

DRY MATTER PRODUCTION AND
DISTRIBUTION BY TWO MAIZE (ZEA MAYS L.)
HYBRIDS AND THEIR PARENTAL LINES

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ABSTRACT

A study of dry matter accumulation and N, P distribution and other agronomic characters was conducted on two hybrids of maize (Zea mays L.) and their parental lines.

Highly significant difference was observed in total and ear dry matter accumulation among the genotypes, the growth stages and growth stage by genotype interaction. The highest total and ear dry matter were produced at the final stage of maturity. The analysis of leaf and stalk dry matter indicated that there was highly significant difference among genotypes and growth stages. However, there was no interaction. In general a decreasing tendency of dry matter accumulation was observed in the non grain part as growth stage advanced. This loss is assumed to be due to translocation of carbohydrates to the grain late in the season as grain development advances. The association between leaf number and total dry matter production was found to be positive and significant ($r = 0.86$). 31.4% and 68.6% averaged over all the genotypes was grain and non grain, respectively. The translocation of shoot dry matter into the ear indicated that H611

and its parental lines are more efficient than S.R. 52 and its parental lines. Highest harvest index of 0.44 and 0.43 was produced by H611 and SR52, respectively. Further more, an increasing and a decreasing trend of dry matter production was observed in the different plant parts as growth stage advances except for the ear and grain. From this study it could be suggested that Parental lines which are efficient in production and distribution of dry matter should be included in future breeding program to produce high yielding hybrids. The differences observed in the production and translocation of dry matter after flowering suggested that genotypes having such characters are very important. Eventhough, it is imposible to point out a particular growth stage at which hybrid vigor is expressed, insect pests, diseases, moisture and nutrient deficiencies which affect the rate of leaf development should be avoided in order to have a healthy plant growth for maximum yield production.

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INTRODUCTION

Use and Economic Importance of Maize (Zea mays L.)

Next to wheat and rice, maize is the most important cereal in the world and is the highest yielding of all grain crops. It is a staple food, particularly in the tropics; it is used as a livestock feed especially in the developed countries, and is a raw material for many industrial products such as starch, syrup or sugar, oil alcohol, etc. Numerous important products and by-products are reported to be obtained from maize (FAO, 1972).

Classification, Origin and distribution

Maydae is one of the 15 tribes of the family Graminae into which maize is classified under the genus *Zea*. Many researchers reported that maize originated in southern Mexico. Now it is grown or cultivated throughout the world in areas with suitable growing conditions. The reasons for its popularity to be grown in many parts of the world are (i) it gives one of the highest yield per man-hour of labor invested on it, (ii) it provides nutrients in a compact form, (iii) it is easily transportable, (iv) the husks give protection against birds and rain, (v) it is easy to harvest and hull, and it doesn't shatter, (vi) it stores well if properly dried (vii) it can be harvested over a long period of time (Purseglove, 1972).

Maize (*Zea mays* L.) is said to have been introduced into East Africa and hence into Ethiopia, by the Portugese in the 16th

or 17th century. There are many different varieties, the most important among them are dent maize (Zea mays var indentata). Flint maize (Zea mays var indurata). Most of the maize in Ethiopia is very heterogenous. Late types are prevalent (Huffnagel, 1961; Acland, 1975).

Maize is one of the most popularly grown cereals in Ethiopia. It ranks first in yield per hectare, (10 to 16 Q/ha), fourth in total grain yield (1,470,000 tons), and fifth in total hectareage it occupies (882,000 ha.) coming after tef, barley, sorghum and wheat. There was a constant and gradual hectareage increase for the production of maize. The principal maize producing administrative regions of Ethiopia are Wollega, Sidamo, Keffa, Illubabor, GamoGofa, and a high percentage of cultivated farm in Hararge (Dejene, 1979).

According to the Food and Agricultural Organization of the United Nations (FAO), the area under cultivation of maize has increased from 742,000 hectares to 1,001,000 hectares from 1976 to 1979, respectively. Whereas, the yield has decreased from 14.5 Q/ha to 10.7 Q/ha which is far below the average world production of (32.7 Q/ha) (FAO, 1980). This low yield could be attributed to several factors such as unfavorable enviromental conditions, genetic and management practices.

Dry Matter

The distribution of dry matter over the various parts of the plant is not only important for the evaluation of the product finally harvested, but also for the growth rate and yield level. Differences in growth rate between species and even varieties are mainly due to the rate at which newly produced dry matter is converted to assimilating tissue (VanDobben, 1962 - 63). Owing to the inverse response of different crops and the mutual effect of the various growth factors, research has been especially directed to the general inter-relationship of assimilation and dissimilation. The formative development of the plant is extremely important to the grower.

Because it determines to what extent and during which period of the year the crop is able to make use of available solar energy, and moreover the values of production is largely influenced by the distribution over the various parts of the dry matter produced. The latter factor plays a very divergent role in various crops because, as for example, in green fodder crops, all parts above ground are valuable as cattle feed. On the other hand in many feed and food crops the harvest only constitute a small part of the formative development. As a result the influence of distribution of dry matter inside the plant has become a field of research which is constantly expanding and in which many phenomena occur which are difficult to fit into general inter-relationships (Brouwer, 1962-63).

It also stands to reason that agriculture in many cases will profit by a dry-matter accumulation which is as large as possible in the product to be harvested for next to quality, quantity is the most important aspect. The parts which are not harvested in certain sense keep balance of the plant but often a necessity, as they serve to provide the product to be harvested with essentials for its development. There is no gaining of grain without straw or stalk or leaves. The question that may be asked is whether it is possible to increase the useful output by influencing the percentage of dry-matter in the product to be harvested. With this regard studies were carried out and an increase of dry matter was achieved through the manipulation of population densities (Stivers et al, 1971; Allison, 1969; Adelana, 1972; Bashir and Shalaby, 1976), fertilizer rate (Hanway, 1962; Brouwer, 1962; Spratt and Gasser, 1970; Moss and Peaslee, 1972; Singh and Anderson, 1978; Jordan et al, 1950; Gasman et al, 1980), moisture (Mcpherson and Bouwer, 1977; Alberda, 1968; Hodges et al, 1979; Wardlaw, 1967; Denmead and Shaw, 1960; Doyel and Fisher, 1980), genotype (Hoshino and Ujihara, 1978; Diaz and Rivera, 1960; Hanway and Russel, 1969; Johnson and Tanner, 1972; Rhodes and Jenkins, 1976), temperature (Cooper and Shaw 1980; Benoit and Regland, 1965; Regland et al, 1965; Knoll et al, 1964).

Furthermore, the importance of dry-matter production and distribution was emphasised by Brouwer (1962) in that an increase in yield resulting from the use of better varieties may be limited to a shift in the distribution of dry-matter to more valuable organs without an increment in total yield. In addition, Yoshida (1972) in his review of physiological aspect of grain crops indicated that the economic yield (grain yield) could be increased either by increasing total dry-matter or by increasing harvest index according to the following equation : Y_{econ} (economic yield) = K_{econ} (harvest index) X Y_{biol} (biological yield or total dry matter. Thus, emphasizing the importance of the production and distribution of dry-matter to the final grain yield.

Yield in the tropics is much lower than in the temperate zones. The tropical maize allocates less of its total dry-matter to grain (35-40%) as compared to 50% of the total dry-matter of the temperate maize (Inter-national Agric.Dev., 1980). This being one of the many reasons for obtaining low yield, the present study is undertaken to indicate the trend of production and distribution of dry-matter of two maize hybrids and their parental lines at different stages of growth to accomplish the following specific objectives:

1. To determine the basic principle of dry-matter production and distribution to different maize plant parts at different growth stages.
2. To determine the stages at which highest dry-matter is produced to help indicate the active growth stage and provide the necessary management practices in order to obtain higher yield.
3. To find out the stages at which the considered hybrids differ in dry-matter production, from their parental lines and thus resulting in the increased final grain yield.
4. To identify those genotypes which are efficient in translocating more of the produced dry-matter to the sink (grain) to utilize them in future breeding programme.

REVIEW OF LITERATURE

Translocation of Dry-Matter

The aim of most types of agriculture is to obtain high yield of those plant parts which are of economic interest. The yield depends on the total dry-matter present at harvest and on dry-matter distribution over the parts of the plants. To analyze the productivity of field crops one should know the actual and optimum daily dry-matter production per unit of soil area and the actual and optimum patterns of dry-matter distribution during the development of the crop (Gaastra, 1962-63). Processes associated with allocation of photosynthate to various plant organs are one of the most important factors determining the economic yield of crops. Some aspects of these processes which underlie crop yield have been reviewed by Evans and Wardlaw (1976).

Grain yield depends on the dry-matter producing capacity of the crop. Hence, the dry-matter which is produced at the different growing stages of the crop is very important for the grain yield. Allison and Watson (1966), and Van Eijnattene (1963) have indicated that the grains start accumulating carbohydrate after flowering. The carbohydrate starts to be translocated from the stem to the ear within 2-3 weeks after silking (Dynard et al, 1966). The dry-matter continues to be stored in the stem during the first three weeks of silking due to inadequate sink, in the ear. The

eventual loss of photosynthate from the stem may be due to an adequate ear-sink capacity of the plant or to a reduction of the plant or to a reduction of photosynthate by the leaf canopy towards the end of the growing season (Asanum et al, 1967).

The decrease in stem weight occurred during the period in which the crop growth rate declined to essentially zero, suggesting an abrupt reduction in canopy effectiveness. (Adelana and Me Melbourne, 1972). The decrease reported in other experiments (Dynard et al, 1969) seem to indicate situations of intermediate canopy effectiveness during the ear filling period. It was also indicated by these researchers that there is 48 percent stem weight loss. Eventhough, there is a general loss in the final analysis of the stem and leaf weight, there is a tendency of increase in sugar content of stems and leaves after silking (Johnson et al, 1967). On the other hand, the findings at International Center for Wheat and Maize Improvement (CIMMYT, 1974) indicated that the stem soluble sugar which was 19 percent of the dry-matter at tasseling was found to be 22 per cent at maturity indicating the inability of the grain to store the available soluble sugar. This suggests that there is a room for improving yield through selection.

The works of Allison and Watson (1966) indicated that stem weight decreased in half-defoliated plants, but remained nearly constant in intact plants from two weeks after flowering. The

result suggested in half-defoliated plants the dry-matter which was supposed to be distributed to the leaves is translocated to the ears. The possibility of such movement was shown by keeping premature harvested shoot in the dark for two weeks with their cut ends in water. The dry weight of the grain increased and that of the stem, laminae, husk and cob decreased. It was finally concluded that the dry matter produced after flowering was more than sufficient for grain growth and previous photosynthate probably contributed little to the grain. Translocation of dry-matter or nutrients from different plant parts to the grain is reported as established fact. However, all plant parts do not contribute equally. This was proven by Genter et al (1970) that husks and the upper stalks showed the greatest decreases. Hence, the higher the weight in the final grain yield the better the distribution of dry-matter to the ear and the accepting capacity of the grain (Karami and Weaver, 1980). Weight that is lost from different plant parts is not always totally accepted by the sink because certain energy is also required for respiration at the expense of loss in accumulated dry-matter. According to Duncan et al (1965), the average weight loss for stalk per day was 4.8 grams while the average increase in kernel weight was 2.8 grams per day.

Effect of Genotype

The economic yield of a crop is an outcome of many factors. Comparison of different hybrids with their parental lines has

revealed that the hybrids are more efficient to produce more dry matter and hence, final grain yield. Regarding this view, Major et al (1979), and Johnson and Taner (1972), have compared the yield of 44 single cross hybrids with their parental lines over a wide range of population by determining the yield at unit interval of leaf area. The yield of inbreds was found out to be 60 percent of the mean hybrids yield regardless of whether the yields were compared at a common plant density or leaf area index. Under such condition the difference was higher for the hybrids than for the inbreds.

The rate of daily dry-matter production vary for different varieties. However, there could be no differences in the final grain due to the inability of the sink (grain) to accept the produced dry-matter (Hanway and Russel, 1969).

According to Diaz and Rivera (1980) dry-matter produced per plant was generally highest in those genotypes with the greatest number of days to flowering. It was also reported that these group of genotypes showed the lowest dry-matter accumulation in grain. Comparison of short and tall isogenic lines has revealed that lateness is correlated with tallness. Even though lodging is a problem, grain yield and total dry-matter have **positive correlation** with tallness (Hoshino et al, 1978). Bucher and Ester (1976) noted the efficiency of dry-matter production per unit phosphorus absorbed was greatest for the later maturing hybrids which could be one of the basic differences in the yielding ability of the late varieties than the early ones.

Effect of Growth Stage

In many studies with maize, samples of the plants are collected for dry weight determination and for various kinds of laboratory analysis. In these studies, sampling is often made based on the number of days after planting, the number of days after plant emergence, plant height etc. It would facilitate and improve the evaluation and comparison of the data from different studies to know the physiological and morphological stage of plant development.

Nelson (1956) reviewed the works of Pearl and Surface in the first-quarter of the 20th century that they have recognized and grouped the growth stages of maize into four. The first or root cycle, which is marked by a rapid increase in the root system; the second, by rapid increase in the leaf area; the third, by development of reproductive organs and the last, by development of the ears and maturation.

This indicates the period of rapid dry-matter accumulation of the respective cycles. Hanway (1963) reported ten stages of maturity in the physiological development of maize plant. He grouped the early stages before tasseling or silking based on the number of days up to physiological maturity (black layer formation). Accordingly, he recognized the third stage as a period when dry-matter accumulation is rapid which coincides with the maximum leaf area.

Whereas, Gasigar (1965) mentioned that maize plants grow most rapidly just before tasseling, and its vegetative organs reached their highest weight in the next ten days. (Allison 1969), Allison and Watson (1966), Williams et al, (1965), collected samples of plant tissues and grain every two week intervals determining the dry-matter accumulation of maize plant. Except under very careful controlled conditions in fields or experimental plots there will be differences in dry-matter accumulation between different plants that have received the same treatments.

The highest total dry-matter yield per acre appeared to be between dent and glaze stages (Johnson et al, 1966). At final stage of growth the ear dry-matter was reported to be 60 percent of the total dry-matter. On the other hand, Furlani et al (1980) reported that the daily rate of nutrient uptake and dry-matter accumulation was highest between 28 and 42 days after emergence.

Population Effect

Different varieties respond differently to varying population densities in accumulating dry-matter (Sato et al, 1978). Bashir and Shalaby (1976) indicated that sowing dates and spacing seem to affect accumulation of stem dry-matter. In their study they found that wider spacing encouraged the accumulation of more dry-matter than closer ones (per plant basis). On the other hand, Hoshino et al (1978) found highly significant difference in tiller number, dry-matter accumulation and leaf area per unit area of land among

different plant densities. That is, these characters were higher in high densities than in low densities. The relative proportion of different maize plant parts varied between hybrids with different maturity rate; however, population has only slight effect (Bryand and Blaser, 1968).

Allison and Watson (1966) in their experiment showed that when maize was grown in a population near the bottom of the range the leaves produced more dry-matter than grain could accommodate, so that when some leaves are removed the grain received a larger fraction of the total dry-matter produced after flowering. Increase in population also evidently enabled the grain to accommodate proportionately more dry-matter. Although the increase with population created large sink for dry-matter, the supply of dry-matter did not increase proportionately, presumably because there was more mutual shedding and faster senescence of leaves in the denser population. Although total dry-matter increases as population increases, (Stiver et al, 1971; Adelana and Melbourne, 1972) the grain yield decreased because of competition for resources below and above the ground. Hence, the interest in the dry-matter production depends on the objective of the producer. If the producer is interested in the biological yield (total dry-matter), as in the case of silage, large populations would be preferred.

On the other hand, if the interest of the producer is on the economic yield (grain) optimum population should be determined. Allison (1969) found out that grain and total dry-matter of maize at final harvest increased by about 50 percent and 30 percent, respectively, when the population increased from 23,000 to 48,000 plants/ha, but did not increase further with population up to 74,000 plants/ha. He also mentioned that stem weight increased until 3 to 4 weeks after flowering, then it remained constant when population was 23,000 plants/ha, but decreased in denser populations.

Eventhough, total dry-matter and grain yield increase with increasing population upto optimum level the figures given here could vary with variety, environmental condition, and other management paractices.

Influence of Leaf Area

The dependence of rate of dry-matter production of crop communities on quantity of leaf surface had been well established. The relevance of leaf area is due to its influence on radiant energy interception. This was justified by the works of Shibles and Weber (1965), which indicated solar radiation and rate of dry-matter production increased with increasing leaf area development. In relation to this Russel (1972), Eik and Hanway (1966), Fakorede and Mock (1980) tried to identify the type of leaf

arrangement due to the shading effect of lower leaves by the upper leaves. Hence, any factor influencing the rate of leaf development could as well reflect upon leaf area there by causing a decrease or an increase in the economic yield of the crop. Hanway (1962) has clearly demonstrated the influence of soil nutrients on the leaf area thereby reflecting on the rate of dry matter production. Regland et al, (1965) reported the rate of growth of leaf area of maize planted early was more correlated with temperature than any factor measured, while the rate of leaf area growth of late planted maize was equally correlated with temperature and relative humidity.

The potential yield of maize grain which is produced late in the season is determined by the leaf area which always completes its growth relatively early in the season. However, less potential yield of grain will be attained if a) such as moisture deficiencies in the season or b) the leaf area prematurely reduced by some factors that result in premature death of the leaves such as nutrient deficiency, insect, disease or hail damage. Thus anything that results in the reduction of leaf area reflects upon dry-matter production thereby affecting the yielding capacity of the crop (Hanway, 1962). In their sowing date experiment, Eik and Hanway (1966) demonstrated that during the period of rapid dry-matter accumulation the curves were linear for all sowing dates, except that the phase of rapid dry-matter accumulation was shorter for late plantings due to short leaf area duration thus reflecting on the final yield.

Defoliation Effect

Maize plant may be damaged by hail, mechanical injury, insect or disease resulting in loss of photosynthetic area of the plants. This loss in leaf area, which interferes with the production of dry-matter, may occur at various times during the growing period and is expected to reduce dry-matter production thereby affecting the final grain yield. Defoliation researches have been conducted by many investigators at different times. Egharebva et al (1976) had observed significant dry-matter reduction in total dry-matter when leaves are removed within 30 days after silking. They further indicated that complete defoliation was detrimental (6.4 to 82 per cent yield loss) than partial defoliation (1.5 to 32.7 percent yield loss). However, these losses varied with time and position of the leaves on the plant (Pendelton and Hamond, 1969). The effect of 50 and 100 percent defoliation Hanway, 1969) at various stages of development of early, mid-season and late maturing maize hybrids grown at three plant populations revealed relative reduction in grain yield. He further concluded that the loss in grain yield was associated primarily with reduction in dry-matter accumulation during grain formation. On the other hand, Hick et al (1977) observed almost identical results on defoliation at later stages; however, the early complete defoliation or leaf removal in their experiment

manifested 48 percent yield increase for which they were unable to give any satisfactory answer for that particular period.

Effect of Temperature

Crop yield is determined by both the growth rate and length of the growth period. This period depends on the rhythm of development. The effect of temperature on the length of the period from emergence to flowering is independent of the effect of temperature on growth rate. This was demonstrated that when temperature is raised from 16^oc to 25^oc vegetative growth in small cereals and peas is distinctly accelerated in the seedling but only slightly in the following stage whereas development is speeded up considerably as a result the plant remained smaller at 25^oc. as compared to 16^oc. A reverse relationship was observed for maize and beans, i.e. when temperature raises from 16 to 25^oC growth is accelerated relatively more than development, so that the plant finally becomes larger. Thus maize and beans have the faculty of compensating the acceleration of growth at higher temperature by relatively still greater increase in daily growth rate (Van Dobben, 1962-63).

For some tropical crop plants, high temperatures in many regions are in fact unfavorable. For example, for rice total grain weight is higher when the grain develops and ripens under conditions gradually rising and falling temperatures, which could be explained

by the transport of carbohydrates to the grains. With high temperatures the transport is rapid but lasts for a short period only. Renewed tillering is also accelerated which depletes much carbohydrate and nutrient, whereas with low temperature the transport of materials is low and lasts long followed by late occurring senescence of leaves and the prolonged ripening of the grains which results in higher grainweight than under high temperature (Best, 1962-63). Low root zone temperature affects development and high root zone temperature likely stimulated growth (Knall et al, 1964; Cooper, 1980; Benoit et al 1965).

Bashir and shalaby (1976) quantified the relationship between dry-matter accumulation of stem plus leaf sheath and the mean daily effective temperature from sowing till flowering time. Every of one degree centigrade rise in mean daily temperature was associated by 7.69 g/plant. Low temperature affects crop yield in different ages (Powers et al, 1964). The dry-matter production increases only slightly with increasing of P concentrations in the plant tissue. At above optimum temperatures, P concentrations were quite high, but a small increase in percent phosphorus resulted in a large increase in dry-matter production indicating the influence of temperature on the uptake of nutrients thus affecting the dry-matter producing capacity of a crop.

The specific difference in temperature response are greater for development (Van Dobben, 1962-63), and since growth rate is mainly governed by the shoot-root ratio (the dry weight of the shoot over the dry-weight of the root) it may be suggested that the distribution of materials in the plant is the key to the important problem of the influence of temperature on plant production.

Effect of Moisture

The magnitude of yield reduction due to water deficits in maize (Zea mays L.) is dependent upon the growth stage at which the water deficiency occurs, and the severity and duration of the deficiency. The few days around ear emergence and pollination have been identified as being most sensitive to drought, but substantial yield losses also occur when drought occurs during vegetative growth and grain fill (Clausen and Shaw, 1970). Vaada (1961) reviewed the works of Robinson and Diamingo that in field experiment abundant moisture is essential during the tasseling stage for maximum corn yield. Water deficiency during this period caused an irreversible reduction in yield. Even though there is a crop difference Alberda (1968) had also emphasized that the yield of grass herbage has increased significantly when optimum nutrient and moisture is supplied. The works of Denmead and Shaw, (1960) and Clausen and Shaw, (1970) has clearly demonstrated the importance of moisture at different

growth stages and quantified the reduction caused by moisture stress. They reported stress prior to silking caused 25% yield reduction, stress at silking reduced 50% stress after silking caused 21% yield reduction whereas Clausen and Shaw reported 12-15% yield reduction at early ear shoot and ovule development.

Hodges et al (1979) in modeling dry-matter accumulation and yield of grain sorghum, reported potential gross photosynthesis was reduced by a water stress factor when available moisture was less than 35% of maximum available soil moisture.

In plants placed under stress 15-20 days after anthesis, there is a progressive reduction in photosynthetic rate of the wilted leaves and the movement of the assimilates into the conducting tissues was also prolonged, where as the velocity of translocation was not affected (Wardlaw, (1967)). It was also reported that water stress directly acts on leaves rather than indirectly through effect on growth or movement of water through the conducting tissue. Wilson et al (1980) showed that the dry-matter accumulation rate of plants was greatly reduced by water deficit. This reduction occurred due to two reasons, I) The leaf area index was reduced, II) The substrate production rate per unit of leaf area by photosynthesis decreased.

Translocation is less inhibited than photosynthesis during drought. This fact was demonstrated by Mcpherson and Boyer (1977) that grain yield exceeded the small amount of dry-matter accumulated

during grain filling. Thus translocation must have occurred despite the cessation of dry-matter accumulation by the shoot. It was further indicated that water use by maize was influenced markedly by the mesitute treatment, that when a severe deficit occurred during fertilization period, water use was lowered by reduction in size of plants as well as by reduction of transpiration during the deficit period which affects the dry-matter production and the yield of the crop.

Influence of Nutrient

The distribution of dry-matter over the various organs of a plant is essentially due to the relative growth rates of these organs. Since growth depends on the availability of various essential nutrients to the growing tissues, correlation seems a question of competition. It is true that the Coordination is controlled in a very complex manner, that is both hormonal and nutritive features play a role, the later being the most important in agricultural practice (Brouwer, 1962 - 63). That soil fertility level plays important role in dry-matter accumulation in plants was recognized long ago. Dry-matter accumulation through out the growing period is linear over the major part of the growing season. Differences in soil fertility resulted in different sized plants; however it doesn't markedly influence the relative proportion of each plant (Hanway, 1962; Singh and Anderson, 1978). Eventhough

many researchers have demonstrated nutritional influence on the production and distribution of dry-matter, it should be noted that nutrition represents only one of the many factors influencing distribution of dry-matter in the plants; however, in agricultural practice it is the most important factor. Nutrient deficiencies are reflected both in leaf area and in the chemical composition of the leaves. Thus while grain yield is primarily a function of dry area, leaf area, is a function of nutrient status of the soil which is reflected in the chemical composition of the leaves. Deficiencies result in reduced leaf-area, which in turn-results in reduced dry-matter accumulation and grain yield.

Accumulation of Nitrogen (N) and Phosphorus (P)

The curve for N accumulation in the whole plant part parallels, or slightly precedes the curve for dry-matter production until some time following tasseling and silking (Syre, 1948); whereas Bromfield (1969) reported increased N uptake one week before the stage of linear increase in dry-matter production. Between the fourth and fifth weeks of growth stages N uptake averaged 2.3 lb per acre per day which decreased as the season progresses.

The daily rate of nutrient uptake and dry-matter accumulation by two single maize hybrids was highest between 28 and 42 days after germination (Furlani et al, 1980). Syre (1948) reported that one month old plants contained about 3.5 lb/plant ten days

later, when the dry-matter production was increasing rapidly the plants had accumulated 15 lb/acre. At about silking time during most rapid dry-matter production, they were accumulating 41 lb per acre per day. Further more, following tasseling and silking the pattern of N uptake was not clear-cut and apparently depends upon other factors affecting absorption. He further noted that N, accumulation in the whole plant, after reaching a peak about silking time, continued for another four weeks and then stopped somewhat abruptly. However, Jordan et al (1950) observed a continuous accumulation up to maturity. During growth, the total N content of leaves, sheath, husks, and tassels reached a maximum and then decreased, (White head et al, 1948) the net loss being attributable to gain in the ears.

Jaques et al (1975), Allison (1969), Karlan and Whitney (1980), all have observed similar situation that nutrient accumulation is high early in the season and decreases late in the season. The grain as the major sink for N has been reported by Drysdale (1965-66). The general pattern for percent P in the different plant parts is similar to those for percent N. Compared to N, there is a slow decrease for percent P followed by rapid and then a slow decrease late in the season (Hanway, 1962).

The greatest part of P accumulation usually parallels the period of most rapid dry-matter production as pollination approaches. P starts to migrate into the developing, but yet seedless ear (Early and De Turk, 1949; Mohamed & Marshal, 1979; Hanway, 1962) and then

accumulates rapidly in the grain until maturity. The leaves, stalks, sheaths, and cobs lose P to the grain also. With the approach of productive period much of the P is translocated from the roots to top than the amount of P actually absorbed from the soil throughout the period of growth preceding pollination. A gradual decrease in P concentrations was noted in the tops owing to more rapid production of plant tissue as compared with the rate of P uptake from the soil (Neson, 1965).

Regarding the behavior of different varieties Agboola (1972) observed differences in accumulation. However, the concentration of P accumulation in the ears and leaves by the different hybrids could not be explained on the basis of the P absorption characteristics of the root but due to the existence of genetically controlled character involving at least with two genetic factors with the possibility of dominance (Baker et al, 1967).

On the other hand Barker and Thomas (1972) reported a significant difference between P accumulation measured as the mean of P concentration of the ear leaf blade of progeny in each class. Their results was considered as indicative of at least one genetic locus that influence relative P accumulation. It was also postulated here that a minimum of six genetic loci that affect relative P accumulation. Thus resulting in differences in P absorptive capacity of genotypes.

Materials and Methods

Experimental Site

The experiment was conducted at fruit farm, Dire Dawa, located in Hararge administrative region, eastern part of Ethiopia at latitude $09^{\circ}31'$ N and longitude $41^{\circ}51'$ E on an altitude of 1160m above sea level. The area receives a minimum amount of rainfall throughout the growing season.

The mean monthly rainfall, temperature and relative humidity of the area summarized for 20 years and for 1980 growing season are indicated in figure A₂. The mean maximum monthly temperature during the growing period (June-December) ranges from 31°C to 35°C whereas the 20 years mean indicates a range of $31 - 34^{\circ}\text{C}$. The mean minimum temperature for the same years ranges from $18 - 22^{\circ}\text{C}$ and $18 - 21^{\circ}\text{C}$, respectively for which low relative humidity (36 - 51%) is observed.

Dire Dawa and its surrounding fall under semi-arid sub-tropical belt of eastern Ethiopia. The soil type on which this particular research conducted was a clay loam. Soil test at the College of Agriculture, Alemaya, soil testing laboratory indicated that the soil is 7.95pH in the plough layer, 1.52% organic matter, 3.25ppm P.N content and cation exchange capacity of the experiment site was not done due to facility problem.

Land Preparation and Planting

The experimental area was ploughed in May of 1980 and the normal seed bed preparation was carried out. One application of 75kg/ha of P_2O_5 under the seed at sowing was done for which DAP was a source. Recommended rate of Seeds were planted on June 19, 1980. UREA was applied at 75kg/ha as the side placement when plants were at about a knee high. Precipitation was very low as indicated in figure A₂. Hence, moisture deficit was supplemented with irrigation every fortnight to facilitate normal plant growth.

Normal weeding, by hand or hoe was carried out in order to keep the experimental area free of weed. .5% DDT was applied to protect the plants from larvae of stalk borer. It was also observed that plants were partly attacked by charcoal rot (caused by fungus *Microphomina phaseoli*) at about the time of tasseling.

The experimental treatment consisted two hybrids, H611 (varietal cross) and SR52 (Single cross), their parental lines, Ec573, K.Syn.II, N3233, and Sc 5522; respectively.

Treatment and Design

The experimental plots were arranged in a split-plot to fit into a randomized complete block design with three replications in such a way that varieties are assigned randomly in the sub plots and the stages at which the plants were sampled to determine the dry-matter accumulation in the main plots. Each sub-plot was 4 rows wide with rows 75cm apart and 30 cm between plants. There

were five hills per row which make the row 1.5 m long. Two seeds were planted /per hill which was later thinned to one plant per hill after germination except at the two end hills.

Experimental measurement

Data were collected on the following plant characteristics from the two middle rows of a four-row plot; date of emergence, plant height at each sampling date which is referred to as growth stages, the respective leaf number, date of tasseling, silking, maturity, and final grain yield.

The samples were taken for dry matter determination from each plot. The first sample was taken, 14 days after emergence. The remaining 9 samples were taken every two weeks intervals there after till physiological maturity. For samples one and two the whole plant part including the root from the two middle rows were taken.

For the rest of the sampling dates plants were cut at ground level from an area of 1.125m^2 from the two middle rows. Fresh weights were taken immediately after harvest. These samples were separated into ears (husks, cobs and grain), stem (stalk and leaf sheath), and leaf (laminae only). For harvest stages fifth to the eighth and into leaf, stalk, leaf sheath and husk, cob, and grain for sample nine and 10 to identify the proportion of dry matter constituted by different plant parts around maturity.

Representative sub-samples of about 500 gm from each separated plant part were put into drying oven at 105°C for 24 hours for determining dry weight of the samples. The total dry-matter produced was then computed by proportion from the dry weight of the sub-samples.

The dried samples were ground in a Willey mill by passing through a one mm sieve for total nitrogen (N) and phosphorus (P) determination, in different plant parts at various growth stages.

Nitrogen and phosphorus determination was carried out at Holleta research station soil testing laboratory. N was determined by macro Kjeldhal digestion distillation method, whereas P was determined by Molybdenum blue method.

Data Analysis

The dry-matter produced by each plant was determined according to the following equation:

$$\text{Dry matter/plant} = \frac{\text{fresh weight/plant} \times \text{sample dry-weight}}{\text{Sample fresh weight}}$$

The daily growth rate (GR) in g/plant/day was calculated at successive growth stages as follows

$$\text{GR} = \frac{W_2 - W_1}{t_2 - t_1}, \text{ where } W_2 \text{ is the dry weight}$$

at t_2 , W_1 is the dry weight at t_1 , t_1 and t_2 being any two consecutive sampling dates.

Regression equation and coefficients of correlation and the normal statistical analysis for split-plot design was carried out for the following parameters, total dry matter and sampling dates referred to as growth stages, between leaf, ear, stalk and growth stages; and for leaf number, plant height and the dry matter produced at various growth stages and with the growth stages.

Curves $W = a + bt + ct^2$ were fitted to the forthcoming dry weight (W) values (Allison and Watson, 1966), the curves fitting the data satisfactorily.

Dry weight produced after flowering was estimated by linear interpolations of the preceding and succeeding harvests. The increment of dry weight after flowering estimated by subtracting dry matter produced at flowering from the highest dry matter produced at or around the final harvest (Allison, 1971). Every data is reported in gram/plant.

Final grain yield was determined by harvesting ten plants from the two middle rows of each plot of the three replications making 30 plants over all. This yield was adjusted to 12.5% moisture and reported in quintals per hectare.

RESULTS AND DISCUSSIONS

Total dry matter accumulation

The hybrids and their parental lines had similar pattern of dry matter accumulation throughout the growing period (Fig. 1). Since the pattern of accumulation appeared to be similar for all genotypes considered in this experiment, the regression equation for the total dry-matter production was calculated by using the mean data for genotypes (Fig 2).

The rate of growth, as measured by the difference in the dry matter weight for the sampling dates, was slow and similar for all genotypes upto 6th weeks after emergence (Table 2). Only K.Syn.II has accumulated significantly higher dry matter (119.4 g/plant) at this stage. The slow dry matter accumulation was followed by a rapid acceleration upto 12th week after emergence which subsequently slowed down from 14 weeks onwards. There was no significant increase in dry matter production for the last two growth stages (Table 1b).

The response of genotypes in accumulating dry matter at different growth stages was compared starting from 8th week after emergence till to the final growth stage. H611 out yielded all genotypes significantly at all growth stages with the exception of the 12th week after emergence. At the 12th week after emergence, K.syn. II has out yielded all genotypes significantly by producing 326.37 g/plant (Table 1a).

A non-significant yield difference was observed between the parental lines of SR52 (N3233 and Sc5522) through out the growing period. Except for the period between 14 and 16 weeks after emergence. At this stage N3233, the male parent significantly out yielded Sc5522. K.Syn. II competed with H611, the highest yielder, in dry matter production upto 14th week after emergence. At the final growth stage, significant yield difference was observed between the hybrids and the parental lines. The lowest yield of 283 g/plant was produced by Sc5522 and the highest yield of 525.71 g/plant was produced by H611.

Table 1b compares the response of the genotypes for total dry matter accumulation at different growth stages. At the early stages of growth (upto 4th week after emergence), there is no significant yield difference. However, all genotypes accumulated significantly higher dry matter after the 4th week after emergence with the exception of the last two growth stages. The trend of dry matter accumulation is similar for all genotypes. This trend of dry matter accumulation was high at early stages of development and subsequently followed by an increase at a decreasing rate. This trend and rate of accumulation has continued upto the 18th week after emergence. After 18th week after emergence there was no significant dry matter produced in all genotypes. This pattern of dry matter accumulation formed a segmoid curve as reported by Syre (1948), Hanway (1969), Besset et al (1970),

TABLE 1a: Total dry-matter (g/plant) accumulated by the two maize hybrids, and their parental lines

Genotype	WEEKS AFTER EMERGENCE										Mean
	2	4	6	8	10	12	14	16	18	20	
SR52	2.09a	18.30a	75.62b	142.70c	233.14ab	280.20bc	319.88c	332.01c	394.42c	401.02c	219.90c
N3233	1.09a	12.86a	66.33b	104.76d	183.14de	215.82d	262.31d	276.60d	287.74e	302.87e	171.35e
Sc5522	1.57a	5.36a	48.21b	101.79d	159.38e	197.37d	226.89e	234.68e	277.71e	283.52e	153.66f
H611	3.77a	25.65a	68.37b	179.44a	251.02a	297.21b	399.52a	473.09a	502.75a	525.79a	272.66a
K.Syn.I	1.88a	16.83a	119.38a	170.53ab	216.76bc	326.37a	349.20b	405.60b	455.95b	466.87b	252.94b
Ec573	1.76a	15.23a	69.60b	145.08bc	205.83cd	260.18c	304.57c	327.70c	346.14d	350.28d	202.64d

Means followed by the same letter along each column are not significantly different according to Duncan's Multiple Range Test at 5% level of probability.

TABLE 1b:

Genotype	2	4	6	8	10	12	14	16	18	20
SR52	2.09g	18.30g	75.62f	142.30e	233.14d	280.20c	319.88b	332.01b	394.42a	401.02a
N3233	1.09g	12.86g	66.33f	104.76e	183.14d	215.82c	262.31b	276.60b	287.74a	302.87a
Sc5522	1.57g	5.36g	48.21f	101.79c	159.38d	197.37c	226.89b	234.68b	277.71a	283.52a
H611	3.77h	25.65h	68.37g	179.44g	251.02e	297.21d	399.52c	473.09b	502.75a	525.79a
K.Syn.II	1.88g	16.83g	119.38f	170.53e	216.76d	326.37c	349.20c	405.00b	455.95a	466.87a
Ec.573	1.76g	15.23g	69.60f	145.08e	205.83d	260.18c	304.57b	327.70ab	346.14ab	350.28a
MEAN	2.03h	15.71h	74.59g	140.65f	180.75e	262.86d	310.40c	341.61b	377.47a	388.39a

Means followed by the same letter across the same row are not significantly different by Duncan's Multiple Range Test at 5%

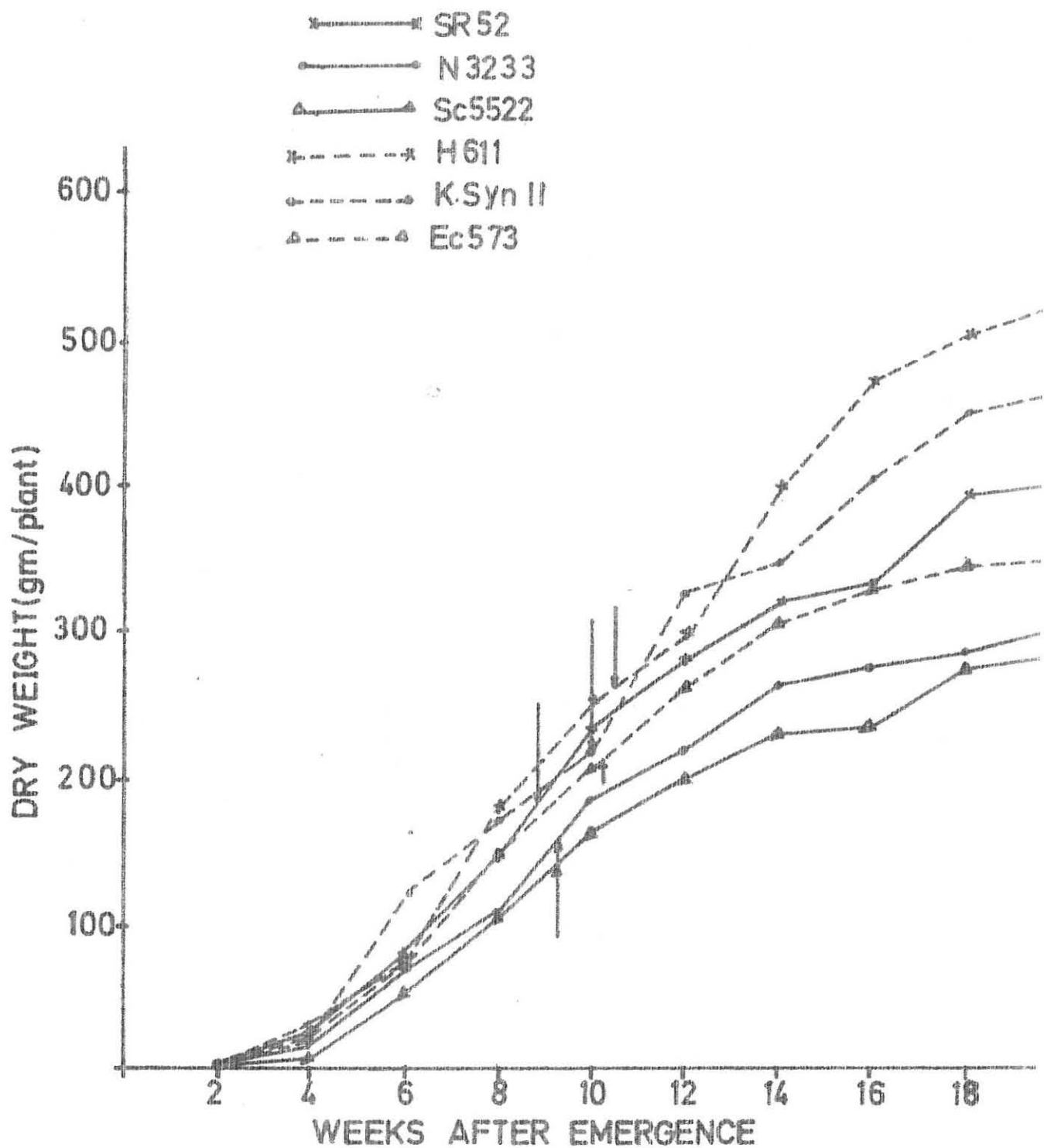


Fig 1 Total dry matter accumulation of the two hybrids and the parental lines at different stages of the growing period. The arrows indicate time of tasseling.

From this data it is difficult to suggest a particular stage to which attention should be given to increase the rate of dry matter accumulation. However, one can see that at early growth stages, upto 6 weeks after emergence, the rate of dry matter accumulation is slow; then followed by faster rate of accumulation. The fast rate of dry matter accumulation has coincided with the high leaf development rate. It was investigated that the faster rate of dry matter accumulation is positively correlated ($r = 0.86$) at the 5% level of probability to leaf number. Hence due to its synthesizing capacity, leaf development enabled the plant to accumulate dry matter at a faster rate. This finding is in agreement with the results obtained by Allison (1971). Hence, anything that is responsible for reducing the development of leaves and photosynthetic area such as nutrient deficiencies, diseases, insect pests, shortage of moisture should be avoided.

Leaf dry matter accumulation

Leaf dry matter accumulation of the two hybrids and their parental lines is shown in table 3b. No significant yield difference was observed among the genotypes regarding leaf dry matter accumulation at 10th week after emergence. However, in the latter stages of growth the genotypes behave differently. At the 12th week after emergence K.Syn.II significantly outyielded

TABLE 2: growth rate (g/plant/day) of the two hybrids, and their parental lines.

Days after emergence	Genotype					
	SR52	N3233	Sc5522	H611	K.Syn.II	Ec.573
00 - 14	0.15	0.08	0.11	0.27	0.13	0.13
14 - 28	1.16	0.84	0.27	1.56	1.07	0.96
28 - 42	4.09	3.82	3.06	3.05	7.33	3.88
42 - 56	4.76	2.74	3.83	7.93	3.65	5.43
56 - 70	6.49	5.60	4.11	5.11	3.30	4.34
70 - 84	3.36	2.33	2.70	3.30	7.83	3.88
84 - 98	6.07	3.32	2.12	7.31	1.63	3.17
98 - 112	0.87	1.02	0.56	5.26	4.03	1.65
112 - 126	4.46	0.80	3.08	2.12	3.60	1.32
126 - 140	0.47	1.08	0.41	1.65	0.78	0.30

genotypes by accumulating 106.99 g/plant followed by SR52 (65.73 g/plant), and Ec573 (57.79 g/plant). The least yield of 42.31 g/plant was produced by N3233 at the same stage. The analysis of variance (Table 10) indicated that there is highly significant difference among the genotypes in leaf dry matter accumulation.

Attempts have been made to indentify the favorable growth stages for maximum leaf dry matter accumulation by genotypes. There is a general trend of decreasing in leaf dry matter accumulation as the growth stage advances. Nevertheless, responses appear to be different in comparing the hybrids and their parental lines (Table 3a). Hence, SR52 has high yield (65.73 g/plant) at 12 weeks after emergence.

The leaf dry matter produced by N3233 and Sc5522 at all stage of growth did not differ significantly. Probably earlier growth stages than those considered here could have been appropriate to identify at which growth stage the highest leaf dry matter could be accumulated for the parental lines. H611 and its parental lines showed an increasing and a decreasing trend as growth stage advances in leaf dry matter accumulation. H611 has accumulated significantly high leaf dry matter (95 and 83 g/plant) at 14 and 16 weeks after emergence. K.Syn.II has produced significantly high yield (106.99 g/plant) at 12 weeks after emergence. However, no significant yield difference was observed for Ec573 at all the growth stages considered.

TABLE 3a: Leaf dry matter (g/plant) accumulation of two maize hybrids and their parental lines at different growth stages.

Genotypes	WEEKS AFTER EMERGENCE					
	10	12	14	16	18	20
SR52	58.97ab	65.73a	59.61ab	53.72ab	48.10ab	42.30b
N3233	48.22a	42.31a	40.67a	37.67a	34.38a	33.54a
Sc5522	42.31a	47.30a	39.00a	37.30a	33.53a	31.83a
H611	57.88cd	46.18d	95.69a	82.70ab	69.30bc	63.21cd
K.Syn.II	69.33b	106.99a	75.02b	70.43b	66.53b	60.23b
Ec.573	57.50a	57.79a	58.15a	52.44a	47.03a	39.68a

Means followed by the same letter along the row are not significantly different according to Duncan's Multiple Range Test at the 5% level of probability.

TABLE 3b:

Genotypes	WEEKS AFTER EMERGENCE						MEAN
	10	12	14	16	18	20	
SR52	58.97a	65.73b	59.61bc	53.72bc	48.10bc	42.30bc	54.74b
N3233	48.22a	42.31c	40.67c	37.67c	34.38c	33.54c	39.47c
Sc5522	42.31a	47.30bc	39.00c	37.30c	33.53c	31.83c	38.55c
H611	57.88a	46.18bc	95.61a	82.70a	69.30a	63.21a	72.99a
K.Syn.II	69.33a	106.99a	75.02b	70.43ab	66.53ab	60.23ab	74.75a
Ec.573	57.50a	57.79b	58.15bc	52.44bc	47.03bc	39.68c	52.10b

Means followed by the same letter or letters along the same column are not significantly different according to Duncan's Multiple Range Test at the 5% level of probability.

The high leaf dry matter produced by H611 and K.Syn.II could be due to prolonged leaf age and lateness in maturity as compared to other genotypes. Hence, the prolonged green leaves might have provided the plants with enough photogynthates late in the season which have accounted for high leaf dry matter. This result is in agreement with the findings of Van Eijnatten (1963).

The decreasing trend of leaf dry matter accumulation from the 10th week to the 20th week after emergence was observed. The percentage decrease in leaf dry matter based on the respective total dry matter for all genotypes for the 10th and the 20th week, respectively was as follows: H611 24% and 12% ; K.Syn.II, 33%, and 13%; Ec573, 19% and 11%; SR52, 29% and 11%; N3233, 26% and 11%; Sc5522, 29% and 11%. The low percentage of leaf dry matter obtained at the final growth stage for all genotypes could not be accounted only for differential translocation of dry matter from the leaf part to the developing ears; but it could also be due to the falling off of the senesced leaves. Similar findings had also been reported by Allison (1969); Allison and Watson (1967); Hanway and Russel (1969); and Osafo (1972).

Stalk dry matter accumulation

Highly significant yield difference was observed among growth stages and among genotypes in stalk dry matter accumulation (Table 10). Table 4a shows that there is no significant yield difference at different stages of growth for SR52, N3233 and

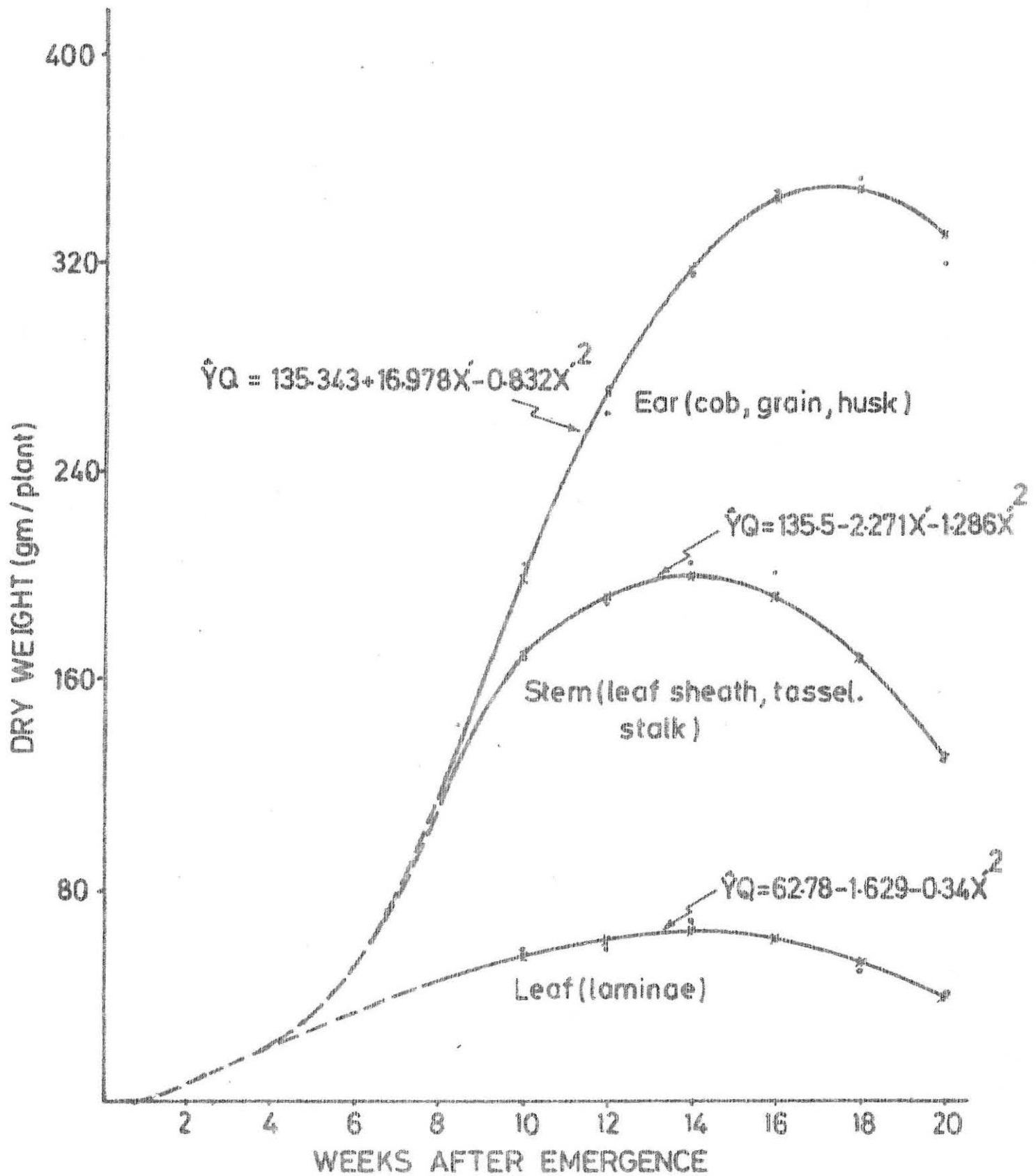


Fig.2 Cumulative dry weight of the different parts of the maize plants at successive stages of plant development, average of two hybrids and their parental lines.

Sc5522 from 10 weeks to 14 weeks after emergence. The highest stalk dry matter (136.69 g/plant) which is about 43% of the respective total dry matter was produced by SR52 at 14 weeks after emergence. However, at the final harvest stage the stalk dry matter accumulation declined which commensurate to 27% of the total dry matter (Table 11, Fig 5). N3233 and Sc5522 have also accumulated highest dry matter 119.35 and 110.03 g/plant, respectively at 14 weeks after emergence. At the final stage of growth 87 and 95 g/plant was obtained for the two parental lines, respectively. The reduction in stalk dry matter was 16% and 15% for N3233 and Sc5522, respectively. A significant difference was observed between the growth stages for H611 and its parental lines, K.Syn.II and Ec 573 regarding stalk dry matter. H611 produced highest stalk dry matter yield of 195.0 g/plant at 16 week after emergence, (28 to 40 days after tasseling). A significant difference was observed between the growth stages for H611 and its parentals K.Syn. II and Ec573 regarding stalk dry matter.

The peak stalk dry matter, 161.92 g/plant which is about 40% of the respective total dry matter was produced by K.Syn.II at 16 weeks after emergence. This stalk dry matter percentage has finally decreased to about 23% of the total dry matter at physiological maturity. Ec573 has no significant reduction in stalk dry matter at the final stage as compared to the first growth stage. Highest dry matter (133.85 g/plant) was obtained at 14

week after emergence. In this genotypes the stalk dry matter has decreased from 44% at tasseling to about 28% of its respective total dry weight at final growth stage.

Comparisons of the responses of genotypes to stalk dry matter accumulation was considered at the same growth stage (Table 4b). At 10th and 12th weeks after emergence, H611 significantly out yielded only the parental lines of SR52. It is interesting to note that the parental lines and the respective hybrids produced a non-significant yield difference upto 12 weeks after emergence; and the gap between the stalk dry matter yield was not so wide. However starting 14 weeks after emergence, H611 significantly out yielded all, except K.Syn.II.

Eventhough SR52 and its parental lines seem to follow the same trend as H611 and its parental lines, they did not out yield them in stalk dry matter upto the physiological maturity. The relatively late season types, H611 and its parental lines seem to incorporate the current photosynthate produced because the leaves of these genotypes remained green for longer period as compared to SR 52 and its parental lines. This finding is in agreement with the results obtained by Genter et al (1970), Van Eijnatten (1963).

The stalk dry matter at the physiological maturity for all genotypes was not significantly different from that produced at 10 weeks after emergence. However, an increasing and decreasing trend is observed (Table 4a). This shows the loss of stalk dry

TABLE 4a: Stalk dry matter accumulation (g/plant) of two maize hybrids and their parental lines at different growth stages.

Genotypes	WEEKS AFTER EMERGENCE					
	10	12	14	16	18	20
SR52	105.70a	116.06a	136.69a	128.38a	114.72a	107.02a
N3233	94.03a	99.57a	119.35a	108.65a	89.14a	87.26a
Sc5522	86.87a	95.06a	110.03a	104.61a	96.11a	94.80a
H611	133.15c	138.48c	169.96ab	195.00a	149.96bc	120.93c
K.Syn.II	120.17bc	147.38ab	152.92a	161.92a	117.00bc	109.63bc
Ec.573	112.64ab	132.41a	133.85a	118.96ab	103.29ab	97.49b

Means followed by the same letter in each row are not significantly different by Duncan's Multiple Range Test at 5% level of probability.

TABLE 4b:

Genotypes	WEEKS AFTER EMERGENCE						MEAN
	10	12	14	16	18	20	
SR52	105.70ab	116.06bc	136.69bc	128.38c	114.72b	107.02ab	118.10c
N3233	94.03b	99.57b	119.35c	108.65c	89.14b	87.14b	99.70d
Sc5522	86.87b	95.06b	110.03c	104.61c	96.11b	94.80ab	97.91d
H611	133.15a	138.48a	169.96a	195.00a	149.96a	120.93a	151.24a
K.Syn.II	120.17ab	147.38a	152.92ab	161.92b	117.00b	109.63ab	134.84b
Ec.573	112.64ab	132.41a	133.85bc	118.96c	103.29b	97.49ab	116.44c

Means followed by the same letter on each column are not significantly different according to Duncan's Multiple Range Test at the 5% level of probability.

matter at the latter stage of development. Similar result was also reported by Allison and Watson (1969); Hanway and Russel (1969); Allison (1969); Osafo (1972); Hume and Campbell (1972).

In reference to related phenomena in small grains, Archbold (1945) and Thorn (1966) have suggested that late season change in stem weight is primarily a respiration loss. However, measurements on wheat by Wardlaw and Perer (1967) and Lupton (1968) has revealed that stem respiration rates are too low to account for more than a small part of the stem weight reduction. On the other hand such weight decrease has not been observed from the data reported by Campbell (1964), and Allison and Watson (1969), for unfertilized maize plants, and it seems unlikely that the stalk weight loss in the fertilized counter parts is primarily a respiratory loss. Therefore, it is suggested that changes in the stalk dry matter late in the season could be due to differences in the photosynthetic capacity of the plant and the sink capacity of the ears. This latter suggestion is supported by earlier findings showing an increase in the movement of assimilates from the stalk when leaves are damaged or shaded (Hoyt and Bradfield, 1962; Allison and Watson, 1969) and an accumulation of stalk assimilate when fertilization is prevented (Allison and Watson, 1969; Campbell, 1964).

Ear dry matter accumulation

The analysis of variance (Table 10) shows that there is highly significant difference among the genotypes in accumulating ear dry matter at different growth stages. It was also observed that certain genotypes gave good performance at certain growth stages, while others did not. As it is shown in Table 5a, all the genotypes except N3233 and Sc5522 gave similar yield response at each growth stage. SR 52 produced ear dry matter ranging from 69.1 to 225.91 g/plant at 10th and 20th week after emergence, respectively. A significant difference was detected among growth stages.

N3233 and Sc5522 produced ear dry matter yield ranging from 40.89 to 157.58 g/plant, and from 30.20 to 143.0 g/plant, respectively. The final ear dry matter yield of these parental lines accounted for 70% and 63% of their counter part hybrid, respectively.

On the other hand, H611 produced ear dry matter yield ranging from 60 upto 310.51 g/plant. This was 24% and 59% of the respective total dry matter yield at 10 weeks and 20 weeks after emergence, respectively (Table A1, Fig 5). The ear dry matter produced by the two parental lines of H611 was from 27.56 to 269.91 g/plant and from 36.69 to 217.91 g/plant fro K.Syn.II and Ec573, respectively. In general K.Syn.II produced about 87% and Ec573 about 70% of the total ear dry matter yield of their counter-part hybrid at final harvest.

TABLE 5a: Ear dry matter accumulation (g/plant) of two maize hybrids and their parental lines at different growth stages.

Genotypes	WEEKS AFTER EMERGENCE					
	10	12	14	16	18	20
SR52	69.10f	98.40d	123.52c	150.21c	202.30b	225.91a
N3233	40.89e	74.01d	102.32c	130.26b	144.66ab	157.58a
Sc5522	30.20d	55.01cd	77.86bc	92.77b	123.98a	143.39a
H611	59.99f	89.64e	145.66d	195.39c	247.68b	310.51a
K.Syn.II	27.56f	72.00e	121.26d	172.90c	225.43b	269.91a
Ec.573	35.69f	69.98e	112.57a	154.32c	186.74b	217.91a

Means followed by the same letter on each row are not significantly different by Duncan's Multiple Range Test at the 5% level of probability.

TABLE 5b:

Genotypes	WEEKS AFTER EMERGENCE					
	10	12	14	16	18	20
SR52	69.10a	98.40a	123.52ab	150.21bc	202.30cd	225.91c
N3233	40.89bc	74.01ab	102.32b	130.26c	144.66e	157.58d
Sc5522	30.20c	55.01b	77.86c	92.77d	123.98e	143.39d
H611	59.99ab	89.64ab	145.66a	195.39a	247.68a	310.51a
K.Syn.II	27.56c	72.00b	121.26ab	172.90ab	225.43bc	269.91b
Ec.573	35.69c	69.98b	112.57b	154.32bc	186.74d	217.91c

Means followed by the same letter on each column are not significantly different according to Duncan's Multiple Range Test at the 5% level of probability.

Genotypes were compared under each growth stage for production of ear dry matter (Table 5b). SR52 followed by H611 have significantly out yielded the rest of the genotypes. At 12 weeks after emergence the rate of ear dry matter accumulation was high in N3233, thus there was no significant difference between N3233, SR 52 and H611. At the first two growth stages, the rate of ear dry matter accumulation was similar for all genotypes except for Sc5522 which was 2 g/plant/day. However, the rate of accumulation was not constant throughout the growth stages. H611 accumulated 2.12 to 4.49 g/plant/day, while K.Syn.II 3.17 to 3.75 g/plant day. Such high rate of accumulation by the two genotypes could be attributed to the slow death rate of their leaves, which actively played a role in photosynthesis. This result is in agreement with the findings of Van Eijnatten (1963).

In general the parental lines of H611 have translocated more photosynthates as compared to the parental lines of SR52. This is so because K.Syn.II is a synthetic and Ec573 is a variety with a wide genetic background which enabled them to yield more than the inbred lines. This result agrees with Allard's (1960) view.

The continued increase in ear dry matter in all genotypes could be due to 1) translocation of current photosynthate produced 2) translocation from previously stored carbohydrates in the stalks leaves, and other parts of the maize plant except the ear. Since ear development was taking place when the stalks and leaves were

loosing weight and increase in ear weight was also taking place when the leaves were aging , it is most likely that assimilation from the current photosynthate by the relatively late season types, H611 and K.Syn.II and translocation late in the season from the previously stored carbohydrates has taken place. This is in agreement with the findings of Dynard et al (1967); Assanum et al (1967); Adellana and Melbourne (1972b); Allison and Watson (1969); and Genter et al (1970).

Sheath and husk dry matter accumulation

Sheath and husk dry matter was determined at the last two growth stages, 18 and 20 weeks after emergence. The analysis of variance (Table 10) indicates that there is significant difference among the genotypes. Eventhough, there is decreasing tendency of the sheath and husk dry matter, as growth stage advances there is a non-significant yield difference observed between the growth stages (Table 6). This could be due to latenes in determining rate of dry matter accumulatuon for this part of the plant.

Haxway and Russel (1969) determined sheath and husk dry matter accumulation separately and found out that leaf sheath and husk attained their highest weight at about stage 4.5 (9 weeks after emergence). A decrease in dry matter accumulation has taken place due to translocation as grain development proceded. One of the probable reasons in obtaining a value which did not differ significantly between the growth stages in the present study could be ~~due to determining~~ of the sheath and husk dry matter at late stages of growth.

TABLE 6: Sheath and husk dry matter (g/plant) content for the last two growth stages of the two maize hybrids and their parental lines

Genotypes	WEEKS AFTER EMERGENCE		
	18	20	Mean
SR52	59.15	50.97	55.06
N3233	53.63	49.05	51.34
Sc5522	38.87	36.52	37.70
H611	71.10	62.30	66.70
K.Syn.II	57.76	54.20	55.98
Ec.573	55.74	51.58	53.66
Mean	56.04	50.77	53.41

L.S.D at 5%: between growth stage means, 19.84
among variety means, 14.50;
between variety means at the same growth stage, 20.51;
between the same variety means at different growth stages, 24.31.

Cob dry matter accumulation

Analysis of variance (Table 10) shows that there is a highly significant difference among the genotypes in accumulating cob dry matter. However, there is no significant difference between growth stages. Such result could be due to lateness in determining cob dry matter as in the case of the sheath and husk.

H611 and K.Syn. II produced highly significant cob dry matter yield than the rest of the genotypes. Cob dry matter comprised the following percentage of the total dry matter in each genotype. H611, 9.2%; K.SynII, 10.1%; SR52, 6.9%; N3233, 8.7% Sc5522, 8.7%; and Ec573 9.2%. It appears that there is a pattern of similarity among the hybrids and their parental lines in dry matter content of the cob. Hanway and Russel (1969) observed that the highest dry matter content of the cob was attained at about stage 6.5 (about 2 weeks after silking) Hence it seems appropriate to consider earlier growth stages than considered in the present experiment for determining peak cob dry-matter.

Grain dry matter accumulation

Highly significant difference was observed between the parental lines and the counter part hybrids in accumulating grain dry matter (Table 10). However, there was no significant difference between the growth stages which could be due to the last

TABLE 7: Cob dry matter (g/plant) content for the last two growth stages of the two maize hybrids and their parental lines.

Genotype	WEEKS AFTER EMERGENCE		Mean
	18	20	
SR 52	34.39	27.69	31.04
N 3233	28.27	26.33	27.33
Sc 5522	30.26	24.65	27.46
H 611	54.02	48.34	51.18
K.Syn.II	52.62	47.10	49.86
Ec. 573	35.91	32.16	34.04
MEAN	39.24	34.38	

L.S.D At 5% between growth stage means, 14.37;
among genotype means ; 7.49
among genotype means at the same growth stage,
10.58
among the same genotype means at different growth
stage, 16.22.

few growth stages (18 and 20 weeks after emergence) considered in the sampling. As the plants approached maturity the leaves were almost aging ; hence, the dry matter expected to be translocated from the current photosynthate is very minimal. Further, the amount of dry matter translocated from the previously stored carbohydrates in the different parts depends upon the size of the grain. Similar finding was reported by Dynard et al (1965).

When the grain approaches physiological maturity the amount of dry matter that is accumulated by the grain is very minimal. This agrees with the data of Table 3a and 3b of leaf dry matter and Table 4a and 4b of stalk dry matter because there was no significant reduction in stem and leaf weight during the last two growth stages. The translocation taking place to the developing grain during this period was minimal. This agrees with the results of Hanway (1963), Van Eijnatten (1963).

At the final growth stages the grain dry matter accumulation was significantly different for the genotypes H611 has out yielded all the genotypes except K.Syn.II. The grain dry matter of the genotypes constituted in H611, 44%; K.Syn.II, 42%; SR52, 43%; Ec573, 36%, N3233, 35%; and Sc5522, 34% of the total final dry matter (Table A₁,).

N3233 and Sc 5522 produced about 62% and 57% of the final grain dry matter of their counter part hybrid grain dry matter. K.Syn.II and Ec573 produced 85% and 56% of the grain dry matter

of their counter part hybrid H611 final grain dry matter.

The reduction in percentage of grain dry matter in the parental lines of both hybrids indicates that translocation of dry matter to the grain was not taking place at the same rate as in the hybrids. This could be due to the difference in the dry matter accepting capacity of the grain. Similar result has also been reported by Allison (1971). Moreover, the low percentage observed in the parental lines relative to the respective hybrids could be due to a slower rate of grain growth towards the end of growing period in response to a decreased rate of production of assimilates by the photosynthetic system, or because grain growth has ceased shortly before those of the hybrids owing to the exhaustion of the supply of materials which could be translocated to the grain. However the kernels appear to maintain their set rate of growth, inspite of a substantial decrease in the supply of current asimilates, at the expense of the rest of the plant parts, particularly, stem, husks, and ear cobs. This is in agreement with the findings of Wilson and Allison (1978).

Proportion of grain and non grain Parts at final harvest

H611 gave the highest total dry matter yield (525g/plant) followed by K.Syn.II (446.87 g/plant); SR52 (402/02g/plant), Ec573 (350.28g/plant); N3233 (302.87 g/plant); and lastly Sc5522 (283.52g/plant) (Table 9, Fig.4). An average of 39.13% of the

TABLE 8: Grain dry matter (g/plant) content for the last two growth stages of the two maize hybrids and their parental lines.

Genotype	WEEKS AFTER EMERGENCE		Mean
	18	20	
SR 52	138.33	172.73	155.53
N 3233	82.35	106.72	94.53
Sc 5522	79.04	95.71	87.38
H 611	158.09	231.02	194.56
K.Syn.II	143.93	195.71	169.82
Ec.573	104.17	129.41	116.79

LSD 5%: between growth stage means, 38.38
among genotype means , 31.72
between the genotype means at the same growth stages
44.86
between the genotype means at different growth
stages, 53.25.

total dry matter weight was grain and 60.87% was non grain (Table 9, Fig. 3). However the relative proportion of grain and above ground non grain part varied widely among the hybrids and their parental lines. The grain dry matter varied from 33.8% in Sc5522 to 43.9% in H611. Of the 66.2% above ground non grain in Sc5522, the stalks, leaves, leaf sheaths and husks, and cobs constituted 51.17, 19, and 13%, respectively.

In N3233, the above mentioned non grain parts constituted 42, 17, 25, and 13%; in SR52, 47, 19, 22, and 12%; in H611, 41, 21, 21, and 17% in K.Syn.II. 40, 22, 20, and 18%, and in Ec 573, 44, 18, 23, and 15%, respectively. The major part of the above ground non grain dry matter is constituted by stalk in both the hybrids and their parental lines.

The highest % stalk dry matter was found in Sc5522 followed by SR 52 and Ec 573, N3233, H611, and K.Syn.II. In all cases the parental lines of SR 52 produced a non significant above ground non-grain dry matter as compared to their counter part hybrids. At the final harvest, the grain dry matter of Sr 52 and its parental lines differed significantly (Table 9). The parental lines of H611 produced a non significant stalk dry matter as compared to H611. K.Syn.II and H611 produced a non significant grain dry matter as well as grain yield (Table 9). Comparison of the parental lines of the two hybrids revealed that the H611 parental lines are more efficient in total dry matter production, and finally total grain yield. This could be due to the relatively

TABLE 9: Mean dry weight (g/plant) produced at final harvest by different maize plant parts for the two maize hybrids and their parental lines.

Genotype	Leaf	Stalk	Sheath and Husk	Cob	Grain	Total	Grain yield Q/ha		Non grain part Dry matter
	% of total								
SR 52	42.61bc	107.02ab	50.97ab	27.69b	172.73b	401.02c	57.81	288.29	56.9
N3233	33.53c	87.25b	49.05ab	26.32b	106.72c	302.87e	31.40	196.15	65.8
Sc5522	31.83c	94.80ab	36.52b	24.65b	95.71c	283.52f	29.50	187.80	66.2
H 611	63.20a	120.93a	62.30a	48.34a	231.02a	525.79a	66.23	294.77	56.1
K.Syn.II	60.23ab	109.63ab	54.20ab	47.10a	195.71ab	466.87b	57.99	271.16	58.1
Ec 573	39.68c	97.48ab	51.58ab	32.14bc	129.40bc	350.28d	37.62	220.88	63.1
Mean									60.87

Means followed by the same letter on each column are not significantly different at the 5% level of probability according to Duncan's Multiple Range Test.

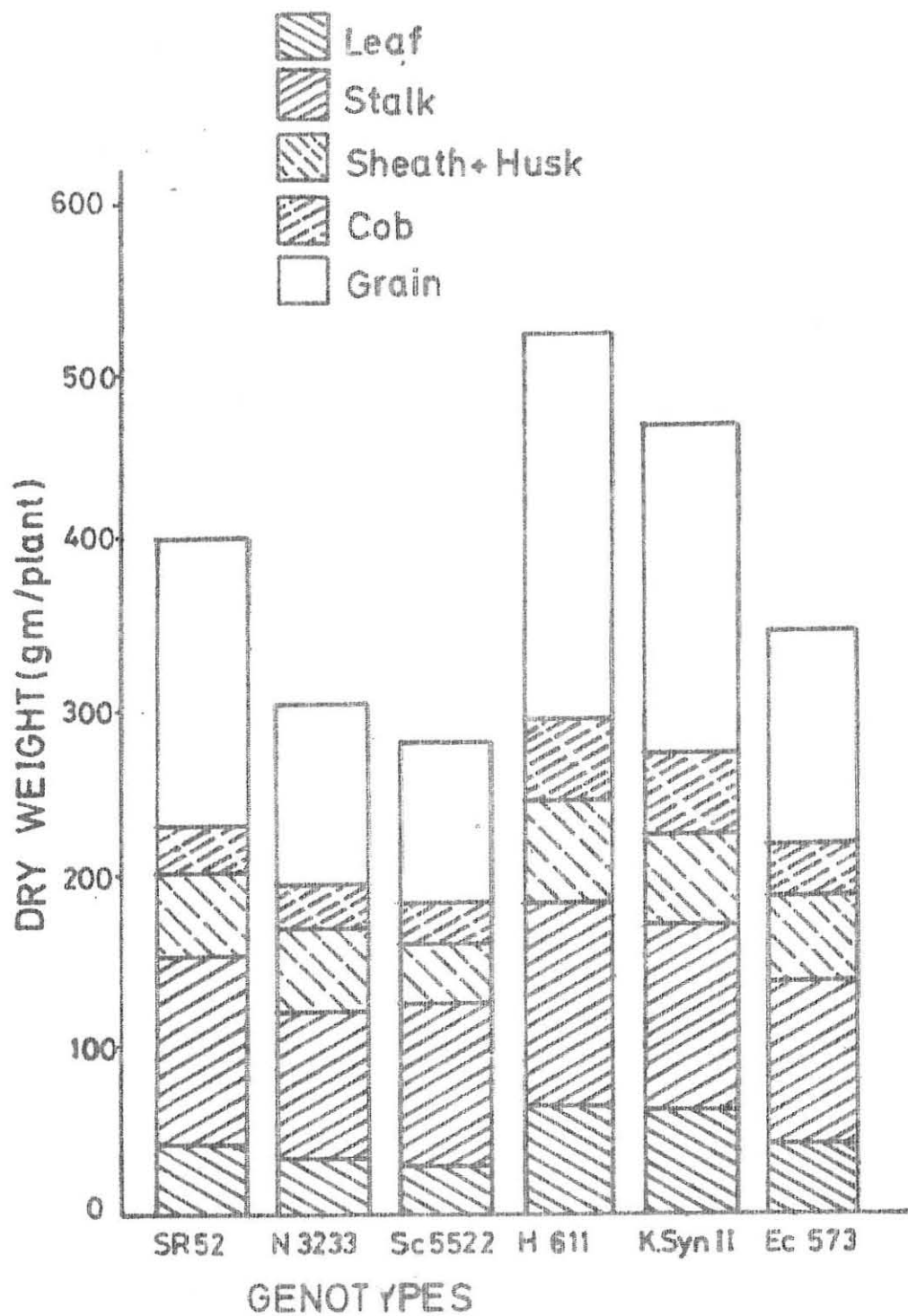


Fig. 3 Commulative dry matter production in different part of maize plant at final stage of maturity.

lateness in maturity observed in parental lines of H611 which enabled them to exploit the longer grain filling period for maximum dry matter and grain yield production. Similar result has also been reported earlier by Van Eijnatten (1963).

Vegetative weigh and Components

Successive dry weight of the leaves, stems, ears and grain was made at different growth stages at two week intervals starting 10 weeks to 20 weeks after emergence (Table 11). As shown in Table 11, leaf weigh was lower than stem weight in all genotypes. This might suggest probably earlier growth stages could be more appropriate to determine the stage at which the leaf weight out stripes the stem weigh. Similar finding was reported by Osafo (1972). In general, there is much tendency of more weight loss from leaves than from stems which could partly be attributed to the proportion of the leaf dry matter lost through decay or dropping off of senesced lower leaves in addition to the translocation process.

Stem weight to shoot weight ratio

This ratio determines the amount of shoot dry matter found in the stem at any time. As it is shown in Table 11, it has declined with time. The rapidity and extent of decline of the ratio is determined by the rate at which the ears increased in weight through current photosynthetic gains as well as the dry matter

TABLE 10: Analysis of variance for the different maize plant parts of the two hybrids and their parental lines.

Source of Variation	Mean Square						
	Leaf	Stalk	Ear	Sheath and Husk			
				Husk	Cob	Grain	Total
	dry matter g/pl.						
Main Plots							
Replications	219.52	1099.11	1409.48	45.28	380.00	23.04	877.92
Harvest Stages(H)	943.49**	3775.20**	78634.45**	250.06	213.21	12637.71	388778.22**
Error (a)	250.32	448.27	415.52	191.31	100.54	715.73	544.67
Sub Plots							
Varieties (V)	4439.65**	7605.98**	17565.98**	524.77**	714.84**	11286.33**	63068.25**
H x V	205.13	327.12	1717.02**	10.23	4.45	670.04	4165.91**
Error (b)	126.24	329.52	216.02	144.98	38.63	693.64	262.37

*, ** Significantly different at the 5% and 1% level of probability, respectively.

redistribution to the ears or lost by respiration from the stem. The highest ratio of stem weight to shoot weight was recorded for Sc 5522 (0.33) followed by N 3233 (0.29). The least ratio was encountered by K.Syn.II and H611 (0.23, 0.23), respectively.

Ear weight to shoot weight ratio

Sequential ratio of ear weight to shoot weight is presented in Table 11. The translocation of shoot dry matter into the ears was initially more efficient in the two hybrids. SR 52 (0.30) and H611 (0.24) followed by N3233, Ec573 and K.Syn.II. However, this efficiency was maintained only by H611 which produced 0.59; K6yn.II has increased the efficiency level to about 0.58 which was initially relatively lowest. The lowest proportion at the final grain filling period was encountered by Sc 5522, and N3233 which was 0.51 and 0.52, respectively. The probable reason for such low value could be attributed to the inability of the inbreds to accept more of the produced dry matter during the current photosynthate production or by translocation due to lack of enough room in the ear. This finding is in agreement with the results of Allison, and Watson (1969). On the other hand H611, K.Syn.II, and Ec573, being relatively late maturing types, they might have exploited the longer grain filling period in assimilating more of the photosynthates in the developing ears. This result agrees with the previous works of Van Eijnatten (1963); Allison (1971).

TABLE 11: Proportion of different maize plant to one another for the two hybrids and their parental lines at different growth stages.

CHARACTER	GENOTYPES	WEEKS AFTER EMERGENCE					
		10	12	14	16	18	20
LEAF WEIGHT	SR52	0.56	0.57	0.44	0.42	0.42	0.40
TO	N3233	0.51	0.42	0.34	0.35	0.39	0.38
STEM WEIGHT	Sc5522	0.49	0.50	0.35	0.37	0.35	0.34
RATIO	H611	0.43	0.33	0.56	0.42	0.46	0.52
	K.Syn.II	0.58	0.73	0.49	0.43	0.57	0.55
	Ec.573	0.51	0.44	0.43	0.44	0.44	0.41
STEM WEIGHT	SR52	0.45	0.41	0.43	0.39	0.30	0.27
TO	N3233	0.51	0.46	0.45	0.39	0.31	0.29
SHOOT WEIGHT	Sc5522	0.54	0.48	0.48	0.44	0.35	0.33
RATIO	H611	0.53	0.46	0.43	0.41	0.30	0.23
	K.Syn.II	0.55	0.45	0.44	0.40	0.26	0.23
	Ec.573	0.55	0.51	0.44	0.36	0.30	0.28
EAR WEIGHT	SR52	0.30	0.35	0.39	0.45	0.51	0.56
TO	N3233	0.22	0.34	0.39	0.47	0.50	0.52
SHOOT WEIGHT	Sc5522	0.19	0.28	0.34	0.40	0.45	0.51
RATIO	H611	0.24	0.30	0.36	0.41	0.49	0.59
	K.Syn.II	0.13	0.22	0.35	0.43	0.49	0.58
	Ec.573	0.17	0.27	0.37	0.47	0.51	0.57
GRAIN WEIGHT	SR52	-	-	-	-	0.35	0.43
TO	N3233	-	-	-	-	0.29	0.35
SHOOT WEIGHT	Sc5522	-	-	-	-	0.28	0.35
RATIO	H611	-	-	-	-	0.31	0.44
	K.Syn.II	-	-	-	-	0.32	0.42
	Ec.573	-	-	-	-	0.30	0.37

Grain weight to shoot weight ratio

The rate of translocation of shoot dry matter into grain was determined at the last two growth stages (Table 11). H611 produced the highest proportion (0.44) followed by SR 52 (0.43) and K.Syn. II (0.42). The least proportion was produced by Sc 5522 (0.34) and N3233 (0.35).

Loss in Vegetative weight during grain filling

In this experiment the decline in vegetative weight from the peak is given in Table 12. The decline which has occurred after initiation of ear growth was presumed to have been partly due to the remobilization of carbohydrate reserves into the ears (Dynard et al, 1969; Van Eijnatten, 1963; Johnson et al, 1966). Quite apart from respiratory losses, much of this dry matter loss is due to the decline in leaf weight obviously, resulted from the fall or decay of senescent leaves. However, such decay conditions could not normally occur under normal environment and in healthy maize stems. Stem respiratory losses are expected to be minimal and relatively un-important (Osaf, 1972). Attention is given to the decline of stem weight which, by virtue of its morphological position relative to the ears and leaves, is considered by Osaf (1972) to be important in the partition of dry matter in the maize shoot.

TABLE 12: Losses in vegetative weight during grain filling period.

Genotype	Leaf weight			Stem weight			Total vegetative	
	g/plant peak	% weight loss	peak %	g/plant peak	peak weight	peak loss%	weight loss from peak (%)	
SR52	65.73	23.43	36	136.69	29.67	22	27	
N3233	48.22	14.68	31	119.35	32.09	28	28	
Sc5522	47.30	15.47	33	110.03	15.03	14	20	
H611	95.69	32.48	33	195.00	74.04	37	37	
K.Syn.II	106.99	46.76	48	161.92	52.29	32	37	
Ec573	58.15	18.47	32	133.85	36.36	28	29	

In the present experiment, the accumulation of dry matter in the stalks after silking may most likely be due to a limited ear sink capacity or possibly, a reduced photosynthetic ability. According to Duncan et al (1965), the latter case holds true under the conditions where a period is characterized by warm days and with low amount of incident daily solar radiation relative to the early growing conditions. However, this condition seems unlikely to occur under our condition where enough daily solar radiation occurs. Therefore, the most probable cause for the reduction of stalk dry matter could be the enlarged sink capacity.

Moreover, according to Dynar et al (1969), maize varieties of a low yielding potential might be expected to show no remobilization of stalk soluble carbohydrates. However, Allison and Watson (1969) showed that translocation of the stalk soluble carbohydrate from the stem part did not take place in the unfertilized maize plant only. In the present experiment some of the low yielding genotypes, N3233 and Sc 5522 (Table 12), seem to translocate comparable stalk dry matter, though low grain is obtained indicating relatively more of the translocated dry matter being accumulated in the non grain part of the ear.

Dry matter production after flowering

Total dry weights at the time of flowering was measured by interpolation of the weight at the preceding and succeeding harvests at tasseling. The increment of dry weight after flowering estimated by subtracting these values from the total dry weight at the final growth stage were 213.30; 147.72; 144.71; 264.87; 200.11 and 136.69 g/plant for SR 52, N3233, Sc 5522, H611, K.Syn.II, and Ec 573, respectively (Table 13, Fig.4). The distribution of grain dry matter as percent of the total dry matter produced after flowering is also shown in Table 13. The proportionately greater amount of dry matter was accumulated by the grain in the hybrids than in the parental lines. This was at the expense of stem, ear husks and cobs (Table 4a; 4b, and Table 9). The reduction in these plant parts of the hybrids has taken place at 14 and 16 weeks after emergence in Sr 52 and H611, respectively. Similar findings have been reported by Allison (1971).

Dry matter Attributes of the parental lines after flowering as the percentage of their hybrids.

Dry matter attributes of the parental lines as the percentage of their respective hybrids and all genotypes as the percentage of the highest producer, H611, is given in Table 14. The parental lines of SR 52, N3233 and Sc 5522 produced 69.3% and 67.8% of their hybrids total dry weight after flowering , respectively.

TABLE 13: Total dry matter produced after flowering by the two maize hybrids and their parental lines, and final grain yield expressed as percentage of dry weight produced after flowering.

Variety	Dry weight		Final Grain weight as % of the dry weight
	Production after flowering	Grain yield Q/ha.	
SR52	213.30	57.81	81
N3233	147.72	31.40	76
Sc5522	144.71	29.50	66
H611	264.87	66.23	87
K.Syn.II	250.11	57.99	78
Ec.573	176.69	37.62	73

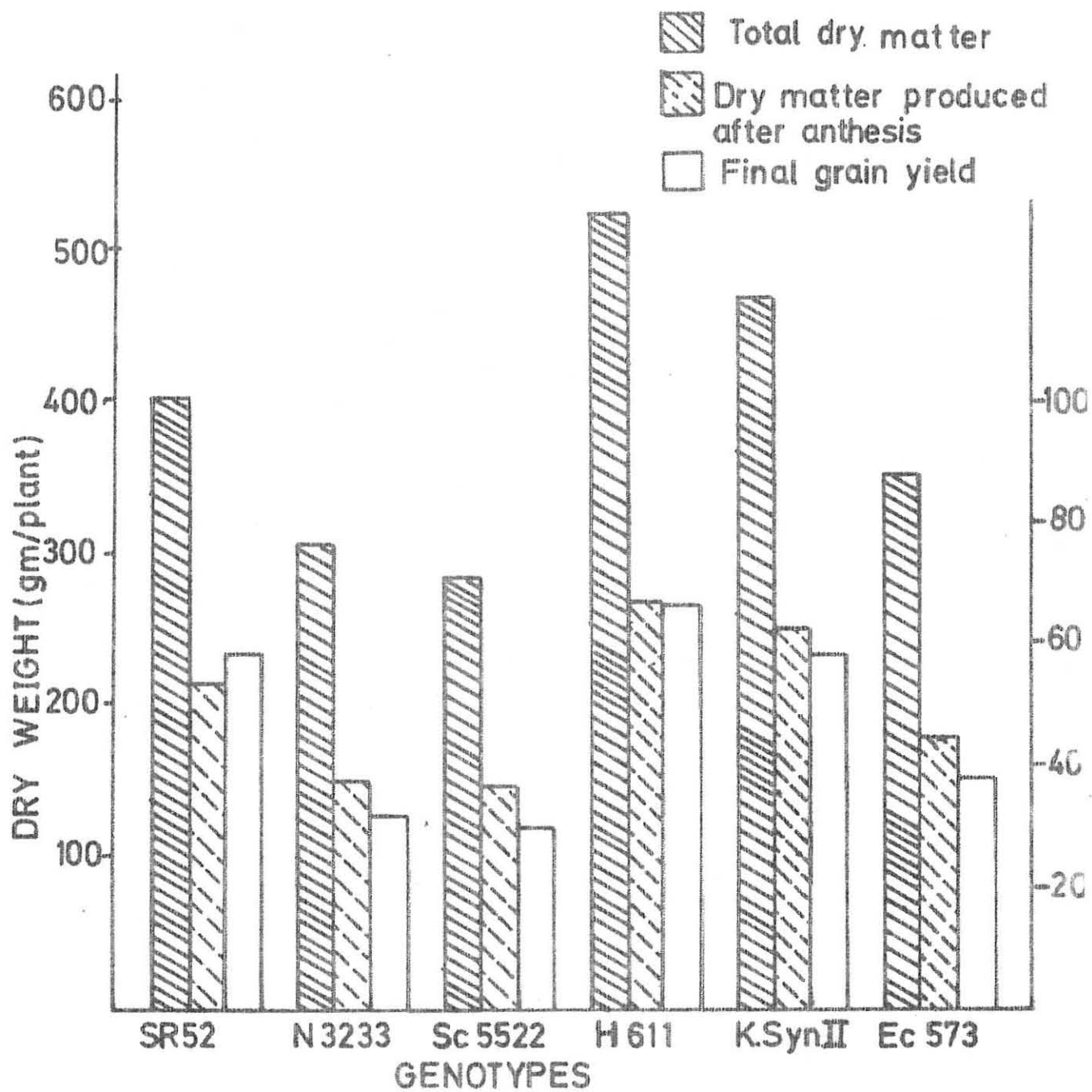


Fig. 4 Total dry matter produced by each genotype through out the growing period and after anthesis and final grain yield of the respective genotypes.

Regarding the grain yield, they produced about 54.3% and 51%; respectively.

On the other hand the parental lines of H611, K.Syn.II and Ec573, produced about 94% and 68% of their hybrids dry matter after flowering, respectively.

However, the grain yield was about 88% and 57% of their hybrids grain yield. Eventhough the efficiency in converting the produced dry matter after flowering into grain is less in the parents of SR 52 as compared to the parents of H611, in both cases the parents were not as efficient as their hybrids in producing dry matter after flowering and even in converting the produced dry matter into grain.

The difference observed in the produced dry matter after flowering could be due to lateness in leaf aging observed in the hybrids and their parental lines which might have resulted in differences in assimilating rate during the later part of the plant growth. This is in agreement with the findings of Allison (1971).

The grain yield of the inbreds may also have been limited by the ability of the grain to accept the produced dry matter after flowering. Thus, the observed difference in the final grain yield between the hybrids and their parental lines in the present experiment has taken place. Hybrid H611 and one of its parental lines, K.Syn. II may have not differed much in inherent efficiency of the leaves after flowering because it was observed that K. Syn.II had almost the same period in leaf aging, as its hybrids. The substantially

TABLE 14: Dry matter attributes of the parental lines after flowering, expressed as percentage of respective hybrids and all the varieties as the percent of the highest producer, H 611.

Variety	Dry weight	Dry weight		
	Production	Production as	Production as	Grain yield
	after flowering	percent of H 611	percent of H 611	as percent of
		Grain yield after flowering		H 611
		Percent		
SR52	100.0	100.0	80.5	87.3
N3233	69.3	54.3	55.8	47.4
Sc5522	67.8	51.0	54.6	44.5
H611	100.0	100.0	100.0	100.0
K.Syn. II	94.4	87.6	94.4	87.6
Ec.573	68.0	56.8	68.0	56.8

lower grain yield of K.Syn.II has taken place mainly due to the low dry matter accepting capacity of the grain. This is so because K.Syn.II has produced 94% as much dry matter, but it has only produced 88% as much grain yield as its counter part hybrid (Table 14).

Harvest index of the hybrids and their parental lines.

Harvest index (HI) is defined by Donald (1962) as the ratio of the grain dry weight to the total above ground dry weight (biomass) of a crop at maturity. It is one of the indices currently used to evaluate a crop dry matter partitioning efficiency. Many of the cereals like maize, develop to large extent a leaf and stem structure in relation to grain yield hence there is imbalance of time for vegetative growth and grain filling (Singh and Stoskopf, 1971). Selecting for those cultivars which produce higher proportion of grain to non-grain parts would assist breeders to produce plants on higher yielding capacity. Since over 90% of the dry weight of a plant is limited by the time in the amount of assimilate it can produce, a better distribution of assimilate into grain and less into non-grain should produce a more efficient plant. Based on this fact, the hybrids and their parental lines used in the present experiment were compared also on HI basis.

Comparison of all genotypes revealed that those with the highest total dry matter accumulation proved to have highest HI (Table 15) except for SR 52 and K.Syn.II, SR52 produced lesser dry

TABLE 15: Comparison of the genotypes on harvest index basis at maturity.

Variety	Total	Grain	Harvest Index	Grain Yield Q/ha.
	Dry weight	Dry weight		
	at harvest	at harvest		
SR52	401.02	172.73	0.43	57.81
N3233	302.87	106.72	0.35	31.40
Sc5522	283.52	95.72	0.34	29.50
H611	525.79	231.02	0.44	66.23
K.Syn. II	466.87	195.71	0.42	57.99
Ec.573	350.28	129.41	0.37	37.62

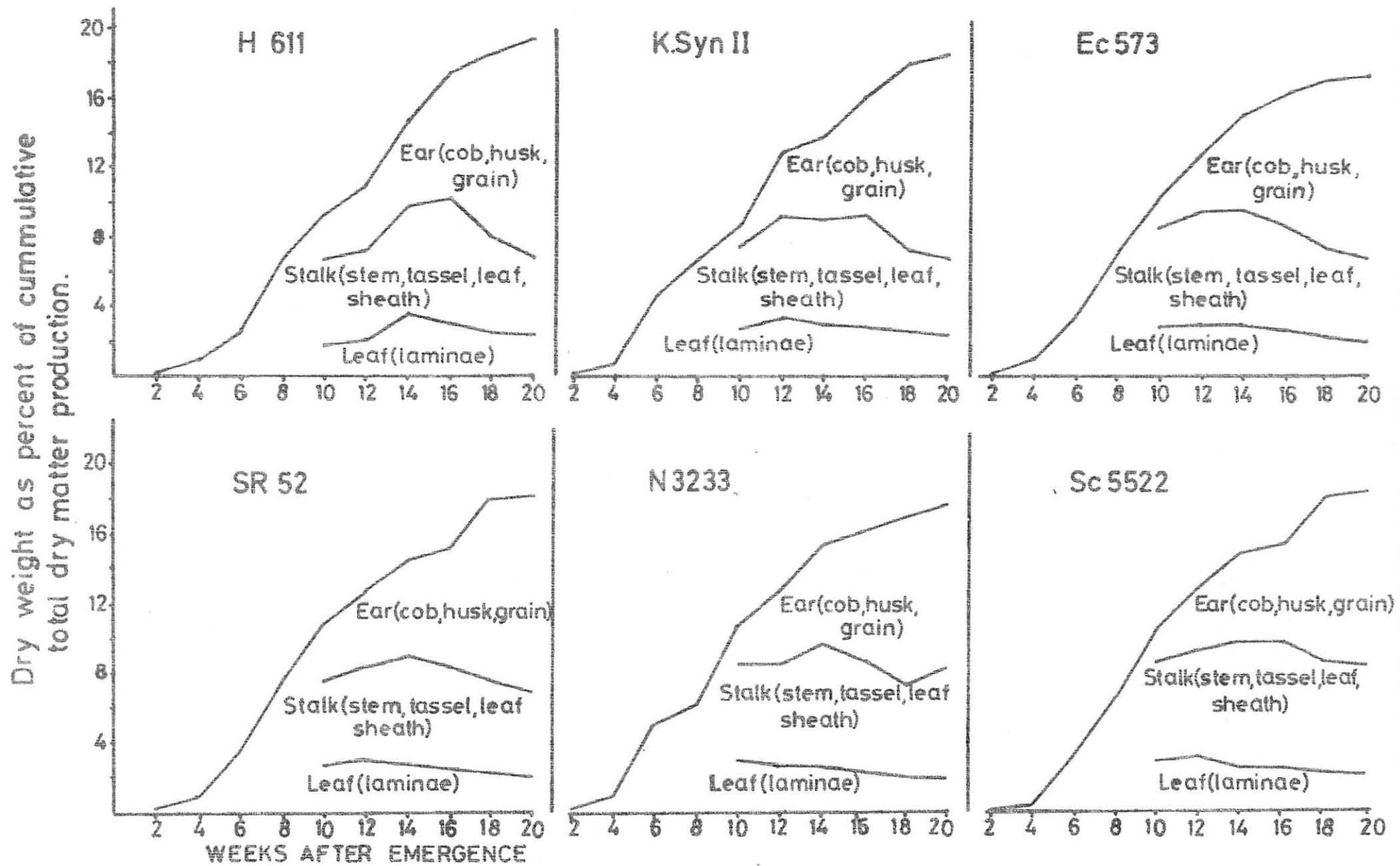


Fig. 5 Dry matter produced by different plant parts as percent of the cumulative total production through out the growing period.

matter (401.02 g/plant) as compared to K.Syn.II (466.87 g/plant). The HI of SR52 and K.Syn.II were 0.43 and 0.42, respectively. This indicates that SR 52 is slightly efficient as compared to K.Syn.II. The highest HI is produced by H611 (0.44) and the least (0.34) by Sc 5522.

Hybrid vigor

The result obtained in the present experiment seem to agree with the findings of Allison (1971). There may be no simple relation between vigor in young plants, a stage at which attention has frequently been directed in studies on physiological basis of hybrid vigor, and grain yield, on which attempts at genetical interpretations of hybrid vigor have often been based.

In this study the young hybrid plants appeared to be more efficient photosynthetically than the inbred plants which had demonstrated itself by more dry matter accumulation. Austin (1963) had similar view on this point. He pointed out that a small difference in the photosynthetic capacity of a plant could cause a larger differences in plant size.

However, competition in the field prevents the expression of the potentially greater size of the hybrid plants. The present result indicated that there is little difference among the hybrids and the parental lines in dry weight at the time of flowering.

However, there was a large difference in grain yield at final harvest (Fig.4). The difference was apparently caused by factors such as rate of aging of leaves and ability of the grain to accept dry matter, which has taken place after flowering. Such factors, according to Allison (1971), may not necessarily be closely related physiologically or genetically, to the factors that have exerted an influence at earlier stages of growth.

In general the present result seems to agree with the view that hybrid vigor results from a general increase in the efficiency and coordination of the array of biochemical processes taking place during the life of the plant (Hegeman, et al, 1967).

Nutrient Concentration and Uptake

Concentration of Nitrogen (N) and phosphorus (P) in all the stems and leaves of the six genotypes increased and then decreased as the growth and maturation process progressed with the exception of the increased N and P in maturing ears.

The concentration of P in the leaves did not vary much in all of the genotypes; however, there is a general declining trend in all of the growth stages (Table 16). There was no much difference in N and P concentrations between the six genotypes but the percentage of N in all plant parts was higher as compared to P concentrations (Table 16). Further, the accumulation of N and P in various plant parts in actual amount is shown in Table A₂).

TABLE 16: Distribution of Nitrogen (N) and Phosphorus (P) in different maize plant parts as percent of their respective dry weight.

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Genotype	Time in weeks	Leaf %		Stalk %		Ear %		Sheath + Husk %			Cob %		Grain %	
		N	P	N	P	N	P	N	P	N	P	N	P	
SR52	10	2.38	0.33	0.78	0.09	1.23	0.19	-	-	-	-	-	-	-
	14	1.26	0.17	0.29	0.13	1.32	0.28	-	-	-	-	-	-	-
	18	1.23	0.11	1.26	0.10	-	-	0.87	0.15	0.70	0.08	1.74	0.45	
	20	1.20	0.12	1.15	0.08	-	-	0.78	0.08	0.59	0.07	1.90	0.62	
N3233	10	2.12	0.26	0.81	0.11	1.25	0.19	-	-	-	-	-	-	-
	14	1.20	0.23	0.98	0.13	1.37	0.27	-	-	-	-	-	-	-
	18	1.18	0.21	1.65	0.10	-	-	1.75	0.20	0.87	0.12	1.74	0.59	
	20	1.12	0.15	0.95	0.05	-	-	0.70	0.09	0.64	0.10	1.90	0.61	
Sc5522	10	2.35	0.31	0.78	0.09	1.18	0.17	-	-	-	-	-	-	-
	14	1.32	0.17	1.72	0.13	1.43	0.26	-	-	-	-	-	-	-
	18	0.87	0.11	1.26	0.10	-	-	1.09	0.15	0.84	0.13	1.62	0.47	
	20	0.12	0.06	0.92	0.05	-	-	0.59	0.08	0.73	0.12	1.85	0.52	
H611	10	2.52	0.25	0.98	0.08	1.43	0.18	-	-	-	-	-	-	-
	14	1.34	0.17	1.12	0.14	1.46	0.24	-	-	-	-	-	-	-
	18	1.32	0.12	1.00	0.13	-	-	0.87	0.13	1.34	0.25	1.68	0.47	
	20	1.09	0.11	0.90	0.08	-	-	1.04	0.10	0.56	0.06	2.02	0.50	
K.Syn,II	10	2.41	0.23	0.95	0.07	1.37	0.18	-	-	-	-	-	-	-
	14	1.37	0.14	1.20	0.11	1.46	0.23	-	-	-	-	-	-	-
	18	1.20	0.12	0.95	0.10	-	-	1.37	0.21	1.12	0.20	1.68	0.50	
	20	1.17	0.10	0.84	0.08	-	-	0.70	0.10	1.98	0.17	1.90	1.37	
Ec573	10	2.30	0.25	0.95	0.05	1.12	0.17	-	-	-	-	-	-	-
	14	2.07	0.25	1.71	0.11	1.62	0.25	-	-	-	-	-	-	-
	18	1.12	0.22	1.15	0.06	-	-	0.90	0.16	1.27	0.26	1.74	0.37	
	20	1.18	0.12	0.81	0.05	-	-	0.78	0.12	0.87	0.19	2.00	0.46	

Nitrogen (N) accumulation and translocation

Nitrogen concentration in the leaves dropped in all the genotypes as growth stage advances. The percentage N content of leaves were 2.38% and 1.2%; 2.12% and 1.2%; 2.35% and 0.87; 2.5% and 1.09%; 2.4% and 1.20%; 2.3% and 1.81% in SR52; N3233; Sc5522; H611; K.Syn.II, and Ec 573, respectively at about 10 weeks and 20 weeks after emergence respectively. The highest cumulative uptake in the leaves was not possible to identify here because the % N was declining in all genotypes due to the ear development processes taking place at the same time encouraging N translocation. Subsequently, the amount of N decreased and much more markedly in K.Syn.II than the rest of the genotypes. At this growth stage, during fast development of ears, the demand for N could be very high, thus the roots can not absorb all the needed amount. This encourages translocation of the previously absorbed and accumulated N. This view agrees with that of Halvey (1976). In all sampling dates of all the maize genotypes, the marked reduction of N in the leaves could be due to translocation to the developing seeds. However, in some of the genotypes like Sc5522, some of the translocated N could have remained in the stem as seen by their higher N concentrations in this part of the plant. The present result seem to agree with the findings of Allison (1969); Joquest et al (1975); and Karl and Whitney (1980).

Phosphorus (P) accumulation and translocation

In the present study there was almost a decrease in the concentration of % P with age in most plant parts. In the leaves, the P concentration ranges between 0.06% in Sc 5522 at the last sampling date, 20 weeks after emergence, to 0.33% in SR 52 at the first sampling date, 10 weeks after emergence.

As it is shown in Table 16, there is difference in % P concentration of the respective dry weight of the genotype. More % P concentration was found in Ec. 573 than in the rest of the genotypes. However, this doesn't necessarily mean larger amount in actual P concentration; as this actual amount which is based on the percentage is influenced by total dry matter accumulated by the total dry matters by the genotype.

Stalk % P concentration tends to increase upto 14 weeks after emergence in all genotypes and then starts declining. On the other hand, ear % P and grain % P content increased all the way. The decrease in % P of leaves could be due to translocation of absorbed P to the newly developing ears and thus to the grain. Part of the translocation could have been 'trapped' by the stem which has manifested by the increase of % P in the stalk when a decline in % P was taking place in leaves. This result is in agreement with the findings of Arnon (1953); Jordon et al (1950), Hanway (1962); Early and DeTurk (1949), and Mohammed and Marshal (1979).

Although the trend of accumulation of P seems to be similar in all genotypes considered here, the efficiency of

accumulation and translocation is different which is due to the inherent absorbing characteristics of the genotypes. ~~Similar~~ findings ~~were~~ also reported by Baker et al (1967); Thomas (1972); and Agboola (1972).

SUMMARY AND CONCLUSION

Two hybrids and their parental lines, planted at Dire Dawa fruit farm were studied for total dry matter accumulation, N,P. distribution and other agronomic characters. Samples were collected at 14 days interval to determine total dry matter accumulation and N,P distribution in different maize plant parts (leaves, stalks, sheath and hus, cob, and grain). Final grain yield was also determined.

The hybrids and their parental lines considered in this study had a similar pattern of dry matter accumulation. However, significant difference in total dry matter yield was observed at different growth stages for the genotypes. A non-significant total dry matter yield was observed between the parental lines of SR52. The parental lines of H611 have accumulated higher total dry matter than the parental lines of SR52. The highest total dry matter yield (525.72 g/plant) was produced by H611, followed by K.Syn.II (466.87 g/plant). The least producer was Sc5522 (283.52 g/plant). The long growing cycle and slow senescence of leaves of H611 and its parental lines have favored for high dry matter accumulation.

There is a general decreasing trend in leaf dry matter as the growth stage advances. Nevertheless, responses appear to be different for the hybrids and their parental lines for different growth stages. In general highly significant leaf dry matter was observed among the genotypes. The highest leaf dry matter was produced by H611 and K.Syn.II at final growth stage. The lowest leaf dry matter yield was produced by parental lines of SR 52.

Highly significant difference was observed among genotypes and among the growth stages in stalk dry matter accumulation. At 14 weeks after emergence SR52 and its parental lines produced their respective highest stalk dry matter. Whereas H611 and its parental lines produced highest stalk dry matter at 16 weeks after emergence. Total stalk dry matter was not significantly different at final growth stage as compared to the 10th week after emergence. Loss of stalk dry matter at latter stage of growth is also observed. This loss could be attributed to translocation of the previously stored carbohydrate to the developing ear.

Ear dry matter accumulation increased as the growth stage advances for all genotypes. In the early stage of growth the accumulation rate was similar for all the genotypes. However the similarity did not appear to be the same at the final growth stage. Hence, highly significant difference was observed among the genotypes in accumulating ear dry matter at different growth stage, as the growth stage advances. Accordingly, H611 significantly out yielded all the genotypes by producing 310.51g/plant at final growth stage.

The final ear dry matter of the parental lines of SR52 (N3233 and Sc5522) accounted for 70% and 60% of their counter part hybrid respectively; whereas, those of the H611 parental lines, K.Syn.II and Ec573 accounted for 87% and 70% of their counter part hybrids, respectively. In general the parental lines of H611 proved to be better in ear dry matter accumulation than those of SR52. The daily ear growth rate was also found to be different for the different genotypes.

The last two growth stages were considered for sheath, husk, cob and grain dry matter accumulation. The analysis of variance table indicated that there is no significant difference between the growth stages; however, there is significant difference among the genotypes. H611 has produced the highest grain dry matter whereas the least grain dry matter was produced by Sc5522.

An average of 31.14% of the total dry matter was grain and 60.86% was non grain averaged over all the genotypes. However the relative proportion of grain and above ground non grain parts varied widely among the hybrids, parentals, and hybrids and parentals. The major part of above ground non grain part is constituted by stalk in both hybrids and their parental lines.

The comparison of ratio of vegetative weight and components for the genotypes indicated that leaf weight was lower than stalk weight in all genotypes. The highest stalk weight to shoot weight ratio was recorded for Sc5522 followed by N3233. The least ratio was encountered by K.Syn.II and H611. The translocation of shoot dry matter into the ears was initially more efficient in the two

hybrids. From the result obtained, H611 followed by K.Syn.II seem more efficient in dry matter production and translocation. N3233 and Sc5522 were found to be the least efficient in translocating shoot dry matter to ear.

Loss in vegetative weight after the peak weight is attained by the different maize plant parts was identified. The loss has taken place during grain filling period. Therefore, it was suspected that weight loss other than falling off of senesced leaves could be due to translocation to the developing grain.

Comparison of the dry matter production after flowering was made among the genotypes. The hybrids were found to be more efficient in production and distribution of dry matter after flowering.

Harvest index is one of the yardstick in measuring the yielding efficiency of a genotype.

In the present experiment, the hybrids and K.Syn.II were found to have the highest harvest index. N and P concentration in the tissue of all the genotypes was also determined. In all the observations made there was increasing and then a decreasing tendency of N and P in stems and leaves except in the ears where there was a continuous increase.

From this study it is observed that responses and rate of dry matter accumulation was different for the different genotypes. It was also observed that peak dry matter accumulation for the

different plant parts was observed at different growth stages for different genotypes. In all the parameters considered, H611 proved to be the highest dry matter producer; and hence the highest grain yielder. K. Syn.II, one of the parental line of H611, has produced the next highest dry matter followed by hybrid SR52. In general the late maturing types seem to be the highest dry matter and grain yield producers due to their efficiency to exploit the longer growing period because of the slow death rate of leaves.

In this study the hybrid which came from the parents of high dry matter producers proved to be highest yielder. From the result of this study it may be suggested that the parental lines that bear good potential in producing and translocating dry matter to the economically important plant part could be considered in the future breeding program for the hybrid production.

It was also observed that dry matter which was accumulated early in the growing season of the plants is translocated to the developing ears late in the season. Therefore, in the future breeding program attention should be given to genotypes with good translocation efficiency of dry matter to the grain.

The analysis of the present study indicated that there is no as such a particular growth stage to which attention should be given to promote the rate of dry matter accumulation. However, any thing that prevents the rate of leaf development such as insect pests, diseases, moisture and nutrient deficiencies should be avoided at early growth stages.

The translocation of N and P to the developing grain suggests that genotypes with better absorbing and translocation efficiency are very important. Hence selection geared towards such efficient genotypes would also seem to increase biological as well as economic yield of maize plant.

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A P P E N D I X

TABLE A₁: Mean weight of different parts of maize plant at different growth stage as per cent of total of the respective harvest stages.

Genotype	STALK						LEAF						EAR					
	Days after emergence						Days after emergence						Days after emergence					
	70	84	98	112	126	140	70	84	98	112	126	140	70	84	98	112	126	140
SR52	45.3	41.4	42.8	38.7	29.1	26.7	23.3	24.2	18.6	16.2	12.3	10.5	29.6	35.1	38.6	45.2	51.3	56.3
N3233	51.1	45.1	45.5	39.3	31.0	28.8	26.3	19.6	15.5	13.6	11.9	11.1	22.3	34.3	39.0	47.1	50.3	52.0
Sc5522	54.5	48.2	48.5	44.6	34.6	33.4	26.5	24.0	17.2	15.9	12.1	11.2	18.9	27.9	34.3	39.5	44.6	50.8
H611	53.0	46.6	42.5	41.2	29.8	23.0	23.1	15.5	24.0	17.5	13.8	12.0	23.8	30.2	36.5	26.2	54.3	59.1
K.Syn.II	55.4	45.2	43.4	39.9	25.7	23.5	32.0	32.8	21.5	17.4	14.6	12.9	12.7	22.1	34.7	48.2	49.4	57.8
Ec.573	54.7	50.90	43.9	36.3	29.8	27.8	27.9	22.2	19.1	16.0	13.6	11.3	17.3	29.9	38.0	52.8	51.0	56.1

Genotype	Sheath + Husk		COB		GRAIN	
	Days after emergence		Days after emergence		Days after emergence	
	126	140	126	140	126	140
SR52	15.0	12.7	8.7	6.9	35.1	43.1
N3233	18.6	16.2	9.8	8.7	28.6	35.2
Sc5522	14.0	12.9	10.9	8.7	28.5	33.8
H611	14.1	11.8	10.7 ⁷	9.2	31.4	43.9
K.Syn.II	12.7	11.6	11.5	10.1	31.6	41.9
Ec.573	16.1	14.7	10.4	9.2	30.1	36.9

TABLE A₂: Distribution of Nitrogen (N) and Phosphorus (P) in g/plant in above ground different maize plant parts of the two hybrids and their parental lines at different growth stages.

VARIETY	Time in WEEKS	LEAF		STALK		EAR		SHEATH + HUSK		COB		GRAIN		TOTAL	
		N	P	N	P	N	P	N	P	N	P	N	P	N	P
SR52	10	1.40	.19	.82	.10	.85	.13	-	-	-	-	-	-	3.07	0.42
	14	.75	.10	1.72	.18	1.63	.35	-	-	-	-	-	-	4.52	.63
	18	.59	.05	1.48	.11	-	-	.51	.09	.20	.03	2.40	.62	5.18	.90
	20	.51	.05	1.23	.09	-	-	.40	.04	.19	.02	3.28	1.07	5.61	1.27
N3233	10	1.02	.13	.76	.10	.51	.08	-	-	-	-	-	-	2.29	.31
	14	.48	.06	1.17	.16	1.40	.28	-	-	-	-	-	-	3.05	.50
	18	.39	.07	1.47	.04	-	-	.38	.05	0.8	.03	1.43	.50	3.75	.69
	20	.40	.08	.83	.09	-	-	.86	.10	.23	.03	2.03	.63	4.35	.93
Sc5522	10	.99	.13	.68	.08	.36	.05	-	-	-	-	-	-	2.03	.26
	14	.05	.04	1.01	.14	1.11	.20	-	-	-	-	-	-	2.17	.38
	18	.44	.06	1.65	.05	-	-	.23	0.06	.22	.04	1.88	.37	3.82	.58
	20	.27	.02	1.19	.09	-	-	.40	.03	.20	.03	1.77	.50	3.83	.67
H611	10	1.46	.14	1.30	.11	.88	.11	-	-	-	-	-	-	3.64	.36
	14	1.26	.12	1.90	.24	2.08	.35	-	-	-	-	-	-	5.24	.71
	18	.93	.12	1.50	.19	-	-	.62	.09	.72	.14	2.66	.79	6.43	1.33
	20	.69	.08	1.09	.10	-	-	.65	.06	.27	.03	4.66	1.09	7.36	1.36
K.Syn.II	10	1.67	.16	1.14	.08	.40	.05	-	-	-	-	-	-	3.21	.29
	14	1.03	.08	1.45	.15	1.66	.28	-	-	-	-	-	-	4.14	.51
	18	.78	.09	.98	.09	-	-	.40	.06	.52	.09	2.42	.72	5.10	1.05
	20	.72	.07	1.45	.12	-	-	.74	.11	.53	.09	3.77	.72	7.16	1.11
Ec.573	10	1.32	.14	1.07	.07	.58	.09	-	-	-	-	-	-	2.97	.30
	14	1.20	.15	1.54	.15	1.26	.19	-	-	-	-	-	-	4.00	.49
	18	.53	.10	1.77	.05	-	-	.50	.07	.31	.48	1.81	.48	4.42	.77
	20	.47	.05	.79	.05	-	-	.40	.08	.41	.09	1.59	.60	4.66	.86

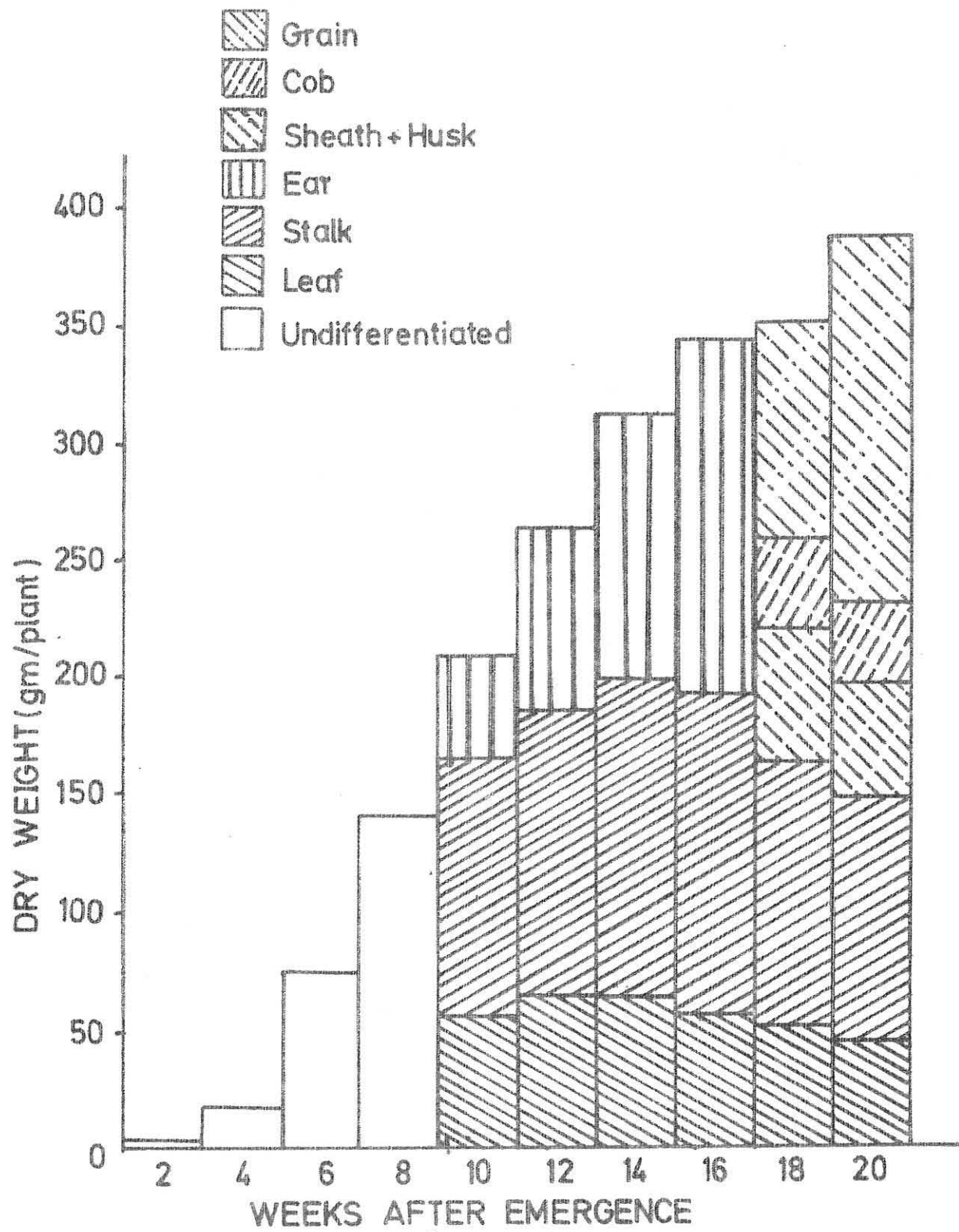


Fig. A₁ Cumulative dry matter produced per maize plant at each harvest stage mean of the hybrids and their parental lines

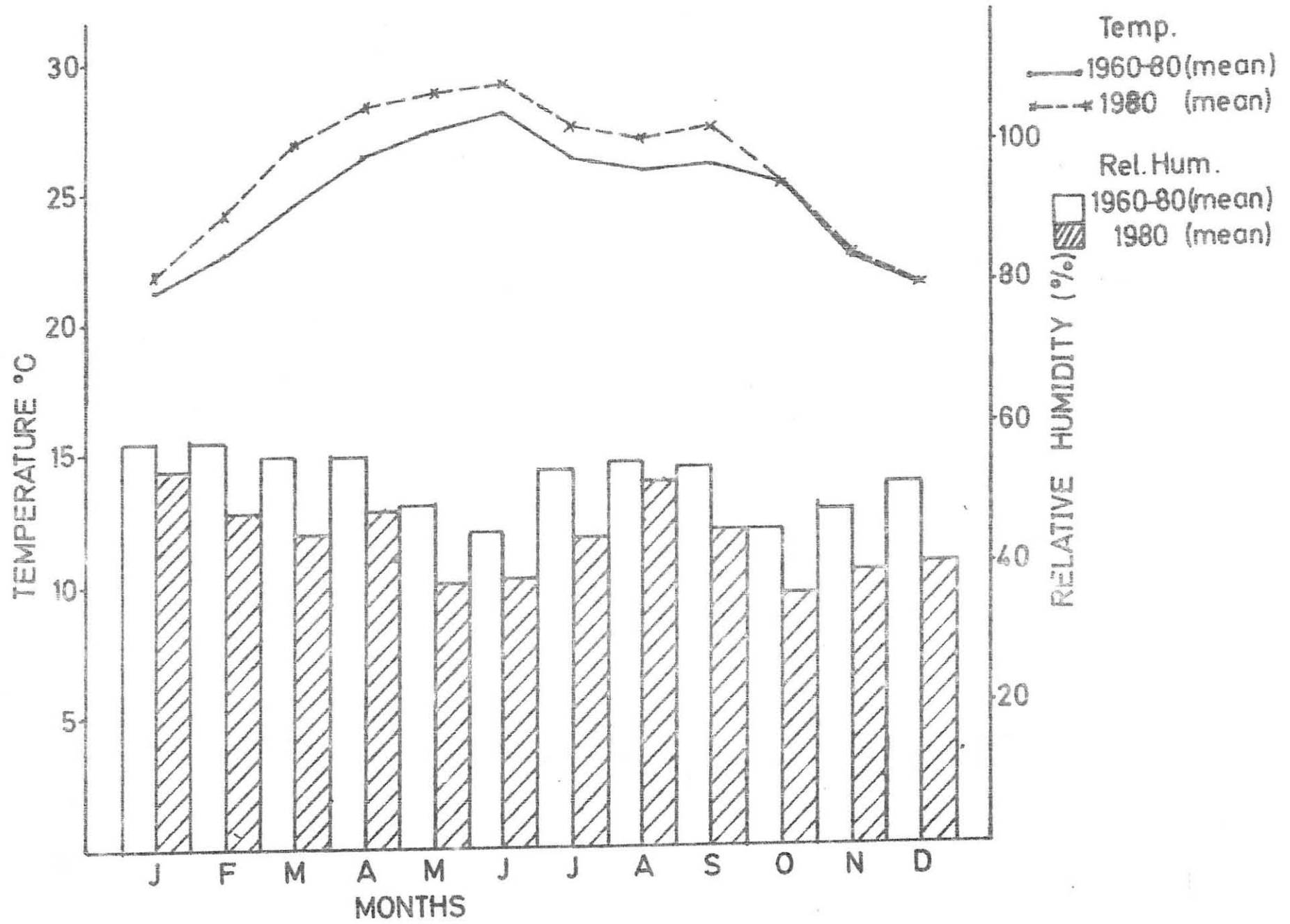


Fig. A₂ Mean relative humidity and temperature data of Dire Dawa from 1960-80 inclusive and for the year 1981

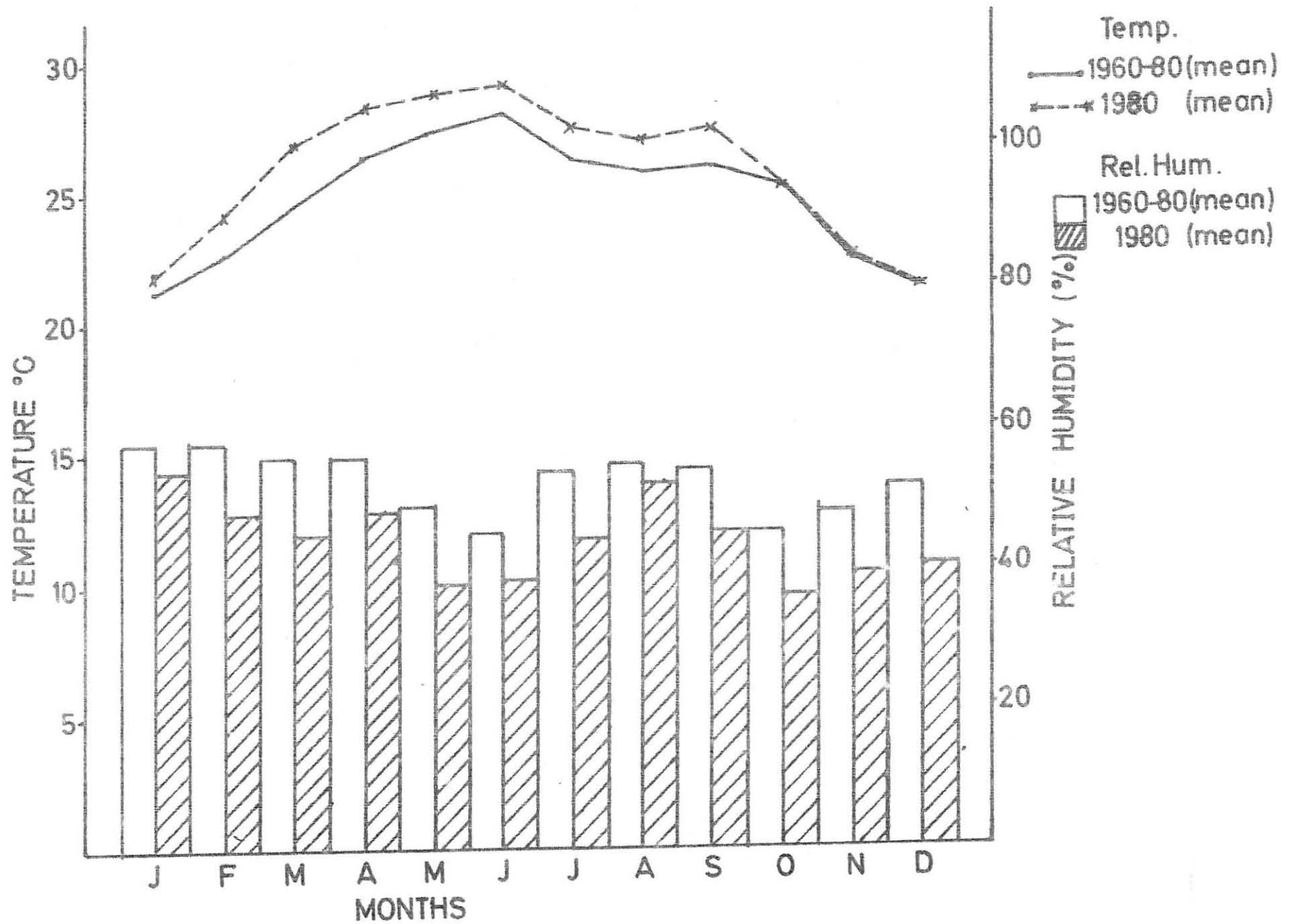


Fig. A₂ Mean relative humidity and temperature data of Dire Dawa from 1960-80 inclusive and for the year 1981

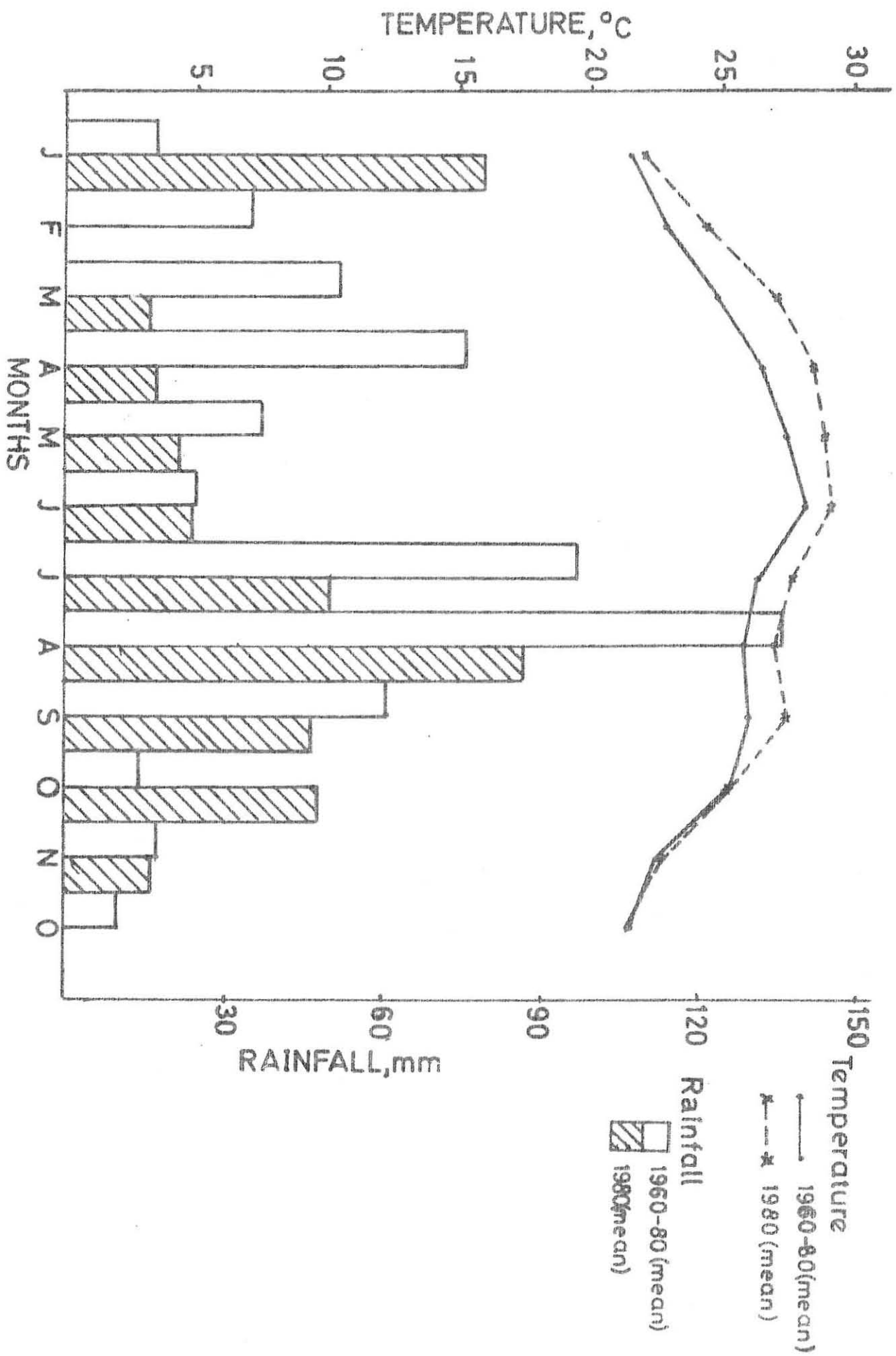


Fig A3 Mean rainfall and temperature of Dire Dawa from 1960-80 and 1980

D E C L A R A T I O N

I, the undersigned, declare that this thesis is my work and that all sources of material used for the thesis have been duly acknowledged.

Name: Aberra Debelo

Signature: _____

Place and date of submission May 26, 1982, Alemaya