EFFECT OF IRRIGATION SCHEDULE AND PLANT POPULATION ON THE YIELD AND OTHER CHARACTERISTICS OF HYBRID CORN

by

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ABSTRACT

An experiment was conducted at the Agricultural Research and Education Center in the Beqa'a Plain during 1964, to study the effect of different irrigation schedules and plant population levels on the grain yield and other agronomic characteristics of hybrid corn.

Weekly irrigation resulted in significantly higher grain yields than did weekly irrigation up to tasseling, followed by biweekly irrigation and biweekly irrigation up to tasseling, followed by weekly irrigation.

A plant population of 5,000 per dunum yielded significantly more grain as compared to 3,500 and 6,500 plants per dunum. There was a drastic reduction in grain yield with 6,500 plants per dunum combined with weekly irrigation up to tasseling followed by biweekly irrigation.

Weekly irrigation increased the stover yield, plant height, ear-weight per plant and the tillering percentage over biweekly irrigation up to or after tasseling, but the barrenness percentage and protein percentage were reduced.

Tasseling and silking were induced earlier by weekly irrigation than by following biweekly irrigation up to or after tasseling.

Increasing the population from 3,500 to 6,500

plants per dunum increased the stover yield, plant-height and barrenness percentage but the protein percentage, tillering percentage and ear-weight per plant were decreased. The same increase in plant population delayed tasseling and silking.

Under weekly irrigation the maximum grain yield was obtained with a population of 5,000 plants per dunum, and the ear-weight per plant was 0.53 pounds. Under weekly irrigation up to tasseling, followed by biweekly irrigation the maximum grain yield resulted from 3,500 plants per dunum and the ear-weight per plant was 0.51 pounds. Biweekly irrigation up to tasseling, followed by weekly irrigation gave the maximum grain yield with 5,000 plants per dunum and the ear-weight per plant was 0.48 pounds.

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INTRODUCTION

Corn (Zea mays L) is one of the major feed and food crops of the world. World production of corn is about two hundred and fourteen million metric tons, produced from one hundred and three million hectares, with an average yield of 2.1 tons per hectare (11).

In Lebanon about 6,000 hectares produce 12,000 metric tons of corn annually with an average of 2 tons per hectare. The total production, however, does not meet the needs of the country and large quantities are imported annually - about 9,000 tons (32).

Hybrid corn has a high yield potential, particularly under irrigated conditions. Both the irrigation schedule and the density of plant population play a major role in determining the actual level of production. As such it would help increase the food production of a given area if the most advantageous combination of plant population and irrigation schedule could be established. Considerable research work has been carried out in relation to optimum plant population. Similarly much research has been carried out with the aim of determining the relation of yield to soil moisture stress. In many cases varying irrigation intervals have been recommended. However, in those areas of the world where irrigation water is not supplied by wells, the individual farmer has little if any control over the time at which his irrigation water is delivered.

Generally water is delivered at a fixed rotation and the interval between irrigations is determined by experience, local soil and climatic conditions and convenience. Such intervals are usually conservative in their estimate of water use and the soil moisture is generally maintained at relatively high level. To achieve economy in water use and a higher yield in relation to the total amount of water applied longer intervals of varying lengths might be recommended. However, since such variations are not within the power of individual farmer the only alternative would be to modify irrigation intervals in terms of multiples of the complete cycle - that is not to irrigate every time it is one's turn to get water but possibly every other time. If such a modified schedule results in similar yields or more efficient water utilization, the water saved might be used to irrigate another crop.

The present work was undertaken to determine the effect of such modified irrigation schedules in combination with various plant population levels on the yield and other agronomic characteristics of hybrid corn. Working at the Agricultural Research and Education Center, where a fixed rotation of one week is adapted, the modified schedules consisted of biweekly irrigations either before or after tasseling. This division was based on the assumption that the period from planting to tasseling is not so sensitive to moisture tension as is the period after it.

A population of 5,000 plants per dunum has proven to be optimum under weekly irrigation at the same Center (36). Therefore, a population of 5,000 plants per dunum and also populations of 6,500 and 3,500 plants per dunum were used in combination with three irrigation schedules.

It is hoped that the results of such studies might prove of benefit to farmers in the area through saving them both water and labour expenses while maintaining the same yield that they are obtaining now or even improving these.

REVIEW OF LITERATURE

In recent years, the problem of optimum plant population and appropriate soil moisture conditions have been the subject of much research, both in non-irrigated and irrigated agriculture.

Reports reviewed in the following pages have been limited to those dealing with plant responses under different plant populations and soil moisture conditions.

Soil moisture status and grain yield

Holts and Doren (18) concluded on the basis of trials in western Minnesota that the water requirement for corn was greatest in the period from tasseling to kernel formation and that it dropped sharply after that period. Kiesselbach (21) reported that in a year of severe drought, there was no grain yield without irrigation, whereas two supplemental irrigations of three inches each were reported to have produced a grain yield of 72.4 bushels per acre. The author suggested that two additional well distributed three-inche irrigations would have raised the yield to about 115 bushels per acre on the experimental plots.

Robins and Rhoades (29) observed that the rates of water used seldom exceed 0.1 inch per day until corn is 6 - 12 inches high, the rate then gradually increases from 0.25 - 0.3 inch per day during the period of growth from silking to soft dough stage. The rate declines gradually as the weather becomes cooler and the plant reaches maturity. A defficiency of moisture during tasseling and silking markedly lowers the yield.

Carlson _et al_. (2) studied the soil moisture effect and concluded that the stage of growth of the plant appeared to influence evapotranspiration rates under irrigated conditions. Although the stage of development coincides very closely with maximum climatic intensity, a detailed study of the climatic record shows that the corn plant requires more water at tasseling and silking stage than during the later periods of growth. Because of changes in climate with the advancement of growth it is difficult to determine whether the stage of plant development had any significant influence on the water use.

Robins and Domingo (30) reported that moisture depletion to the wilting point, at the time of tasseling or pollination, when the moisture deficit lasted for one to two and six to eight days, resulted in yield reduction of as much as 22 per cent and 50 per cent respectively. They also concluded that the depletion of available soil moisture after maturity did not affect the yield and moisture content of the plant.

Davis and Hagood (5) studied the behaviour of sweet corn on a silty clay loam which was irrigated to a depth of about six inches before sowing and reported that the yield ranged from 3.33 tons per acre with four inches of irrigation water to 5.23 tons per acre with 32 inches of irrigation water. They further reported that irrigation was economical and efficiently used over the range of 10 - 24 inches and that, where water supplies are limited, the area actually irrigated should be reduced so that the amount applied would be above the minimum of the economic range.

According to Howe and Rhoades (19) Miller and Duley (1923) indicated that timing a given number of irrigations influenced the yield materially. Three irrigations that maintained a low moisture tension during the stage of growth just before tasseling through silking, and three irrigations that were more midely spaced throughout the growing season resulted in similar yields. The yields were decidedly higher than the yield obtained with three irrigations scheduled during the period prior to tasseling.

Vazquez (37) noticed that there was no significant difference in production between frequent irrigation (when 20 per cent of the available moisture had been depleted from the root-zone) and intermediate irrigation (when 60 per cent of the available moisture had been depleted) applied throughout the growth season or until the hard dough stage. Maximum consumptive use occurred between the tasseling and hard-dough stages, decreasing in the last 45 days of the growing season.

Rosic (31) carried out an experiment on brown forest soil under average annual rainfall of 250 millimeters following three water application levels of 1,000, 2,000 and 4,000 cubic meters per hectare. He noticed an increase of yield amounting to 87.1 per cent from the application of 1,000 cubic meters of water per hectare. He suggested that 400 cubic meters should be applied at the time of tasseling, 300 at earing and 300 at the time of pollen shedding.

Somerhalder (33) observed that once the needs of the corn plants are satisfied, added water is used less efficiently by producing little or no increase in yield. When there was no irrigation after planting, the yield was 111 bushels per acre, while a three inches pretassel irrigation produced 130 bushels per acre and with eight inches of irrigation, the yield was 138 bushels per acre. The first three inches of irrigation produced an increase of 19 bushels compared to an increase of eight bushels for the additional five inches. Three irrigations centered around the pollination stage produced yields comparable to that where soil moisture tension was low up to the time of maturity. Three irrigations beginning ten days before tasseling, applied on a 14 days rotation water delivery schedule, produced similar yields.

Denmead and Shaw (6) mentioned that soil moisture stress prior to silking reduced grain yield by 25 per cent, at silking reduced the grain yield by 50 per cent and after silking reduced the yield by 21 per cent.

Vittum (39) conducted an experiment on sweet corn for five years on silt loam soil capable of retaining 3.4 inches available water in the top two feet depth. Precipitation supplied 8.4 inches of water and irrigation 3.4 inches. Under irrigation, 119 marketable ears were produced per 100 plants, compared with 109 ears for plants grown without irrigation.

Fernandez and Laird (12) conducted a trial at Mexico and found that in plots not subjected to drought, the ear yield varied from 2.7 tons per hectare with no nitrogen to 6.2 tons per hectare with 150 kilograms nitrogen per hectare. For the plots affected by 11 days of drought the corresponding yields were 2.5 and 2.7 tons per hectare respectively. Eleven days of drought had, therefore, little effect on the maize grown at a low level of fertility.

Howe and Rhoades (19) found that the yield of grain ranged from 69 bushels per acre without irrigation during the growing season to 153 bushels per acre where a low soil moisture tension was maintained throughout the season by application of 14.2 inches of water in six irrigations.

<u>Effect of population on corn yield</u>

Fitts (13) reported that for North Carolina, the plant population should be 8,000 to 9,000 plants per acre to expect 50 to 75 bushels per acre, 12,000 to 14,000 plants for 75 to 100 bushels, 14,000 to 16,000 plants for 100 - 150 bushels and 16,000 to 20,000 plants for over 150 bushels of grain per acre.

Drake <u>et al</u>. (8) in a northern island of Japan (Hokkaido) averaging the yields of all hybrids at three locations reported that an increase in plant population from 17,000 to 22,000 plants per acre increased yields by 10.6 bushels of grain per acre.

Colville and McGill (4) observed that there was little difference between yields from populations of 16,000, 20,000 and 24,000 plants per acre. Further increases in population over 24,000 plants per acre generally resulted in decreased yields.

Colville (3) mentioned that yields of irrigated corn have been reported to increase with population increases from 12,000 to 24,000 plants per acre. The yields from populations of 16,000 to 24,000 plants per acre were nearly identical although gradually increasing. Beyond 24,000 plants per acre yields tend to decrease.

Dumenil (9), on the basis of 15 years of research in north Iowa, proposed 16,000 plants per acre at high fertility levels for most conditions and 10,000 to 12,000 plants at low to medium soil fertility. When drought limits yields to 50 - 60 bushels per acre, yields have been nearly constant with 8,000 to 16,000 plants but have decreased above 16,000 plants per acre. However, under severe drought conditions yield will drop if stands are above 8,000 plants per acre.

Viets (38) reported that the moisture supply determines the best planting rate for corn in the 11 Western States. On dryland, corn production depends on at least 15 inches of annual rainfall, with most of it falling in the growing season. Stands must be from 4,500 to 7,500 plants per acre. For irrigated land, stands of about 18,000 to 20,000 plants per acre are needed for high grain yields.

Hinkle and Garrett (17), on the basis of experiments conducted for five years in Arkansas, found that the optimum number of corn plants per acre depends somewhat on the seasonal rainfall distribution. Under unfavourable distribution 12,000 plants per acre were enough for maximum yield but under favourable seasonal distribution, a population of 16,000 plants per acre either gave a tendency toward an increased yield or did not reduce yield significantly as compared to 12,000 plant population.

Termunde *et al.* (35) conducted experiments in eastern Dakota and concluded that grain production reached a maximum along the population levels of 12,000 to 16,000 plants per acre, and fell off drastically if the population level exceeded this optimum. Under conditions of drought, maximum yields may be associated with rather low plant population levels. Lang (22) reported that Duncan came up with an estimate of 16,000 plants per acre for each 100 bushels of grains.

Stover yield

Zuber *et al.* (41) pointed out that under less favourable conditions for grain production, the stover weights were higher and yields of grain were lower. Apparently under such conditions nutrients were not translocated from the vegetative portion of the plant to the grain.

Termunde *et al.* (35) observed that when the population level of 12,000 to 16,000 plants per acre for the maximum grain yield was exceeded, the yield of grain fell drastically whereas the forage production remained at the same maximum.

Tillering

Dungan *et al.* (10) reported that Montgomery (1909) working in Nebraska, found that many suckers which were growing in the early season disappeared during the period of ear formation. They further reported that Thompson et al. (1930) working in Long Island, found that the removal of suckers from sweet corn tended to reduce the yield of marketable ears, especially after the plant had begun to tassel. They also reported that Williams and Etheridge (1912) working in North Carolina pointed out that highly productive soil with adequate soil moisture supply and thin spacing favour the production of tillers. They concluded many investigators have found that the removal of suckers is of no practical advantage.

Stringfield and Thatcher (34) in Ohio observed that tillering decreased rapidly as the stand approached the optimum level for grain production. Macgillway (24) observed that there were always more suckers on the irrigated plants than on the non-irrigated ones. The averages of 2.7 suckers per plant on the dry treatment and 3.5 suckers per plant on the wet treatment were obtained.

Plant and ear height

Macgillway (24) observed that the relative weight and size of sweet corn plants were greatly affected by the amount of irrigation water. In all of four experiments, the weight of the plant was proportional to the amount of irrigation water applied. The same effects were noticable in the successive height measurements. Irrigation treatments made little differences in the heights of young sweet corn, but at maturity the height of the corn plant was roughly proportional to the amount of water applied.

Howe and Rhoades (19) concluded that under favourable soil moisture supply, the corn plant attained maximum height by August; but where the moisture supply was less favourable, maximum heights of corn were obtained at a later date. A reduction in soil moisture supply influenced the plant height by reducing the length of the internodes. Further they reported that Duley (1923) also pointed out that the reduction in length of internodes was the effect of a low soil moisture supply, especially when it occurred during the period of growth 30 - 60 days after planting.

Carlson _et al_. (2) found that the corn plants in the irrigated treatments were taller than those in the non-irrigated treatment. The difference in height ranged from 12 to 18 inches. In the non-irrigated plots wilting occurred in July and August.

Dungan _et al_. (10) reported that Stringfield _et al_. (1947) found that in Ohio the ear node was somewhat higher from the ground on thickly planted corn and concluded on the basis of their work in Illinois and Iowa that plant population had little effect on plant height and ear position. Zuber and Grogan (40) concluded that ear heights above the ground gradually increased as planting rates were increased, because of greater competition for light between plants at the higher rates of planting.

Denmead and Shaw (6) observed that stem elongation was reduced by a high soil moisture stress during the vegetative stage of growth. The variability was such that the small decrease in plant height observed was not significant except where stress was applied in both vegetative and silking stages.

Dates of tasseling and silking

Lang *et al*. (23) found that silking was delayed by one day for each additional 4,000 plants per acre. Stringfield and Thatcher (34) reported that in Ohio, the silking period for a stand of five plants per 42-inch hill has roughly two days later than that for a stand of three plants per hill.

Dungan *et al*.(10) observed that increasing the population density delays plant development. A study of the dates of the half tassel and half silk stage of nine hybrids in conjunction with rates of planting was carried out in central Illinois. It was observed in this test that the increase in time between silking and tasseling because of thicker planting was not great. It amounted to only a little over one day when the population was increased from 8,000 to 20,000 plants per acre.

Barrenness and ear-size

Lang *et al.* (23) were of the opinion that stalk barrenness had the greatest influence on yield and it was affected more by population than by the hybrid or the fertility level. At 4,000 to 8,000 plants per acre, there was not an earless stalk, at 24,000 plants per acre 30 per cent of the stalks were without ears on the low-nitrogen level and 16 per cent barrenness, with the same stand, on high-nitrogen level.

Dungan *et al.* (10) mentioned that Dungan *et al.* (1938) in tests conducted in northern Illinois, found 1.2 per cent barrenness with 8,000 plants per acre, 9.3 per cent with 12,000 plants, 15.7 per cent with 16,000 plants and 23.6 per cent with 20,000 plants per acre. The average number of ears per stalk was 1.01, 0.91, 0.83 and 0.81 for the various populations respectively. Muhr and Rost (26) found that the barrenness declined as the ear-size increased. Conversely barren stalks increased with population increases. Viets (38) reported that if soil moisture becomes deficient due to an increase in stand, ear-size is decreased and barren-stalk percentage is increased. Kiesselbach (21) reported that severe early drought resulted in stunted growth and delayed silking with many partially or completely barren plants. Drought following silking was observed to shorten the ears by drying back from the tip and to reduce the kernel size. Dungan et al. (10) decided that ear-weight per plant is a good index as to the correctness of the plant population. Under central Corn Belt conditions 0.5 pound of ear per plant is the optimum ear-size to obtain maximum grain yield. North of this area, ear-weight per plant for maximum yield will be less and to the south it will be greater.

Lang et al. (23) observed that the ear-weight decreased with increased population in all experiments. They obtained ears averaging 0.71 pound per plant at a population of 4,000 plants per acre and 0.29 pound ears per plant at 24,000 plants per acre. An ear-weight of 0.54 pound was obtained from 12,000 plants per acre which corresponded to the heighest average yield for all hybrids at all fertility levels.

Dungan et al. (10) reported that Huber in 1944 and Stringfield and Thatcher in 1947 observed that a population resulting in an ear-weight of about 0.5 pound per plant indicates efficient use of land . They also reported that Miles (1951) obtained maximum corn yield in Indiana at 14,224 plants per acre and an average ear-weight of 0.54 pound. When the population was 24,890 plants per acre, the ear-weight was 0.31 pound only. They further reported that Rost (1953) in Minnesota obtained the highest yield of grain at a population of 31,360 plants per acre and an ear-weight of 0.36 pound per plant.

Colville (3) noticed that the average ear-weight per plant decreased at a rate approximately equal to 0.05 pound for every increase of 4,000 plants per acre. Lang _et al_. (23) were of the opinion that the weight of the ear decreased with increased population. The range was from 0.71 pound at the 4,000 plants stand to 0.29 pound at 24,000 plants per acre. Vittum (39) on the basis of five years of trials concluded that irrigation increased the average weight per ear from 10.7 to 12.2 ounces and the weight of the ear plus husks from 4.9 to 6.0 tons per acre.

Composition of grain

Prince (28) studied the influence of plant population on the composition of corn grain and concluded that the percentage of crude protein decreased from 10.07 to 7.97 with an increase in population from 4,000 to 13,000 plants per acre. Colville (3) in Nebraska observed that crude protein percentage decreased about 0.8 per cent as the population rate was increased from 8,000 to 28,000 plants per acre. Zuber et al. (41) while working in Missouri observed that the crude protein percentage decreased from 8.60 to 8.22 with an increase in plant population from 8,000 to 17,000 plants per acre.

According to Lang et al. (23) protein content of grain varied significantly with rates of planting, and the nitrogen level of the soil. The highest protein content - 14.02 per cent-was produced with a population of 4,000 plants per acre on a soil having a high level of available nitrogen. The lowest protein content - 7.08 per cent - was produced by growing a population of 24,000 plants per acre on a soil that was low in available nitrogen. Dungan et al. (10) reported that Genter et al. (1956) observed that in Virginia the highest protein percentage was obtained from the higher plant stand and the heaviest application of nitrogen.

Water use efficiency

Water use efficiency, expressed as bushels of grain per acre per inch of water used, was worked out by Carlson et al. (2). Corn was grown at two levels of soil moisture, two plant densities and several rates of nitrogen. They were of the opinion that evapotranspiration was considerably greater for the irrigated plots than for the non-irrigated ones. The weight of dry matter produced per inch of water used was appreciably increased by using a high plant density and nitrogen fertilizer, and was greater on the non-irrigated treatment than on the irrigated ones. They concluded that it is evident that if maximum efficiency of moisture is to be realized, adequate fertilizer and plant densities are required.

Brown and Shrader (1) observed that under extreme drought conditions there was an inverse relationship between forage and grain production. Water efficiency for grain production increased as the amount of stored moisture increased. The efficiency varied from zero bushel per acre inch on the three feet moisture plots with 45,000 and 60,000 plants of sorghum per acre to two - three bushels on the seven feet moisture plots with 60,000 plants per acre. Doss et al. (7) concluded that the average evapotranspiration rate by irrigated corn was generally low in the spring while plants were small, with a gradual increase until a peak-use-rate period was reached during the first tassel to late dought stage and then a gradual decrease until grain maturity.

Stomatal opening

Halevy (16) reviewed the literature on stomatal behaviour, as affected by soil moisture stress, and reported that the use of changes in the stomatal opening as a physiological indicator of moisture stress was first suggested by Loftfield in 1921. In 1941, Oppenheimer and Elze developed a practical technique for determining the degree of stomatal opening and then used this as an indicator for the irrigation of orange trees. They determined the degree of stomatal opening by noting the time elapsed from the time of application of kerosine to the leaves to the beginning of absorption.

Glober (14) and Glober and Lampkin (15) studied the response to drought in maize and sorghum and observed that maize leaves regained turgidity quickly and carbon assimilation continued normally when irrigated after being subjected to one or two days severe wilting. After wilting for a week or more, the plants regained turgidity within a few hours of water application, but many stomata were killed or severely damaged and did not reopen. Carbon dioxide intake was severely curtailed. In young plants subjected to drought, the leaves which had not yet unfolded were not affected. The effect of drought became more serious with the age of the plant.

Maximov and Zernova (25) showed that stomata of non-irrigated wheat plants opened very little and only early in the morning, whereas stomata of irrigated plants remained open throughout the day. Dry weights and yield of grain indicated that this difference in stomatal behaviour between the non-irrigated and irrigated plants seemed to have affected their assimilation. Finally, they concluded that the degree of stomatal opening during the day may indicate how much water is available to the plants and may be used in working out a definite schedule for irrigation of wheat.

MATERIALS AND METHODS

The investigations reported in this thesis were carried out at the Agricultural Research and Education Center of the American University of Beirut, in the Beqa'a Plain, during 1964. The soil was of a calcarious nature with a pH of about 8.0 .

The corn was planted on May 5, 1964, when the soil had warmed up sufficiently to allow good germination of the seeds. Maximum temperatures ranged from 30°C in May to 35.1°C in the month of August while the minimum temperature varied between 1.2°C and 11.2°C during the same months. During the growing period, 23.7 millimeter of rain was received. The maximum relative humidity was 99 per cent on the day of planting and tended to decrease with the advance of the growing season.

The soil was fertilized at the rate of 12 kilograms of nitrogen per dunum[+] in the form of ammonium nitrate and 20 kilograms of P_2O_5 per dunum in the form of superphosphate. The fertilizers were broadcast and disked into the soil before planting.

A split plot design, with three replications was employed. The main plots were the irrigation treatments and the sub-treatments of plant population were

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[+] Dunum is 1000 m^2 of area.

superimposed on each of the main plot treatments.

The details of the treatments are as follows:-

Irrigation

Weekly sprinkler irrigation to all plots for the first four weeks following which

I_1 = (Check) Weekly furrow irrigations throughout the whole growing period.

I_2 = Weekly furrow irrigations up to tasseling, followed by biweekly irrigations.

I_3 = Biweekly irrigations up to tasseling, followed by weekly irrigations.

Plant population

Low = 3,500 plants per dunum.

Medium = (Check) 5,000 plants per dunum.

High = 6,500 plants per dunum.

Cultural operations

Rows were 75 centimeters apart and within the row spacings were kept 38.0, 26.7 and 20.5 centimeters to attain 3,500, 5,000 and 6,500 plants per dunum respectively.

Hybrid Indiana 620 was used. The planting was done with a hand-drop corn planter. All plots were overseeded and later on thinned to a single plant per hill. The plot unit consisted of four rows, each seven meters in length.

Sprinkler irrigation was followed for the first four weeks. After opening the furrows, subsequent irrigations were made by the furrow method with surface gated pipe. The amount of water applied was determined by the actual measurement of the discharge from the sprinkler head as well as from the openings of the gated pipe. Repeated measurements were averaged to determine the quantity of water applied under each irrigation treatment. These were as follows:-

I_1 36 acre inches in 20 irrigations

I_2 28 acre inches in 15 irrigations

I_3 31 acre inches in 17 irrigations

Metasystox was sprayed on July 24, 1964 for the control of aphids. The plots were weeded regularly in the early stages. During the later stages the shading effect of the crop suppressed the weeds.

Stomatal opening

A series of 11 liquid mixtures were used for measurement of stomatal opening. These liquids, as shown in Table 1, were mixtures of kerosine and medicinal paraffin of 0.613 and 6.16 viscosity (compared to water) respectively.

Table 1. Oil mixtures (paraffin + kerosine) used for measuring the degree of stomatal opening in corn grown in Beqa'a Plain, Lebanon in 1964.

Grade	Paraffin per cent	Kerosine per cent
1	100	0
2	90	10
3	80	20
4	70	30
5	60	40
6	50	50
7	40	60
8	30	70
9	20	80
10	10	90
11	0	100

The mixture was applied by a dropper to the median portion of the fully developed leaves, for determining the degree of stomatal opening. The lowest grade of oil which was absorbed within five seconds after application was recorded. Ten plants were tested at each time and the average grades for all plants were calculated and recorded.

Plant height, tillering percentage, ear-height from the soil surface, date of tasseling and silking and ear-weight were recorded. Yields of grain on the basis of 15.5 per cent moisture content and air-dry yields of stover were determined.

From the four rows, constituting a plot only the two central rows, five meters in length - leaving one meter on each end for border effect - were harvested.

For recording the number of days from planting to tasseling, the plots were checked daily during the flowering stage. The date by which 50 per cent of the plants had flowered was recorded. The same was done for silking.

Average plant height and ear-height were recorded by measuring ten plants at random from each plot.

For determining the moisture percentage of the grain, only the central portion of the ears of a representative sample from each plot, taken immediately following harvest, was used.

For determining air-dry yield of stover, a representative sample was chopped and its air-dry weight was recorded by storing the sample for 35 days in the seed-house.

For determining the protein content of the kernels, a representative sample from each plot was dried in an oven for 24 hours, at a temperature of $100^{o}C$ - $103^{o}C$ and then cooled and ground in a Wiley-mill with a 40-mesh sieve and the ground material was collected in a screw top bottle. Before starting the analysis, the samples were put in the oven at $70^{o}C$ for six hours to remove the air-moisture, cooled in a desiccator and weighed on the electrical balance to the nearest tenth of a milligram. Analysis for protein was then made according to the modified Kjeldahl method, as specified in the Association of Official Agricultural Chemists' official method of analysis to determine the percentage of nitrogen (20). Results of duplicates differing from the sample mean by six per cent or over were rejected and the analysis repeated.

Statistical methods, appropriate to the split-plot design were used to analyse the data (27). Analysis of variance and the "T" - test, were used to calculate the difference between the treatments and their interactions.

RESULTS AND DISCUSSION

In evaluating the effect of soil moisture stress at different stages of plant growth, the yield per unit area is of primary importance. The objective of this study, however, was not confined to the yield of grain alone. A number of other plant characteristics such as stover yield, tillering of plant, plant and ear height, days from seeding to tasseling and silking, barrenness, ear-weight per plant, stomatal opening and protein per cent in grain were also studied.

The data pertaining to each factor studied are presented in Tables 2 to 14. The L.S.D. figures for the irrigation schedules, plant populations and interactions between irrigation and population, together with the analyses of variance are also reported in the same tables.

Grain yield

The effect of different schedules of irrigation on grain yield was highly significant as is seen in Table 2. Weekly irrigated plots (I_1) gave significantly higher grain yield than the plots subjected to biweekly irrigation either before tasseling (I_3) or after tasseling (I_2). The reduction in grain yield was more

Table 2. Effect of irrigation schedule and plant population on the grain yield of corn in kilograms per dunum, grown in Beqa'a Plain, Lebanon in 1964. (15.5% moisture level).

Irrigation treatment	Plant population per dunum			Average
	3,500	5,000	6,500	
I_1	724^{xx}	857	813^{x}	798
I_2	621^{xx}	590^{xx}	516^{xx}	576^{xx}
I_3	685^{xx}	756^{xx}	683^{xx}	708^{xx}
Average	677^{xx}	734	671^{xx}	

L. S. D.

	At 5%	At 1%
Irrigation	24	39
Population	22	31
Irrigation x population	38	53

Analysis of Variance

Source	D.F.	M.S.
Replications	2	13,554
Irrigations	2	111,505^{xx}
Error "a"	4	323
Populations	2	10,974^{xx}
Irrigation x population	4	8,067^{xx}
Error "b"	12	452

x Significant at 5% level.
xx Significant at 1% level.

drastic in case of I_2 than it was for I_3.

Denmead and Shaw (6) observed the same trend. They observed that soil moisture stress prior to silking reduced grain yield by 25 per cent, moisture stress at silking reduced grain yield 50 per cent, and moisture stress after silking reduced grain yield by 21 per cent.

A population of 5,000 plants per dunum gave a highly significant increased grain yield, over 3,500 and 6,500 plants per dunum. This indicates that for getting maximum yields under the conditions of this experiment the plant population should be between 3,500 to 6,500 plants per dunum although not exactly at 5,000 plants per dunum. Conville and McGill (4) and Conville (3) observed the same while indicating that there was little difference in grain yield between 16,000 to 24,000 plants per acre. Further increases in the population over 24,000 plants per acre generally resulted in decreased yield of grain. Viets (38) reported that moisture supply determines the best planting rates for corn in the 11 Western States. On dry land with at least 15 inches annual rainfall and most of it falling in the growing season, the stand must be 4,500 to 7,500 plants per acre. For irrigated lands, for grain purposes, a stand of about 18,000 to 20,000 plants per acre is recommended.

The interactions between irrigation schedules and plant population were highly significant. The combination of 5,000 plants per dunum with continuous weekly irrigation I_1 (Check) gave a grain yield of 857 kilograms per dunum. This was significantly higher than any other combination. The combination of 6,500 plants per dunum with biweekly irrigation after tasseling (I_2) resulted in the lowest grain yield - 516 kilograms per dunum.

Where weekly irrigation was maintained throughout the growing season (I_1), the grain yield increased with the increase of plant population from 3,500 to 5,000 plants per dunum. Further increases, however, to 6,500 plants per dunum showed a slight decrease in grain yield.

Where biweekly irrigation up to tasseling was followed by weekly irrigation (I_3) the trend in yield was the same as observed under I_1 but the decrease with the increase in plant population from 5,000 to 6,500 plants per dunum was sharper.

Where biweekly irrigation after tasseling (I_2) was followed, there was a gradual decrease in grain yield, with the increase in plant populations from 3,500 to 6,500 plants per dunum. The probable reason is that under high plant population the competition for soil moisture was more severe.

Stover yield

The data presented in Table 3 clearly indicate

Table 3. Effect of irrigation schedule and plant population on the stover yield of corn hybrid in kilograms per dunum, grown in Beqa'a Plain, Lebanon in 1964. (Air dry weight).

Irrigation treatment	Plant population per dunum			Average
	3,500	5,000	6,500	
I_1	667	750	773	730
I_2	600	637	633	623^xx
I_3	609	661	664	645^xx
Average	625^xx	683	690	

L. S. D.

	At 5%	At 1%
Irrigation	25	41
Population	19	26

Analysis of Variance

Source	D.F.	M.S.
Replications	2	6,590
Irrigations	2	28,545^xx
Error "a"	4	367
Populations	2	11,310^xx
Irrigation x population	4	1,040
Error "b"	12	322

xx Significant at 1% level.

that there were highly significant differences in dry stover yield because of different irrigation schedules. Under weekly irrigation (I_1) the stover yield obtained per unit area was significantly higher than in the plots with biweekly irrigation , either before tasseling (I_3) or after tasseling (I_2).

A population of 5,000 plants per dunum produced significantly higher stover yield than did 3,500 plants per dunum. There was no significant difference in stover yield between 5,000 and 6,500 plants per dunum.

When the trend of grain yield was compared with the stover yield (Tables 2 and 3) it was found that they were different, whereas there was a significant decrease in grain yield with an increase in plant population from 5,000 to 6,500 plants per dunum, the stover yield remained almost unchanged. These findings are in agreement with Termunde et al. (35), who observed that when the plant population level of 12,000 to 16,000 plants per acre was exceeded, the yield of grain fell drastically whereas the forage production remained at the same maximum level. Zuber et al. (41) observed the same indication that under less favourable conditions for grain production, the stover weights were higher and grain yields were lower. The probable reason for this may be that under high plant population (6,500 plants per dunum) the vegetative growth is unaffected but the grain yields are reduced because of the severe shading effect.

The differences amongst the interactions were found to be non-significant. The population of 6,500 plants per dunum in combination with weekly irrigation (I_1) gave the highest stover yield.

Tillering percentage

From the data in Table 4, it is observed that I_1 the check treatment, produced significantly higher tillering percentage as compared with that of I_3. The difference in tillering percentage between I_1 and I_2 was non-significant.

It seems that I_3 produced the lowest tillering percent due to inadequate soil moisture before tasseling, when most of the tillering took place. As such, biweekly irrigation after tasseling (I_2) did not affect the tillering significantly.

These results are in agreement with those of Macgillway (24) who observed that there were always more suckers on the irrigated plants than on the non-irrigated ones.

Dungan et al. (10) reported that Williams and Etheridge (1912) had found that high productive soils, with adequate soil moisture, wide plant spacing and optimum time of planting enhance tillering.

Highly significant differences in tillering

Table 4. Effect of irrigation schedule and plant population on the tillering percentage of corn, grown in Beqa'a Plain, Lebanon in 1964.

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	60	31	19	37
I_2	55	33	16	35
I_3	52	24	12	29^{xx}
Average	56^{xx}	29	16^{xx}	

L. S. D.

	At 5%	At 1%
Irrigation	3.3	5.4
Population	3.4	4.7

Analysis of Variance

Source	D.F.	M.S.
Replications	2	117.15
Irrigations	2	132.48^{xx}
Error "a"	4	6.14
Populations	2	3702.48^{xx}
Irrigation x population	4	9.65
Error "b"	12	10.60

^{xx} Significant at 1% level.

percentage were found among the three plant population levels. The check population of 5,000 plants per dunum produced a significantly lower tillering percentage than did the 3,500 population. The tillering percentage of the check population was significantly higher than that of the 6,500 population.

The reason for low tillering percentage under denser plant stand might be because of severe plant competition for light, soil moisture and rooting space. The results are in agreement with those of Stringfield and Thatcher (34). The interactions were not significant.

Plant height

From the data in Table 5 it is seen that there is a significant response in plant height to different schedules of irrigation. The plants in plots irrigated weekly (I_1) were significantly taller than the plants in plots with biweekly irrigation before tasseling (I_3) or after tasseling (I_2). Carlson et al. (2) reported the same indication, namely that corn plants in irrigated treatments were taller than in non-irrigated ones.

The effect of plant population on the final plant height was highly significant. The highest population of 6,500 plants per dunum produced the tallest plants, followed by 5,000 plants per dunum. The reason may be

Table 5. Effect of irrigation schedule and plant population on the plant height (in centimeters) at harvest of corn grown in Beqa'a Plain, Lebanon in 1964.

Irrigation treatment	Plant population per dunum			Average
	3,500	5,000	6,500	
I_1	238	244	255	246
I_2	222	227	232	227^{xx}
I_3	228	235	244	236^{xx}
Average	229^{xx}	235	244^{xx}	

L. S. D.

	At 5%	At 1%
Irrigation	3.03	5.02
Population	3.79	5.32

Analysis of Variance

Source	D.F.	M.S.
Replications	2	841.1
Irrigations	2	1281.0^{xx}
Error "a"	4	5.9
Populations	2	516.1^{xx}
Irrigation x population	4	7.7
Error "b"	12	13.7

^{xx} Significant at 1% level.

that under dense stands there is always a severe competition for light and as such there is an increased tendency amongst plants to grow taller in search of light.

The analysis of variance in Table 5 clearly indicates that the differences amongst the interactions were non-significant.

Barrenness percentage

The analysis of variance in Table 6 shows that the percentage of barrenness in corn was significantly influenced by irrigation schedules. Biweekly irrigation after the tasseling (I_2) increased the barrenness significantly over that produced under continuous weekly irrigation (I_1). However, there was almost no difference between I_1 and I_3.

On the basis of the data given in Table 6 it was concluded that with 3,500 plants per dunum there were no earless stalks. With 5,000 plants per dunum there was 11 per cent barrenness, which was significantly less than that of 6,500 plants per dunum (17 per cent). These results are in agreement with most of the workers (23, 26, 38) as they observed that the barrenness percentage was increased with increase in planting density.

The interactions of irrigation intervals and plant population levels were found to affect the

Table 6. Effect of irrigation schedule and plant population on the barrenness percentage of corn grown in Beqa'a Plain, Lebanon in 1964.

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	0	6	9	5
I_2	0	18[xx]	31[xx]	16[xx]
I_3	0	8	11	6
Average	0[xx]	11	17[xx]	

L. S. D.

	At 5%	At 1%
Irrigation	5.4	8.9
Population	4.2	5.9
Irrigation x population	7.4	10.4

Analysis of Variance

Source	D.F.	M.S.
Replications	2	17.37
Irrigations	2	351.15[xx]
Error "a"	4	16.76
Populations	2	662.93[xx]
Irrigation x population	4	117.15[xx]
Error "b"	12	17.30

[xx] Significant at 1% level.

percentage of barrenness to a highly significant extent. The lowest plant population - 3,500 plants per dunum - resulted in no stalk without an ear in all the three irrigation treatments. The percentage of barrenness was the highest (31 per cent) in the combination of 6,500 plants per dunum with biweekly irrigation after tasseling (I_2). The reason for this increase in barrenness under high plant population and biweekly irrigation after tasseling might be the intense competition for light, soil moisture and rooting space.

Days from planting to tasseling

The number of days taken from seeding to tasseling is an indication of the relative maturity of the crop.

A study of the data in Table 7 revealed that biweekly irrigation up to tasseling (I_3) significantly delayed the appearance of flowers as compared with weekly irrigation during the same period (I_2 and I_1). This was probably because of retardation in growth in the early stages.

The plant population had a highly significant effect on the number of days from planting to tasseling. As the plant population was increased, the tasseling dates were delayed with a highly significant margin. The interaction of irrigation schedule with plant population was also significant. The increase in plant population

Table 7. Effect of irrigation schedule and plant population on the number of days from planting to tasseling on corn, grown in Beqa'a Plain, Lebanon in 1964.

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	70^{xx}	74	74	73
I_2	71^{xx}	73^{x}	75^{x}	73
I_3	73^{x}	75^{x}	75^{x}	74^{x}
Average	71^{xx}	74	75^{xx}	

L. S. D.

	At 5%	At 1%
Irrigation	0.95	1.58
Population	0.46	0.64
Irrigation x population	0.81	1.13

Analysis of Variance

Source	D.F.	M.S.
Replications	2	0.04
Irrigations	2	6.04^{x}
Error "a"	4	0.54
Populations	2	36.82^{xx}
Irrigation x population	4	0.82^{x}
Error "b"	12	0.20

^{x} Significant at 5% level.

^{xx}Significant at 1% level.

in combination with biweekly irrigation up to tasseling resulted in a longer tasseling period as compared to low plant stands in combination with weekly irrigation up to tasseling. The same results were observed by Dungan et al. (10).

Days from planting to silking

It can be seen from the data in Table 8 that biweekly irrigation (I_3) up to tasseling delayed the appearance of silk as compared with weekly irrigation up to the tasseling stage (I_1 and I_2).

The plant population had a highly significant effect on the number of days taken from planting to silking. The silking was significantly delayed as the plant population was increased from 3,500 to 5,000 plants per dunum and it was further delayed where the plants were increased from 5,000 to 6,500 per acre.

The interaction was not significant.

Stem thickness

It can be seen from the data given in Table 9 that the I_1 treatment of irrigation produced significantly thicker stems than did the I_2 and I_3 treatments. This may be attributed to the continuous high soil moisture condition in I_1 treatment. As the plant population was

Table 8. Effect of irrigation schedule and plant population on the number of days from planting to silking on corn, grown in Beqa'a Plain, Lebanon in 1964.

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	82	84	85	84
I_2	83	84	85	84
I_3	84	85	86	85[xx]
Average	83[xx]	84	85[xx]	

L. S. D.

	At 5%	At 1%
Irrigation	0.3	0.6
Population	0.6	0.8

Analysis of Variance

Source	D.F.	M.S.
Replications	2	1.035
Irrigations	2	6.035[xx]
Error "a"	4	0.065
Populations	2	13.570[xx]
Irrigation x population	4	0.215
Error "b"	12	0.306

[xx] Significant at 1% level.

Table 9. Effect of irrigation schedule and plant population on stem thickness in centimeters on corn, grown in Beqa'a Plain, Lebanon in 1964.

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	2.8	2.6	2.6	2.7
I_2	2.5	2.5	2.3	2.4^{xx}
I_3	2.7	2.6	2.4	2.6^{x}
Average	2.7^{xx}	2.6	2.4^{xx}	

L. S. D.

	At 5%	At 1%
Irrigation	0.07	0.12
Population	0.08	0.12

Analysis of Variance

Source	D.F.	M.S.
Replications	2	0.0490
Irrigations	2	0.0825^{xx}
Error "a"	4	0.0028
Populations	2	0.1600^{xx}
Irrigation x population	4	0.0038
Error "b"	12	0.0065

x Significant at 5% level.

xx Significant at 1% level.

increased from 3,500 to 5,000 and then to 6,500 plants per dunum, the stem thickness decreased significantly at each increment. This decrease in stem thickness might be because of soil moisture, light competition and space competition.

Ear-height

Ear-height is defined as the distance between ground level and the position of the base of the ear on the plant.

The results summarized in Table 10 revealed that the irrigation intervals as well as the plant population did not show any significant effect on the ear-height. The results are in agreement with Dungan *et al*. (10) regarding plant population effect, but Zuber and Grogan (40) observed that ear-heights gradually increased as planting rates were increased.

Ear-weight

Referring to Table 11, it can be noticed that I_1 produced significantly heavier ears per plant than did I_2 and I_3. This may be because of the high moisture tension induced by the latter treatments. Vittum (39) and Viets (38) are of the same view.

A population of 5,000 plants per dunum yielded significantly heavier ear-weight per plant when compared

Table 10. Effect of irrigation schedule and plant population on the ear-height (in centimeters) of corn, grown in Beqa'a Plain, Lebanon in 1964.

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	95	106	111	104
I_2	100	111	108	106
I_3	103	97	96	99
Average	99	105	105	

Analysis of Variance

Source	D.F.	M.S.
Replications	2	303.81
Irrigations	2	135.70
Error "a"	4	120.82
Populations	2	95.15
Irrigation x population	4	128.15
Error "b"	12	114.65

Table 11. Effect of irrigation schedule and plant population on the ear-weight (in pounds) per plant of corn, grown in Beqa'a Plain, Lebanon in 1964. (at 15.5% moisture level).

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	0.67	0.53	0.42	0.54
I_2	0.51	0.47	0.32	0.43^{xx}
I_3	0.61	0.48	0.34	0.48^{x}
Average	0.60^{xx}	0.49	0.36^{xx}	

L. S. D.

	At 5%	At 1%
Irrigation	0.05	0.09
Population	0.04	0.06

Analysis of Variance

Source	D.F.	M.S.
Replications	2	0.0174
Irrigations	2	0.0184^{x}
Error "a"	4	0.0016
Populations	2	0.1509^{xx}
Irrigation x population	4	0.0031
Error "b"	12	0.0017

^{x} Significant at 5% level.

^{xx} Significant at 1% level.

to that of 6,500 plants per dunum but significantly lighter weight when compared to that of 3,500 plants per dunum. The probable causes for greater ear-weight per plant with low planting densities are better light, adequate soil moisture supply and better nurishment on an individual plant basis.

The differences among the interactions were non-significant.

The relation of ear-weight per plant to grain yield

Dungan et al. (10) revealed that the optimum ear-weight on an individual plant basis is a good index to the correctness of the plant population for maximum grain yield per unit area for a locality.

Figure 1 gives the relation between ear-weight per plant, grain yield and plant population. In general, it is apparent that as the plant population decreases the ear-weight per plant increases. The relation between ear-weight per plant and the maximum grain yield is a complex one. It is observed from this graph, that under irrigation treatment I_1, as the plant population was reduced from 6,500 to 5,000 plants per dunum, the ear-weight per plant was increased and the grain yield was also increased. Further reduction in the plant population to 3,500 plants per dunum resulted in a reduction in grain yield but ear-weight per plant was

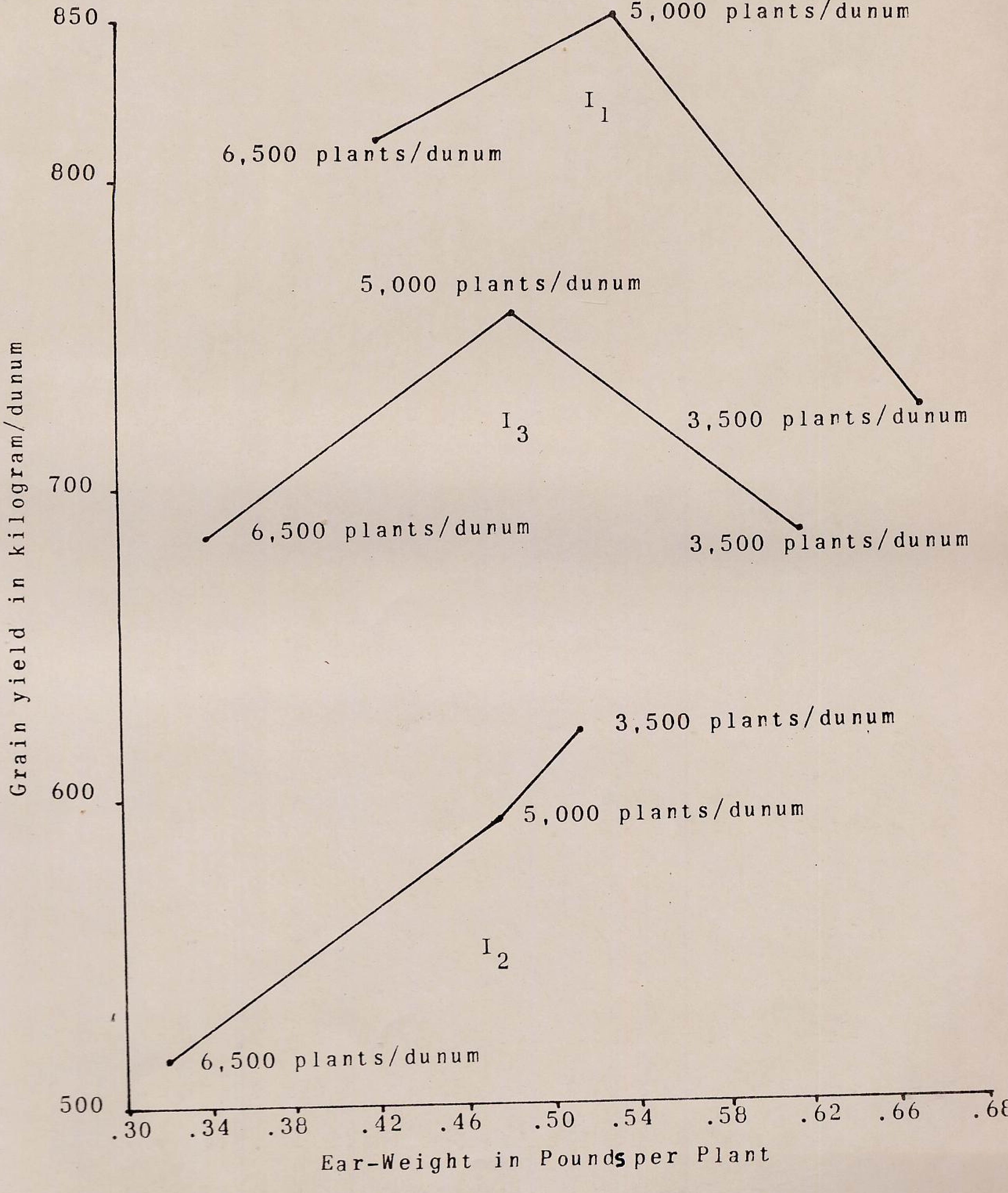

Figure 1. Relation of ear-weight per plant to plant population and grain yield of hybrid corn.

still increasing. The maximum grain yield under I_1 - 857 kilograms per dunum - was obtained when the ear-weight per plant was 0.53 pounds.

The same trends were observed under I_3 but the maximum yield of grain-756 kilograms per dunum - was obtained when the average ear-weight per plant was 0.48 pounds.

Under irrigation treatment I_2, when there was a decrease in plant population, there was an increase in the grain yield even when the plant population level reached 3,500 plants per dunum. The maximum grain yield of 621 kilograms per dunum was obtained when the average ear-weight per plant was 0.51 pounds.

On the basis of these observations, and under the given conditions, a range in the ear-weight per plant from 0.48 to 0.53 pounds per plant is a good indication that maximum yields are being produced.

These findings are in agreement with those of most of the workers (10, 23, 26 and 37).

Dungan _et al_. (10) reported that under Corn Belt conditions, 0.5 pounds of ear corn per plant is the optimum ear-size to obtain maximum grain yield. North of this area, ear-weight per plant for maximum yield will be less and to the south it will be greater.

Protein percentage in grain

The data reported in Table 12 indicate that the protein percentage was significantly affected by the three schedules of irrigation. The regular weekly irrigation gave a lower protein percentage at the one per cent level of significance, than did treatments I_2 and I_3. The differences amongst the densities of plant population were also highly significant. The plant population of 5,000 plants per dunum produced grains having a higher protein percentage than 6,500 plantsper dunum but this protein percentage was significantly less than that of 3,500 plants per dunum. The same trend was observed by other workers (3, 10, 23 and 41).

The differences among the interactions were non-significant.

Water use efficiency

This is defined as the weight of grain per unit area produced by a unit of irrigation water.

The data reported in Table 13 indicate that the grain yield per dunum per inch depth of irrigation, in case of weekly irrigation was significantly more than that of weekly irrigation up to tasseling followed by biweekly irrigation but was significantly less than the grain yield obtained by biweekly irrigation up to tasseling followed by weekly irrigation.

Table 12. Effect of irrigation schedule and plant population on the protein percentage in grain of corn grown in Beqa'a Plain, Lebanon in 1964.

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	9.0	8.8	7.9	8.6
I_2	10.6	9.4	9.0	9.7^{xx}
I_3	9.6	9.2	9.1	9.3^{xx}
Average	9.7^{xx}	9.1	8.7^{x}	

L. S. D.

	At 5%	At 1%
Irrigation	0.15	0.24
Population	0.36	0.50

Analysis of Variance

Source	D.F.	M.S.
Replications	2	0.5298
Irrigations	2	3.4715^{xx}
Error "a"	4	0.0129
Populations	2	2.7781^{xx}
Irrigation x population	4	0.3270
Error "b"	12	0.1204

x Significant at 5% level.

xx Significant at 1% level.

Table 13. Effect of irrigation schedule and plant population on the grain yield of corn in kilograms per dunum per inch depth of irrigation, grown in Beqa'a Plain, Lebanon in 1964. (15.5% moisture level)

Irrigation treatment	Plant population per dunum 3,500	5,000	6,500	Average
I_1	20.1[xx]	23.8	22.6[x]	22.2
I_2	22.4[x]	21.2[xx]	18.7[xx]	20.8[xx]
I_3	21.9[xx]	24.2	21.9[xx]	22.7[x]
Average	21.5[xx]	23.1	21.1[xx]	

L. S. D.

	At 5%	At 1%
Irrigation	0.5	0.7
Population	0.7	1.0
Irrigation x population	1.2	1.7

Analysis of Variance

Source	D.F.	M.S.
Replications	2	13.38
Irrigations	2	8.58[xx]
Error "a"	4	0.11
Populations	2	10.40[xx]
Irrigation x population	4	8.10[xx]
Error "b"	12	0.49

[x] Significant at 5% level.
[xx] Significant at 1% level.

The grain yield per dunum, per inch depth of irrigation was significantly higher with 5,000 plants per dunum than 3,500 and 6,500 plants per dunum. Carlson et al. (2) were of the opinion that if maximum efficiency of moisture is to be realized, adequate fertilizer and plant densities are required.

The differences of grain yields amongst the interactions were in general highly significant. However, there was no significant difference in efficiency between the plant population of 5,000 plants per dunum with weekly irrigation (check) and 5,000 plants per dunum with biweekly irrigation up to tasseling (I_3).

The combination of 5,000 plants per dunum with weekly irrigation produced a significantly higher efficiency than did the rest of the combinations.

Stomatal behaviour

The degrees of stomatal opening were recorded on weekly intervals just prior to irrigation.

The data summarized in Table 14 indicate that in the case of weekly irrigation (I_1) the average grade of the mixture absorbed during the early stage was 7.4 and near the maturity stage was 9.8. In general the less viscous grade of mixture was absorbed as the crop advanced in age, as is evident from Figure 2.

In the case of weekly irrigation up to tasseling

Table 14. Effect of irrigation schedule and plant population on stomatal opening of hybrid corn plant grown in Beqa'a Plain, Lebanon in 1964.

Treatment	Grade of mixture absorbed on														
Irrigation	23/6	30/6	6/7	13/7	20/7	27/8	3/8	10/8	17/8	24/8	31/8	7/9	14/9	21/9	28/9
I_1	7.4	7.4	7.6	8.1	8.7	8.9	9.0	9.2	9.3	9.4	9.5	9.8	9.7	10.0	9.8
I_2	7.5	7.6	7.6	8.1	8.8	9.8	9.2	10.0	9.5	10.1	9.9	10.5	10.3	10.5	10.2
I_3	7.7	8.8	8.2	8.9	8.2	8.0	8.4	8.1	8.3	8.3	8.6	9.0	9.2	9.1	9.2
Plant population															
Low	7.1	7.5	7.4	7.7	8.0	8.2	8.3	8.4	8.3	8.6	8.6	9.0	9.1	9.2	9.1
Medium	7.6	7.9	7.8	8.4	8.5	8.7	8.8	9.1	9.1	9.4	9.5	9.9	9.8	9.9	9.9
High	7.9	8.4	8.2	9.0	9.2	9.8	9.5	9.8	9.7	9.8	9.9	10.4	10.3	10.5	10.2

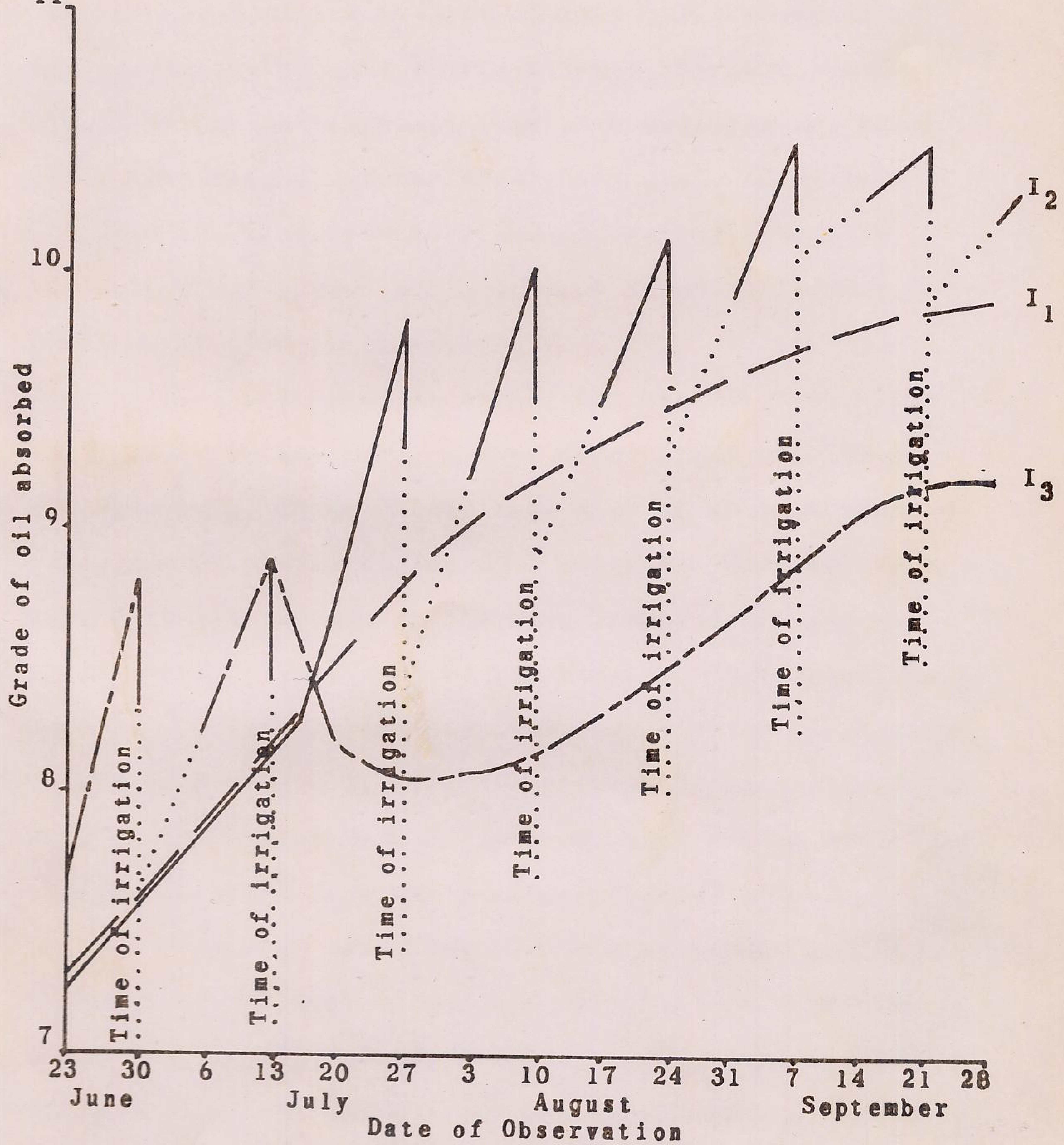

Figure 2. Relationship between grade of oil absorbed and irrigation schedule.

followed by biweekly irrigation (I_2), there was a gradual increase in the grade of mixture absorbed up to tasseling stage. Later as the irrigation interval was increased to biweekly, the grade of the mixture absorbed one week after irrigation was lower than that absorbed two weeks after irrigation. On the whole, the grade of mixture absorbed in irrigation treatment I_2 during biweekly irrigation was higher even one week after irrigation, than was that of I_1 treatment.

In the case of I_3 as the interval of irrigation was reduced to one week, a much lower grade of mixture was absorbed. These grades were even lower than those (absorbed by plots) of the I_1 treatment. This may be a result of the biweekly irrigation before tasseling stage which stunted the growth of the plants. There might have been some physiological adjustment within the plant under this high moisture tension condition. At tasseling stage when weekly irrigation was followed, the plants restarted their growth and absorbed a lower grade of mixture.

It can be seen from Figure 3 that generally a higher grade of mixture was absorbed with the increase in plant population. On the basis of the data summarized in Table 14, one can say that as the soil moisture status is reduced because of lengthening the irrigation interval or increasing the plant population, the stomatal aperture is narrowed and a less viscous grade is absorbed.

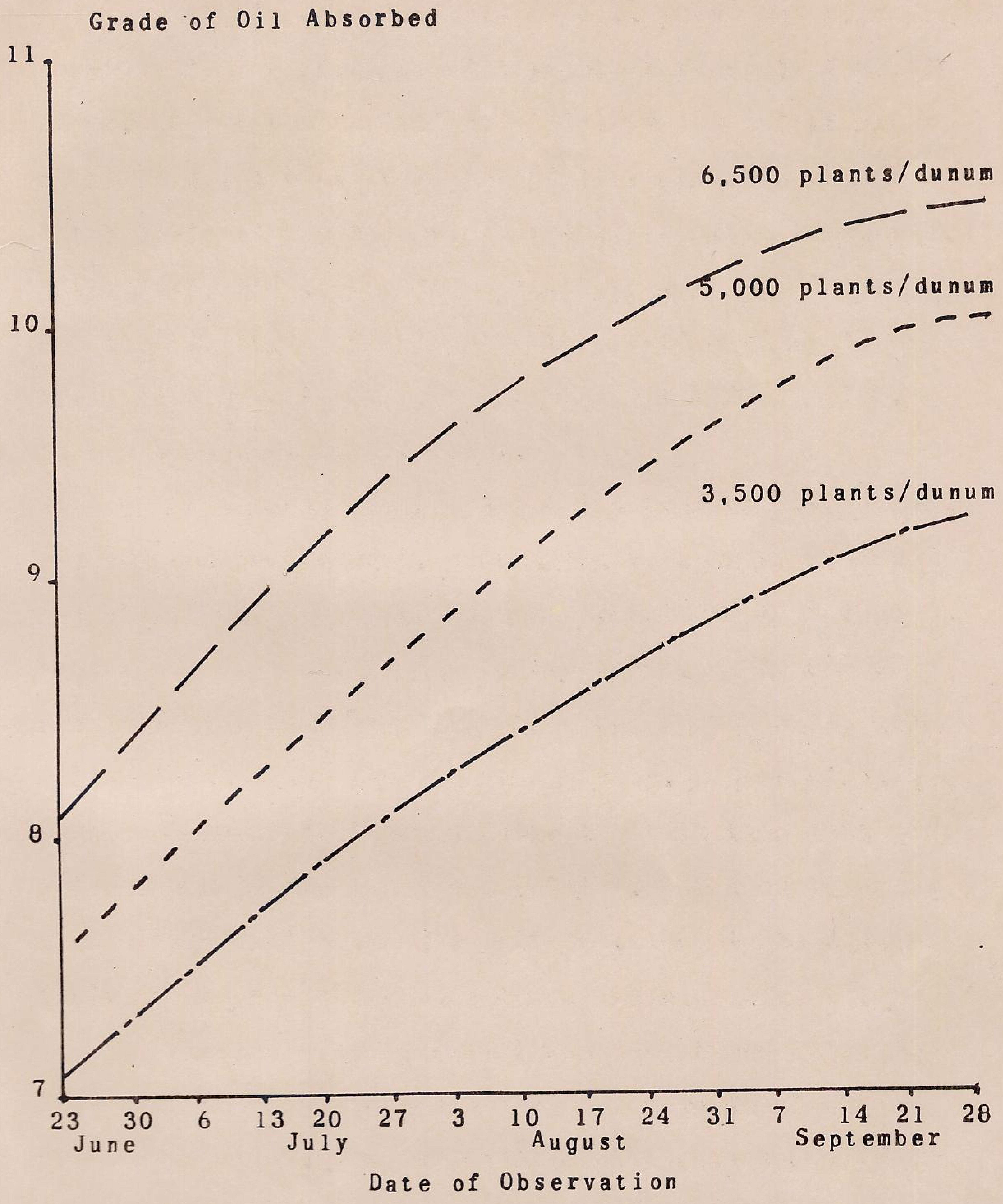

Figure 3. Relationship between grade of oil absorbed and plant population.

SUMMARY AND CONCLUSIONS

This study was conducted at the Agricultural Research and Education Center in the Beqa'a Plain, Lebanon, during 1964, to find out the effect of different irrigation schedules and plant population levels on the grain yield and other agronomic characteristics of hybrid corn (Indiana 620).

The treatments followed were:-

Irrigation

I_1 = Weekly furrow irrigation throughout the growing period - check treatment.

I_2 = Weekly furrow irrigation up to tasseling followed by biweekly irrigations.

I_3 = Biweekly irrigation up to tasseling followed by weekly irrigations.

All plots were sprinkler irrigated for four weeks prior to the above schedules.

Plant population

Low = 3,500 plants per dunum.

Medium = 5,000 plants per dunum - check treatment.

High = 6,500 plants per dunum.

Grain yield was affected significantly by the irrigation schedule and the plant population. Weekly irrigation throughout the growing season (I_1) resulted in higher grain yield than did biweekly irrigation, either up to tasseling (I_3) or after tasseling (I_2). A population of 5,000 plants per dunum gave significantly higher grain yields than did 3,500 and 6,500 plants per dunum. The interaction of weekly irrigation (I_1) with 5,000 plants per dunum gave the highest grain yield, whereas biweekly irrigation after tasseling (I_2) in combination with a plant population of 6,500 plants per dunum resulted into the lowest grain yield.

The stover yield was more in case of weekly irrigation, (I_1) as compared with biweekly irrigation up to tasseling (I_3) or after tasseling (I_2). There was no significant difference of stover yields between 6,500 and 5,000 plants per dunum, but the stand of 3,500 plants per dunum yielded significantly less than 5,000 plants per dunum.

The tillering percentage was significantly lower in case of biweekly irrigation up to tasseling (I_3), as compared with weekly irrigation treatment during the same period (I_1 and I_2). The tillering percentage was reduced significantly with increase in plant population.

The average plant height was significantly greater in the weekly irrigated plots (I_1) than in the plots of other irrigation schedules (I_2 and I_3). The plant heights increased significantly with the increase in plant density.

Barrenness percentage was significantly influenced by irrigation schedules and plant population levels. Biweekly irrigation after tasseling (I_2) resulted in significantly higher barrenness percentage than did weekly irrigation after tasseling (I_1 and I_3). The barrenness increased significantly with increase in plant population.

Tasseling and silking were significantly delayed by biweekly irrigation up to tasseling (I_3) as compared with weekly irrigation during the same period (I_1 and I_2). Tasseling and silking were significantly delayed with each additional increment of plant population.

The ear-height was not affected by the plant population and irrigation interval. The ear-weight per plant was significantly influenced by irrigation schedules and plant population levels. Weekly irrigation (I_1) produced heavier ear-weight per plant than did biweekly irrigation either before tasseling (I_3) or after tasseling (I_2). Ear-weight per plant was significantly increased with decrease in plant population.

Ear-weight per plant had a very useful relation with grain yield. Under weekly irrigation (I_1) the maximum grain yield was obtained with a plant population of 5,000 per dunum and the ear-weight per plant was 0.53 pounds. Under weekly irrigation up to tasseling, followed by biweekly irrigation (I_2) the maximum grain yield was obtained with 3,500 plants per dunum and the ear-weight per plant was 0.51 pounds. Under biweekly irrigation up to tasseling (I_3) followed by weekly irrigation, the maximum grain yield was obtained with 5,000 plants per dunum and the ear-weight per plant was 0.48 pounds.

An increase in protein percentage resulted from biweekly irrigation up to tasseling (I_3) or after tasseling (I_2) as compared to weekly irrigation (I_1). The protein percentage decreased significantly with increase in plant population.

A less viscous grade of parrafin and kerosine mixture was absorbed by the leaves of plants of plots with low population and following weekly irrigation as compared with those from plots with high population and following biweekly irrigation.

Water use efficiency was higher under biweekly irrigation up to tasseling followed by weekly irrigation (I_3) than it was under weekly irrigation (I_1). This latter was significantly higher than that under weekly irrigation up to tasseling followed by biweekly irrigation (I_2).

It appears from the results of this study that, under the given conditions high yields per unit area can not be obtained with a modified irrigation schedule in which a few irrigations might be saved. However yield per unit of irrigation water applied could be improved by modifying the existing irrigation schedule.

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