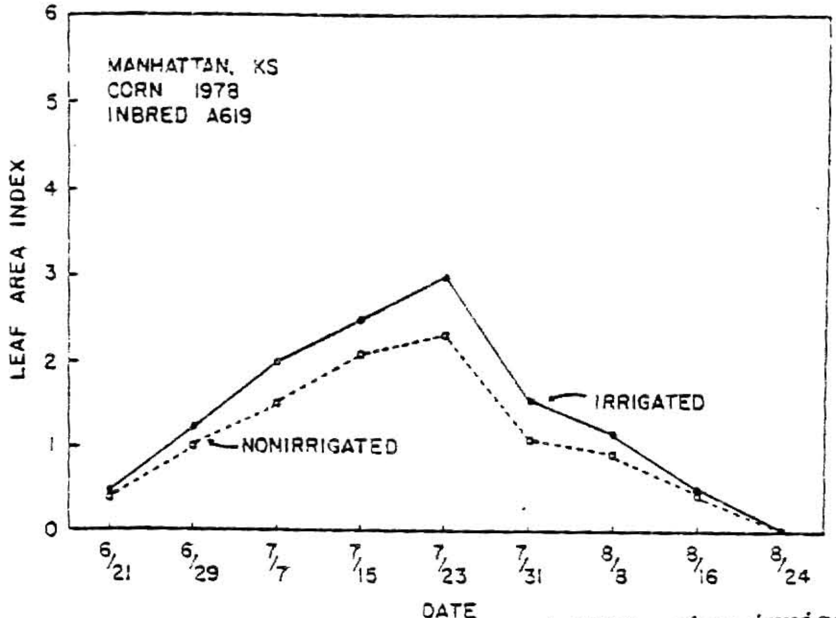

Fig. A1.13. LAI trends of inbred A619 under irrigated and non-irrigated conditions. (summer, 1978)

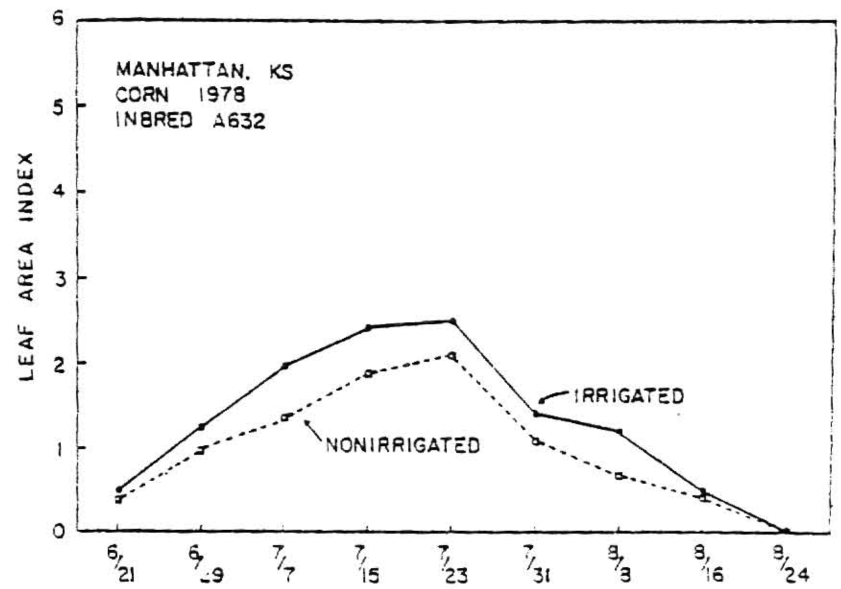

Fig. A1.14. LAI trends of inbred A632 under irrigated and non-irrigated conditions. (summer, 1978)

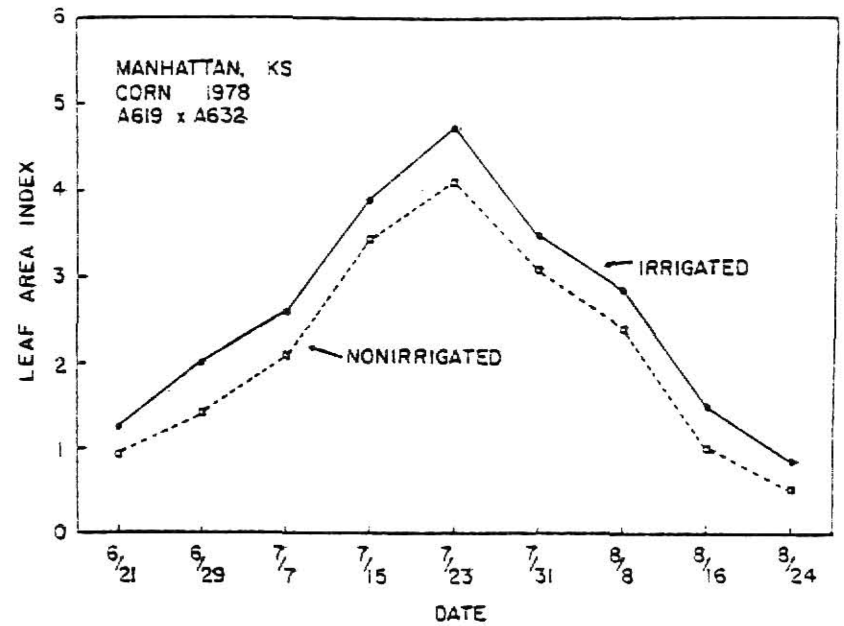

Fig. A1.15. LAI trends of A619 x A632 under irrigated and non-irrigated conditions. (summer, 1978)

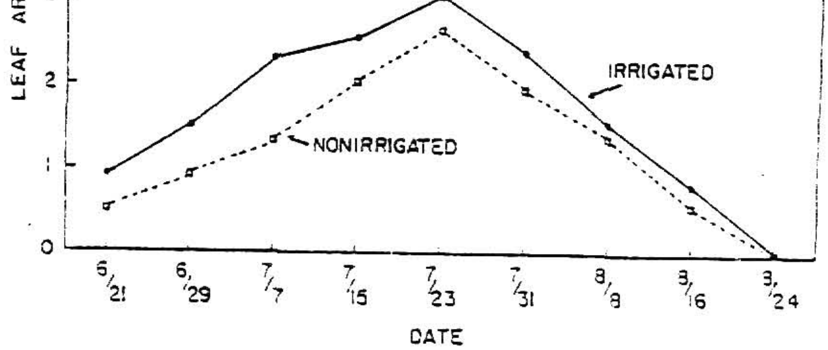

Fig. A1.16. LAI trends of inbred B73 under irrigated and non-irrigated conditions. (summer, 1978)

APPENDIX A2

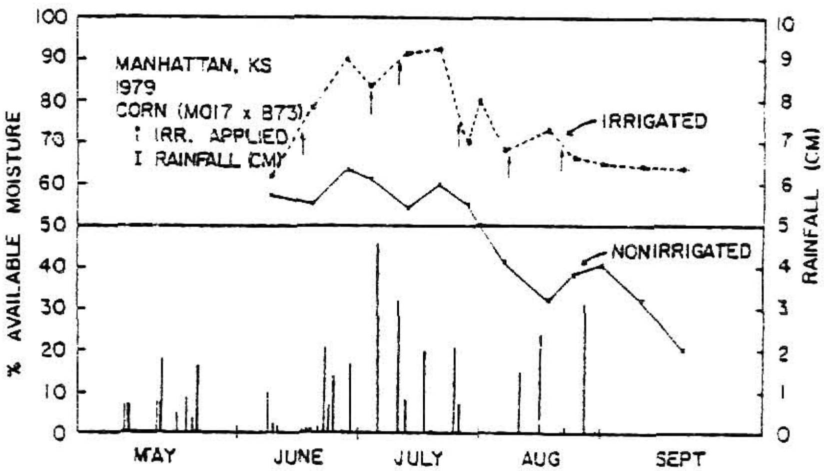

Fig. A2.0. Trends of percentage available moisture rainfall received (cm) during corn growing season. (summer, 1979)

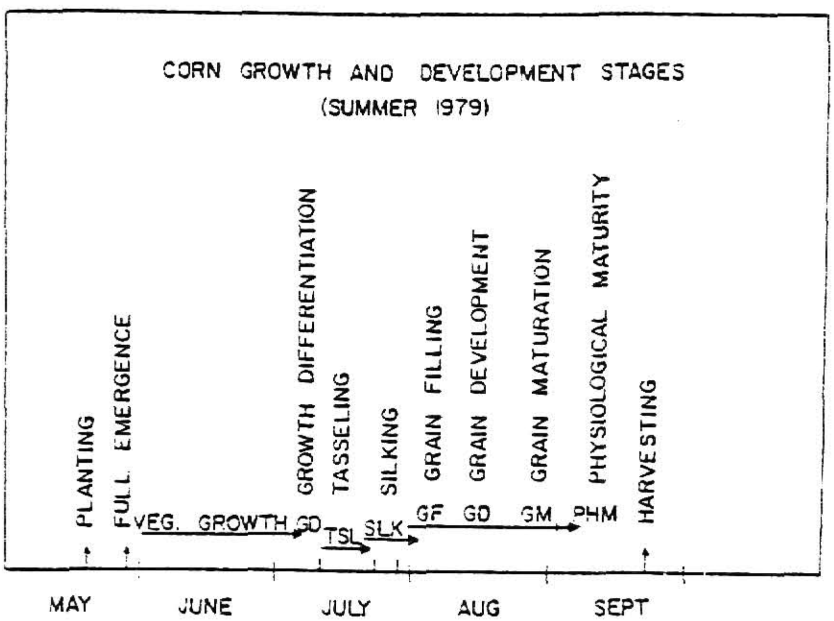

Fig. A2.1. Main growth and development stages of corn genotypes. (summer, 1979)

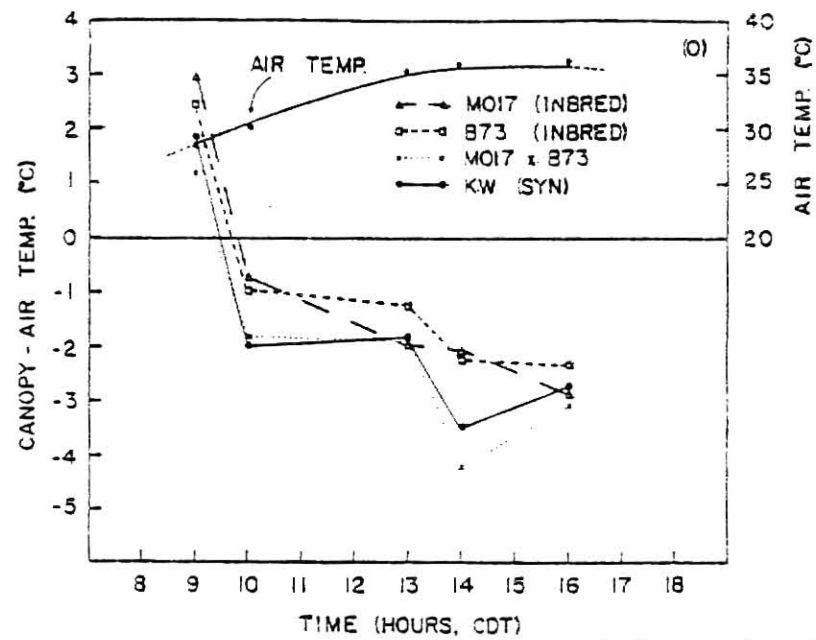

Fig. A2.2. Canopy-air temperature (ΔT) trends of Mo17 x B73, its inbred parents and KW(SYN), IRR, 9 August, 1979.

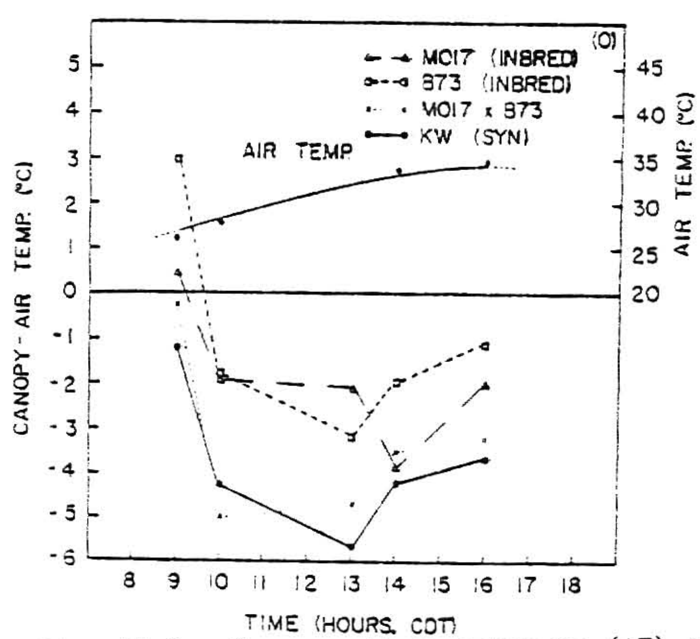

Fig. A2.3. Canopy-air temperature (ΔT) trends of Mo17 x B73, its inbred parents and KW(SYN), NON-IRR, 3 August, 1979.

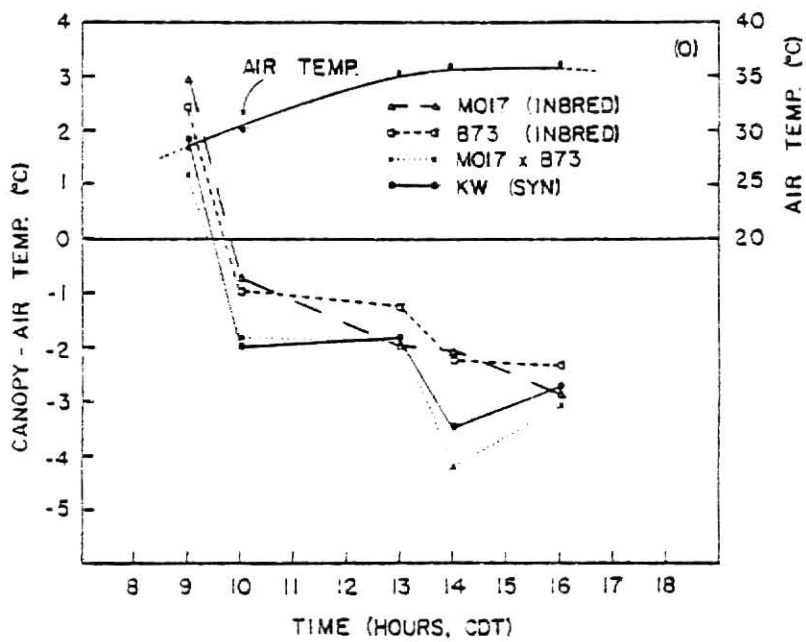

Fig. A2.4. Canopy-air temperature (ΔT) trends of Mo17 x B73, its inbred parents and KW(SYN), NON-IRR, 22 August, 1979.

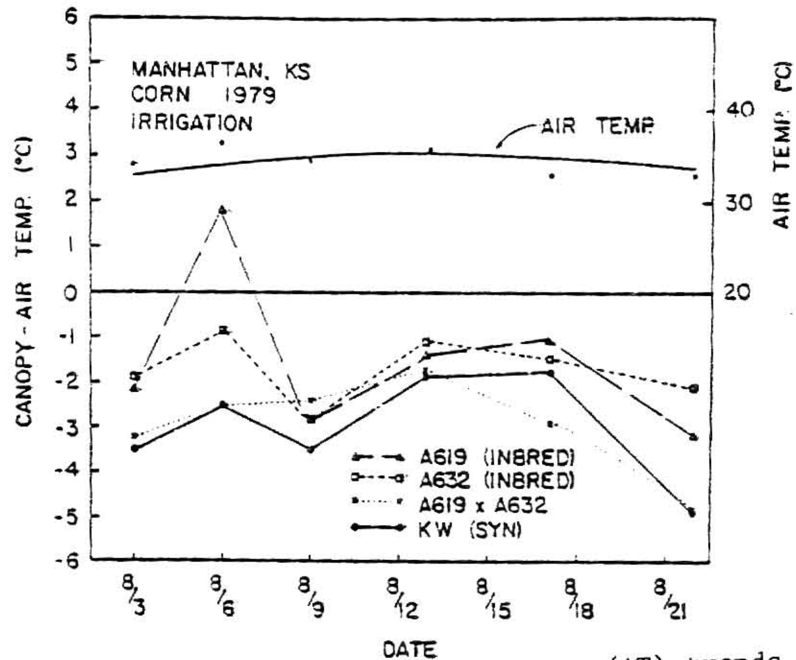

Fig. A2.5. Canopy-air temperature (ΔT) trends of A619 x A632, its inbred parents and KW(SYN) taken at 1300 CDT on various dates under irrigated condition. (summer, 1979)

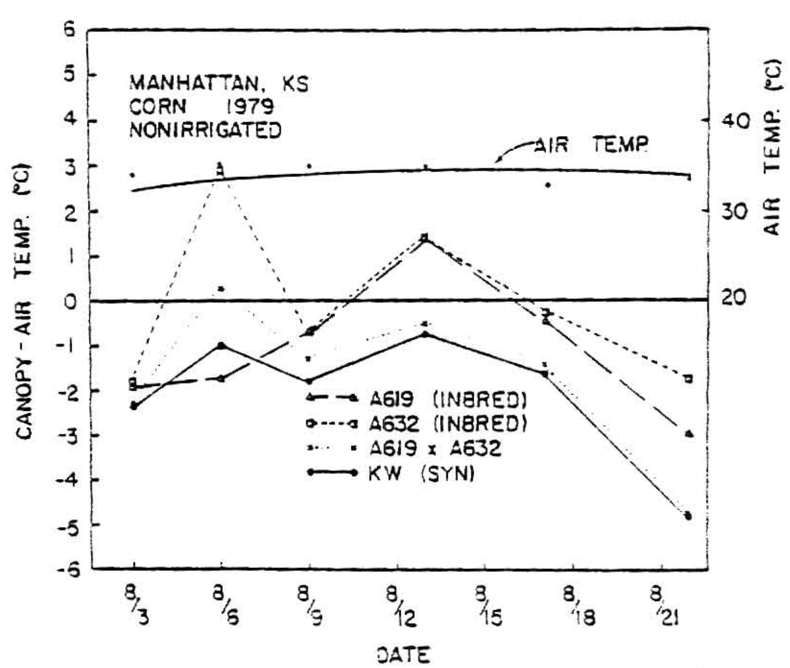

Fig. A2.6. Canopy-air temperature (ΔT) trends of A619 x A632, its inbred parents and KW(SYN) taken at 1300 CDT on various dates under non-irrigated condition. (summer, 1979)

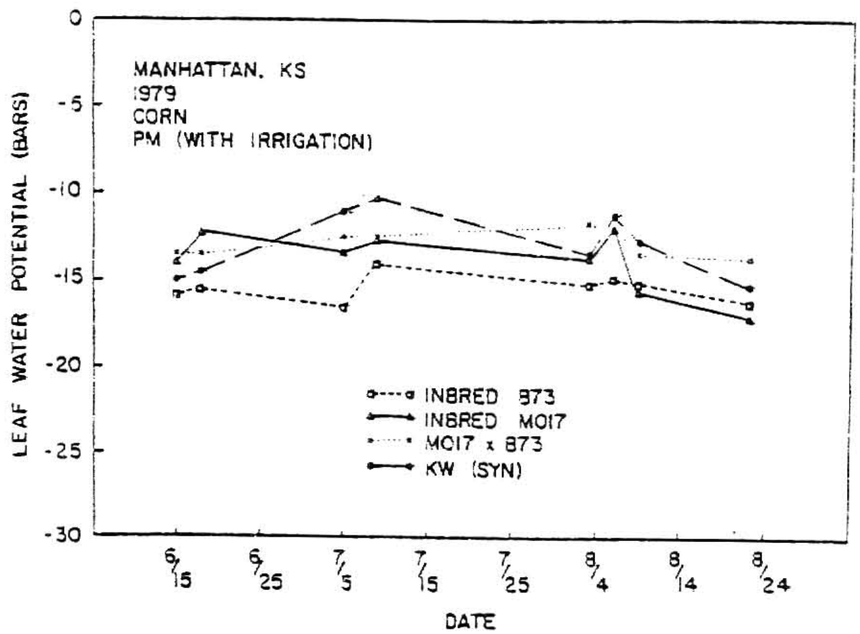

Fig. A2.7. Leaf-water potential trends of Mo17 x B73, its inbred parents and KW(SYN), pm values under irrigated condition. (summer, 1979)

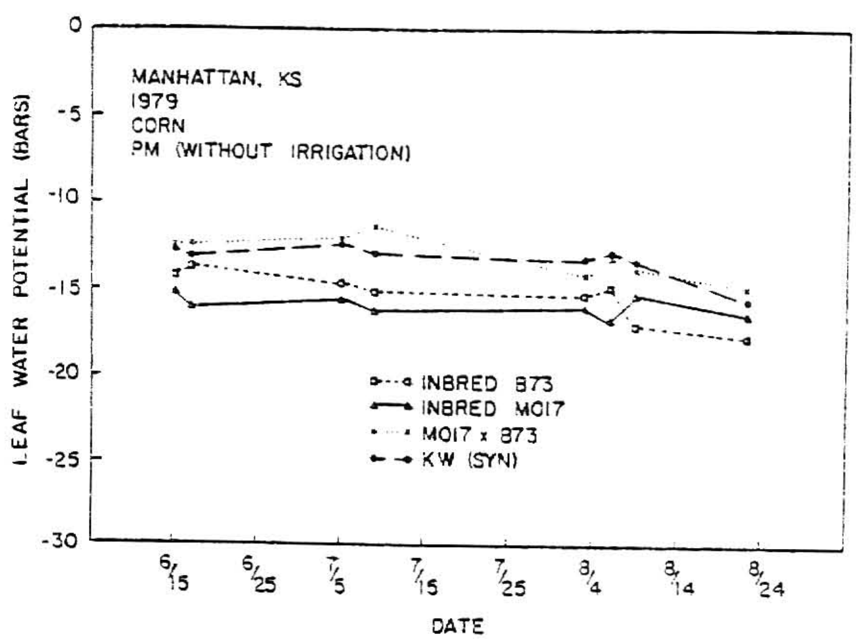

Fig. A2.8. Leaf-water potential trends of Mo17 x B73, its inbred parents and KW(SYN), pm values under non-irrigated condition. (summer, 1979)

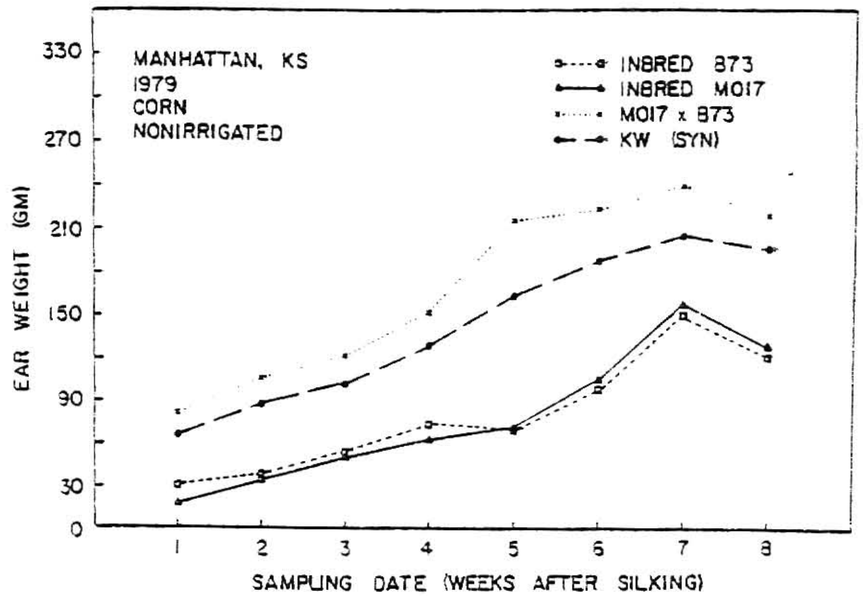

Fig. A2.9. Trends in ear dry weights of Mo17 x B73, its inbred parents and KW(SYN) under non-irrigated condition. (summer, 1979)

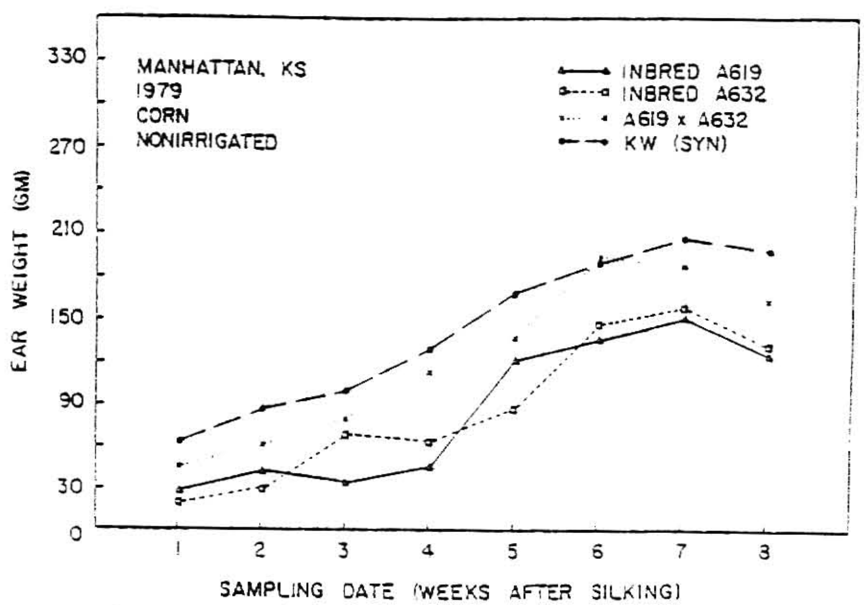

Fig. A2.10. Trends in ear dry weights of A619 x A632, its inbred parents and KW(SYN) under non-irrigated condition. (summer, 1979)

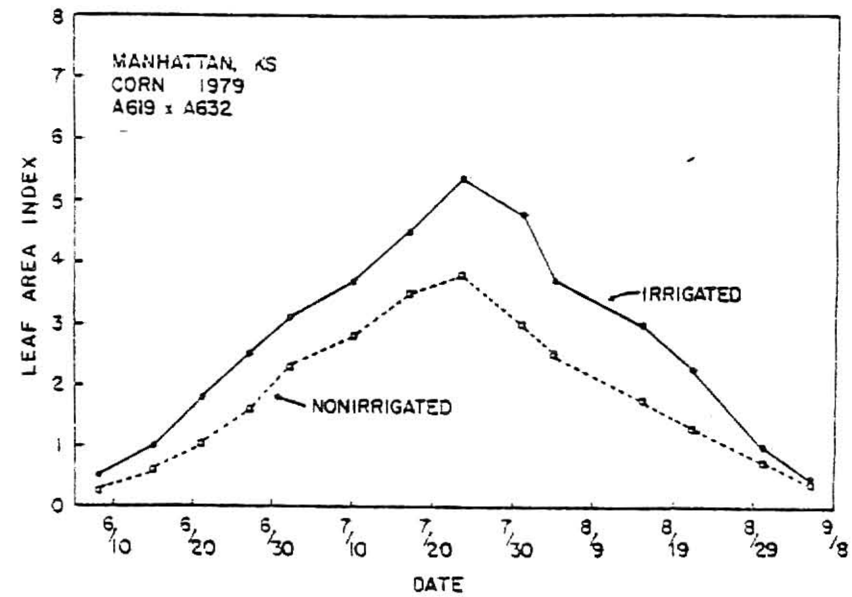

Fig. A2.11. LAI trends of A619 x A632 under irrigated and non-irrigated conditions. (summer, 1979)

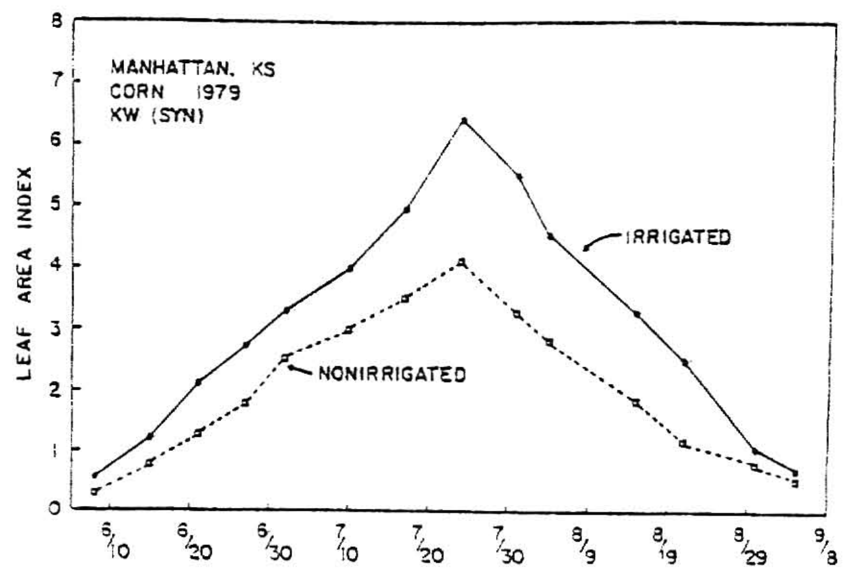

Fig. A2.12. LAI trends of KW(SYN) under irrigated and non-irrigated conditions. (summer, 1979)

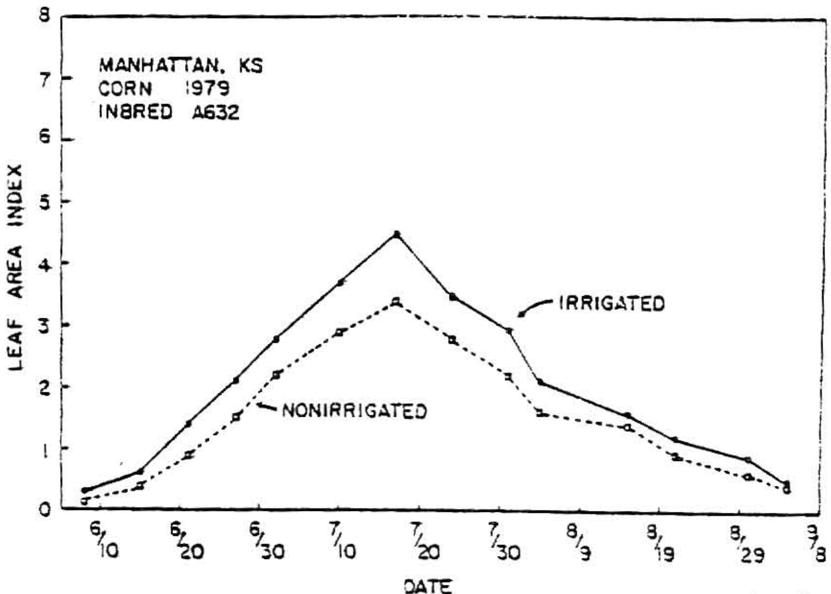

Fig. A2.13. LAI trends of inbred A632 under irrigated and non-irrigated conditions. (summer, 1979)

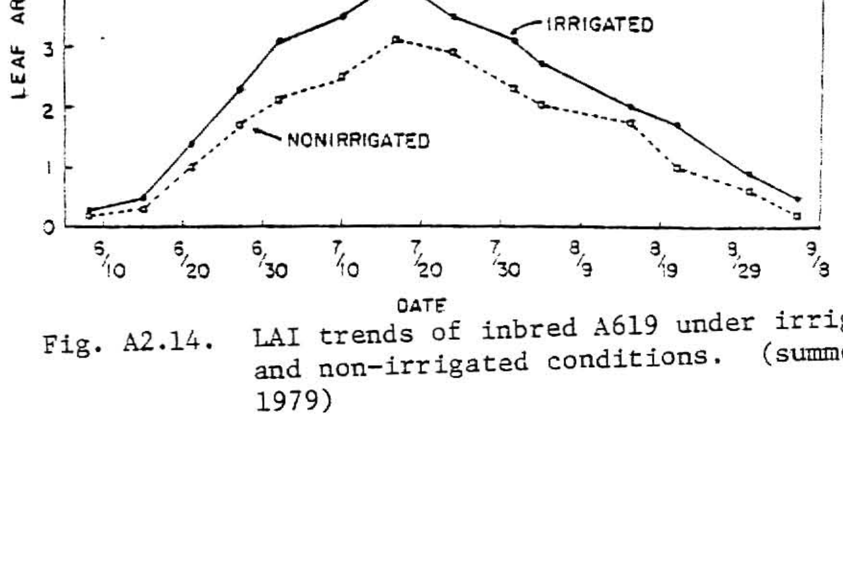

Fig. A2.14. LAI trends of inbred A619 under irrigated and non-irrigated conditions. (summer, 1979)

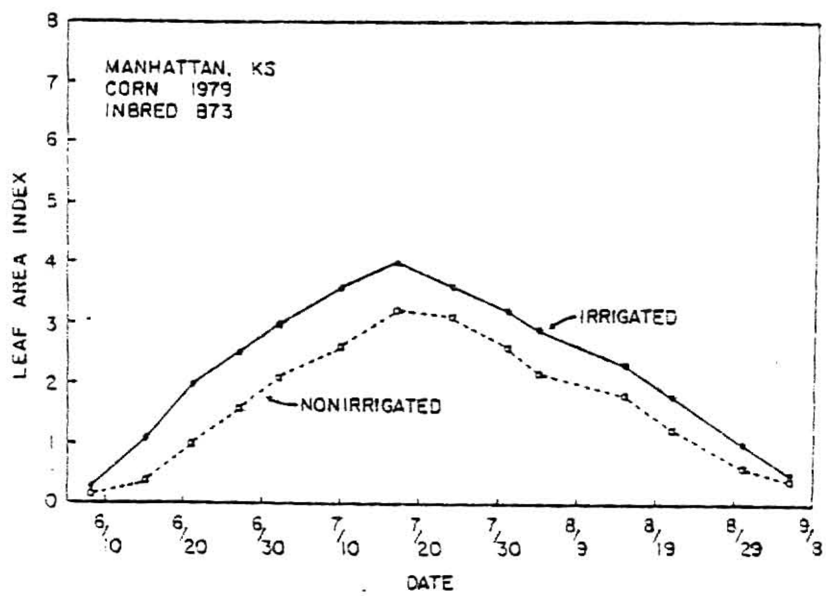

Fig. A2.15. LAI trends of inbred B73 under irrigated and non-irrigated conditions. (summer, 1979)

APPENDIX TABLES

Table A1.0. Cumulative evapotranspiration (ET) values (cm) of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1978)

	June 9th to June 15th		June 15th to June 22nd		June 22nd to June 29th		June 29th to July 7th		July 7th to July 14th		July 14th to July 19th		July 19th to July 25th		July 25th to Aug. 3rd	
Entry	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR
A632	1.04	.90	1.56	2.01	2.21	3.92	4.16	6.00	3.46	4.69	3.25	4.30	4.86	5.96	4.32	5.24
			2.60	2.91	4.81	6.83	8.97	12.83	12.43	17.52	15.68	21.82	20.54	27.78	24.86	33.02
A619	1.55	1.63	1.67	1.80	2.30	3.50	3.50	5.92	4.01	5.23	2.89	4.00	3.90	5.14	2.76	4.87
			3.22	3.43	5.52	6.93	9.02	12.85	13.03	18.08	15.92	22.08	19.82	27.22	22.58	32.09
A619 x A632	1.20	1.57	1.35	1.76	2.81	3.90	6.34	8.02	4.60	6.70	2.40	3.53	5.70	6.54	3.00	4.10
			2.55	3.33	5.36	7.23	11.70	15.25	16.30	21.95	18.70	25.48	24.40	32.02	27.40	36.12
Mo17	1.32	1.50	1.38	1.70	2.70	5.33	4.09	6.10	2.98	4.35	4.18	5.03	3.00	4.38	4.10	5.70
			2.70	3.20	5.40	8.53	9.49	14.63	12.47	18.98	16.65	24.01	19.65	28.30	23.75	34.09
B73	1.25	1.34	1.31	1.50	1.67	2.08	5.81	7.67	4.20	6.60	3.23	3.96	3.21	6.34	3.47	2.50
			2.56	2.84	4.23	4.92	10.04	12.59	14.24	19.19	17.47	23.15	20.68	29.49	24.15	31.99
Mo17 x B73	1.08	1.27	1.73	2.10	4.56	5.95	5.87	7.10	4.29	6.40	4.50	5.25	4.06	5.60	3.06	4.60
			2.81	3.37	7.37	9.32	13.24	16.42	17.53	22.82	22.03	28.07	26.09	33.67	25.15	38.27

Table A1.0 cont'd. Cumulative evapotranspiration (ET) values (cm) cont'd. of the corn genotypes, under irrigated (IRR) and non-irrigated conditions. (summer 1978)

	Aug. 3rd to Aug. 7th		Aug. 7th to Aug. 14th		Aug. 14th to Aug. 21st		Aug. 21st to Aug. 30th		Aug. 30th to Sept. 5th		ΣET (cm)		WUE kg/ha/cm	
Entry	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR
A632	1.80	2.08	2.50	3.40	4.01	5.40	2.60	3.60	1.85	3.20				
	26.66	35.10	29.16	38.50	33.17	35.77	35.77	47.50	37.62	50.70	37.62	50.70	27.44	41.73
A619	3.70	2.79	2.10	3.90	3.50	4.54	2.15	3.08	2.17	3.40				
	26.28	34.88	28.38	38.78	31.88	43.32	34.03	46.40	36.20	49.80	36.20	49.80	50.19	53.11
A619 x A632	3.05	3.74	2.45	4.00	2.54	3.60	2.80	3.40	2.13	2.90				
	30.45	39.86	32.90	43.86	35.44	47.46	38.24	50.86	40.37	53.76	40.37	53.76	78.65	106.78
Mo17	2.80	3.18	2.72	3.79	1.90	3.56	2.14	3.79	1.80	2.94				
	26.55	37.28	29.27	41.06	31.17	44.62	33.31	48.41	35.11	51.35	35.11	50.35	51.56	51.70
B73	3.05	2.46	2.18	4.96	2.10	3.56	2.00	3.09	1.85	2.20				
	27.20	34.45	29.38	39.41	31.48	42.97	33.48	46.06	35.33	48.26	35.33	48.26	56.26	61.34
Mo17 x B73	3.27	3.18	2.50	4.10	2.20	3.50	1.86	3.40	1.40	2.90				
	32.42	41.45	34.92	45.55	37.12	49.05	38.98	52.45	40.38	55.35	40.38	55.35	99.85	128.82

Table A1.1. Corn growth stages (1978)

Entry	Emergence	50% Tasseling	50% Silking	Physiological maturity	Harvesting	Average plant height
Mo17	25 May	12 July	19 July	28 Aug.	5 Sept.	144.0m
B73	25 May	10 July	17 July	26 Aug.	5 Sept.	155.2m
Mo17 x B73	23 May	12 July	18 July	28 Aug.	5 Sept.	199.2m
A632	25 May	10 July	17 July	25 Aug.	5 Sept.	138.4m
A619	25 May	8 July	17 July	28 Aug.	5 Sept.	119.2m
A619 x A632	23 May	10 July	16 July	25 Aug.	5 Sept.	165.2m

Table A1.2. Leaf area index (LAI) of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1978)

Entry	June 21st		June 29th		July 7th		July 15th		July 23rd	
	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR
A619 x A632	.90	1.30	1.42	2.06	2.10	2.61	3.43	3.86	4.14	4.81
A619	.40	.52	.98	1.30	1.52	2.03	2.10	2.48	2.32	2.95
A632	.35	.49	.94	1.23	1.35	1.96	1.83	2.40	2.14	2.48
Mo17 x B73	.92	1.48	1.35	1.90	2.19	2.81	3.15	4.10	5.20	5.80
Mo17	.42	.56	.65	.87	1.11	1.57	1.40	1.80	2.24	2.55
B73	.50	.79	.87	1.49	1.33	2.29	2.04	2.55	2.65	3.04

Entry	July 31st		Aug. 8th		Aug. 16th		Aug. 24th		Sept. 1st	
	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR
A619 x A632	3.10	3.50	2.40	2.80	1.03	1.50	.56	.80	0	0
A619	1.14	1.62	.85	1.17	.42	.53	0	0	0	0
A632	1.10	1.40	.70	1.25	.40	.50	0	0	0	0
Mo17 x B73	3.17	3.91	2.41	3.40	1.60	1.95	.74	.93	0	0
Mo17	1.49	1.78	1.12	1.42	.58	.65	0	0	0	0
B73	1.86	2.35	1.30	1.55	.61	.72	0	0	0	0

Table 2A.0. Approximate dates for major growth and development stages of the corn genotypes, Manhattan, Kansas. (summer, 1979)

Entry	Full Emergence	50% Tasseling	50% Silking	Physiological maturity	Harvesting	Average plant height (cm)
Mo17	29 May	20 July	27 July	11 Sept.	21 Sept.	166.3
B73	26 May	19 July	25 July	10 Sept.	21 Sept.	167.3
Mo17 x B73	26 May	18 July	24 July	12 Sept.	21 Sept.	200.7
A632	29 May	18 July	25 July	10 Sept.	21.Sept.	137.0
A619	29 May	16 July	23 July	10 Sept.	21 Sept.	159.0
A619 x A632	26 May	16 July	22 July	10 Sept.	21 Sept.	176.0
KW(SYN)	28 May	17 July	24 July	13 Sept.	21 Sept.	211.7

Table A2.1 Mean stomatal resistance values (sec cm^{-1}) of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1979)

	(sec cm^{-1}) 0900 Hours		(sec cm^{-1}) 1100 Hours		(sec cm^{-1}) 1400 Hours		(sec cm^{-1}) 1600 Hours	
Entry	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR
Date: 18 June 79								
A632	2.1	1.6			1.8	1.1		
A619	2.4	1.7			2.0	2.0		
A619 x A632	1.7	1.9			1.6	1.5		
Mo17	1.8	1.3			2.8	2.1		
B73	2.8	1.6			2.2	2.1		
Mo17 x B73	2.1	2.0			3.0	2.2		
KW(SYN)	2.5	1.7			2.3	2.4		
Date: 27 July 79								
A632	1.5	.9			1.7	.9		
A619	1.6	1.5			2.5	1.3		
A619 x A632	2.4	1.0			2.5	1.4		
Mo17	1.9	1.2			2.1	1.6		
B73	2.0	1.4			2.3	1.2		
Mo17 x B73	2.4	2.1			2.5	1.4		
KW(SYN)	1.0	1.3			3.0	1.1		
Date: 9 August 79								
A632	2.5	1.2	3.0	1.9	4.3	2.3	3.2	2.4
A619	3.3	2.1	3.5	2.6	3.1	2.5	4.8	3.5
A619 x A632	2.2	1.3	3.2	2.1	4.2	2.6	4.9	3.0
Mo17	2.3	1.4	2.7	2.4	3.1	3.6	3.8	3.4
B73	2.5	2.2	3.0	2.9	4.2	2.4	5.9	4.2
Mo17 x B73	2.4	2.0	3.7	2.9	4.0	3.0	3.9	2.1
KW(SYN)	2.6	1.8	2.4	2.1	2.7	2.3	1.9	2.7
Date: 22 August 79								
A632	3.5	2.3	1.5	1.2	2.8	2.1	3.2	2.3
A619	2.4	2.0	1.8	1.5	2.5	1.9	2.7	2.4
A619 x A632	2.9	2.5	2.4	1.8	2.6	1.6	4.1	2.5
Mo17	4.4	3.7	2.5	1.9	3.0	1.5	3.4	2.9
B73	2.8	3.0	2.8	1.4	2.9	2.5	3.9	2.6
Mo17 x B73	2.4	2.1	4.0	1.6	2.8	2.0	3.0	2.5
KW(SYN)	2.6	2.8	2.8	1.5	3.2	1.8	3.1	2.5

Table A2.2. Leaf area index (LAI) of the corn genotypes, under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1979)

Entry	June 8th		June 15th		June 21st		June 27th		July 2nd		July 10th		July 17th		July 24th	
	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR
Mo17	.15	.20	.50	.70	1.10	1.80	1.50	2.30	2.10	3.00	2.81	3.60	3.30	4.30	2.40	3.50
B73	.23	.31	.42	1.10	1.00	2.00	1.63	2.53	2.10	2.94	2.64	3.62	3.20	4.05	3.05	3.64
Mo17 x B73	.42	.71	.84	1.53	1.40	2.43	2.07	2.94	2.79	3.64	3.50	4.50	4.16	5.80	4.58	7.20
KW(SYN)	.29	.52	.75	1.15	1.28	2.09	1.81	2.74	2.50	3.27	2.95	3.97	3.51	4.92	4.10	6.35
A632	.13	.18	.42	.64	.93	1.43	1.57	2.11	2.18	2.83	2.85	3.70	3.42	4.47	2.80	3.59
A619	.19	.28	.36	.51	.98	1.92	1.70	2.53	2.07	3.05	2.51	3.54	3.18	4.11	2.94	3.59
A619 x A632	.25	.49	.64	.97	1.09	1.82	1.61	2.53	2.27	3.12	2.83	3.65	3.45	4.50	3.85	5.38

Entry	July 31st		Aug. 4th		Aug. 15th		Aug. 21st		Aug. 30th		Sept. 5th		Sept. 14th	
	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR
Mo17	2.00	3.10	1.70	2.60	1.50	2.20	1.00	1.30	.50	.80	.20	.30	0	0
B73	2.60	3.23	2.15	2.91	1.82	2.30	1.25	1.80	.53	1.00	.38	.51	0	0
Mo17 x B73	3.97	6.40	3.04	5.10	2.10	3.92	1.60	2.77	.96	1.28	.57	.86	0	0
KW(SYN)	3.28	5.51	2.79	4.62	1.84	3.22	1.38	2.57	.79	1.14	.46	.65	0	0
A632	2.21	2.94	1.67	2.07	1.38	1.63	.92	1.17	.61	.84	.35	.46	0	0
A619	2.32	3.08	2.05	2.68	1.74	2.00	.98	1.70	.65	.93	.30	.45	0	0
A619 x A632	2.95	4.82	2.43	3.74	1.72	2.98	1.30	2.26	.69	1.06	.41	.59	0	0

Table A2.3. Cumulative evapotranspiration values (cm) and water use efficiency (WUE) kg/ha/cm of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1979)

Entry	June 11th to June 19th NON-IRR	June 11th to June 19th IRR	June 19th to June 27th NON-IRR	June 19th to June 27th IRR	June 27th to July 3rd NON-IRR	June 27th to July 3rd IRR	July 3rd to July 12th NON-IRR	July 3rd to July 12th IRR	July 12th to July 20th NON-IRR	July 12th to July 20th IRR	July 20th to July 27th NON-IRR	July 20th to July 27th IRR	July 27th to July 31st NON-IRR	July 27th to July 31st IRR	July 31st to Aug. 6th NON-IRR	July 31st to Aug. 6th IRR
A619	1.36	1.27	2.32	2.72	1.92	2.94	4.32	5.04	4.30	5.68	3.68	3.98	2.04	2.20	3.70	3.00
			3.68	3.99	5.60	6.93	9.92	11.97	14.22	17.65	17.86	21.63	19.90	23.83	23.60	26.83
A632	1.20	1.44	2.00	2.40	1.74	3.18	4.50	5.40	4.72	5.92	4.90	4.76	3.36	2.80	2.64	3.90
			3.20	3.84	4.94	7.02	9.44	12.42	14.16	18.34	19.06	23.10	22.40	25.90	25.06	25.80
A619 x A632	.96	1.28	1.84	2.32	1.56	2.94	4.59	5.22	5.04	6.40	4.06	4.27	2.80	3.28	4.14	4.50
			2.80	3.60	4.36	6.54	8.95	11.76	13.99	18.16	18.05	22.43	20.85	25.71	24.99	30.21
Mo17	1.52	1.20	1.84	2.40	2.70	3.06	4.14	5.49	4.00	5.60	3.71	4.41	2.48	2.96	3.66	4.08
			3.36	3.60	6.06	6.66	10.20	12.15	14.20	17.75	17.91	22.16	20.39	25.12	24.05	29.20
B73	.96	1.12	2.08	2.40	2.34	2.76	4.50	5.40	4.08	5.76	4.27	5.18	2.32	2.63	3.48	4.08
			3.04	3.52	5.38	6.28	9.88	11.68	13.96	17.44	18.23	22.62	20.55	25.25	24.03	29.33
Mo17 x B73	1.44	1.68	1.92	2.24	2.22	2.88	4.77	5.58	4.80	5.84	4.50	5.62	2.20	2.96	3.72	4.74
			3.36	3.92	5.58	6.80	10.35	12.38	15.15	18.22	19.65	23.84	21.85	26.80	25.57	31.54
KW(SYN)	1.52	1.36	2.18	2.24	2.58	3.66	4.86	6.30	4.48	6.24	4.34	4.06	6.24	2.88	3.54	4.20
			3.70	3.60	6.28	7.26	11.14	13.56	15.62	19.80	19.96	23.86	26.20	26.74	29.74	30.94

Table A2.3 cont'd. Cumulative evapotranspiration (ET) values (cm) and water use of efficiency (WUE) kg/ha/cm of the corn genotypes under irrigated (IRR) and non-irrigated (NON-IRR) conditions. (summer, 1979)

Entry	Aug. 6th to Aug. 17th		Aug. 17th to Aug. 23rd		Aug. 23rd to Aug. 30th		Aug. 30th to Sept. 10th		Sept. 10th to Sept. 20th		ΣET (cm)		WUE kg/ha/cm	
	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR	NON-IRR	IRR
A619	7.04	7.48	2.76	3.66	2.80	3.64	2.75	3.30	2.30	2.71				
	30.64	24.21	33.40	37.97	36.20	41.61	38.95	44.91	41.25	47.62	41.25	47.62	52.10	63.80
A632	5.72	7.70	1.86	3.12	3.15	3.50	2.86	2.97	2.40	2.20				
	30.78	37.50	32.64	40.62	35.79	44.12	38.65	47.09	41.05	49.29	41.05	49.29	47.95	80.16
A619 x A632	6.49	8.14	2.04	3.60	2.10	3.29	2.64	3.08	2.00	2.30				
	31.48	38.35	33.52	41.95	35.62	45.24	38.26	48.32	40.26	50.62	40.26	50.62	109.28	124.69
Mo17	4.51	6.82	2.16	3.48	2.58	3.36	2.42	3.19	2.30	2.50				
	28.56	36.02	30.72	39.50	33.30	42.86	35.72	46.05	38.02	48.55	38.02	48.55	49.91	51.29
B73	5.28	7.37	2.52	3.60	2.10	3.08	2.20	2.64	1.90	2.00				
	29.31	36.70	31.83	40.30	33.93	43.38	36.13	46.02	38.03	48.02	38.03	48.02	53.61	68.42
Mo17 x B73	6.71	9.57	2.52	3.60	2.10	3.08	2.22	2.64	1.90	2.10				
	82.28	41.11	34.80	44.71	36.90	47.79	39.12	50.43	41.02	52.53	41.02	52.53	171.13	180.40
KW(SYN)	6.60	9.90	2.88	3.84	2.24	2.87	2.75	3.30	2.00	2.40				
	36.34	40.84	39.22	44.68	41.46	47.56	44.21	50.85	46.21	53.25	46.21	53.25	116.21	125.30

INDICATORS OF STRESS IN PARTICULAR CORN (*Zea mays* L.)

GENOTYPES UNDER FIELD CONDITIONS

by

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B. Sc. (Agric.) Kansas State University, 1978

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1980

Indicators of Stress in Corn (Zea mays L.)

Genotypes Under Field Conditions.

Abstract:

To isolate plant genotypes that can withstand environmental factors such as heat and drought stress, it is desirable to describe and measure characteristics of plants for possible resistance to heat and drought. A field study was conducted during summer 78 and 79, in which the following corn genotypes: Kansas White Synthetic KW(SYN), hybrids Mo17 x B73, A619 x A632 and their respective inbreds -- Mo17, B73, A619 and A632 were compared in terms of their canopy-air temperature differential (ΔT), leaf-water potentials, and stomatal diffusive resistance under irrigation (IRR) and without irrigation (NON-IRR). Measurements on canopy and air temperatures, soil moisture, leaf area, leaf-water potential, stomatal diffusive resistance and ear dry weights were taken. The results indicated that the canopy temperatures were sensitive enough to distinguish among the corn genotypes both under IRR and NON-IRR conditions. For instance on 22 August 79, 1300 CDT, KW(SYN) indicated a canopy temperature of about 3°C cooler than inbred Mo17 and, the two hybrids and the KW(SYN) were consistently cooler than the inbreds. The leaf-water potentials for summer 78, showed some distinct differences among the corn genotypes. However, the leaf-water potential data for summer 79, showed no substantial differences among the corn genotypes or between the two moisture conditions. The stomatal resistance values showed no consistent trend or variation which could

clearly be associated with or distinguish between the genotypes. KW (SYN) and two hybrids Mo17 x B73 and A619 x A632 showed higher WUE than the inbreds and this was also reflected in their ear dry weight trends, kernel weights, and grain yields.