THE EFFECT OF DATE OF PLANTING ON YIELD AND OTHER AGRONOMIC CHARACTERISTICS IN WHEAT AND BARLEY

By

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WHEAT AND BARLEY TRIALS

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AN ABSTRACT OF THE THESIS OF

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Title: The effect of date of planting on yield and other agronomic characteristics in wheat and barley.

An investigation was conducted during 1966-1967 at the Agricultural Research and Education Center of the American University of Beirut, Lebanon, to evaluate the effect of four dates of planting on the yield and other agronomic characteristics in wheat and barley varieties. Florence Aurore, FAO-8685[1], and Senator Capelli varieties of wheat, and Athinais, Baladi, and Beecher varieties of barley were studied. The various dates of planting were November 1, November 15, November 30, and December 30.

Owing to the appreciably high rainfall and favorable climatic condition recorded throughout the growing season, the yielding performance of the two crops was high. The highest amount of grain was produced from the November 1 and November 15 dates of planting. Protein percentage of the seeds increased in both crops from the November 1 and December 30 plantings. The heaviest seeds of wheat were obtained from seedings made on November 15, while those of barley produced heaviest seeds from the November 30 plantings. The straw yields and plant heights of both crops were reduced as sowings were delayed from the first to the last date of planting. In all varieties studied, the number of days required from planting to heading and maturity decreased as the plantings were delayed from November 1 to December 30.

Among wheat varieties, FAO-8685 produced the shortest plants and the highest amount of grain yield. Florence Aurore produced seeds with higher protein percentages and yielded the highest amount of straw. FAO-8685 and Florence Aurore proved to be the earliest maturing varieties as compared to Senator Capelli. Senator Capelli produced the heaviest grains when compared to Florence Aurore and FAO-8685. In barley, Baladi produced the highest yield of

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[1] An early maturing variety of wheat also called Najah.

grains and straw and had the shortest plants when compared to Beecher and Athinais. Athinais produced short plants, had seeds with high percentages of protein, and was early in maturity. Beecher produced the heaviest grains as compared to those of Baladi and Athinais.

Higher yield of wheat and barley may be obtained in the Beqa'a plain, Lebanon, by planting these crops between November 10 and November 30.

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I. INTRODUCTION

World population is growing at a fast rate. It is believed that there will be more than six billion people by the year 2000 (52, pp 20-21). In view of this, it is necessary that every possible effort be made to ensure adequate availability of food now and in the future. Such an effort must be directed towards augmenting the yield and quality of food through the improvement of existing practices on crop varieties.

Wheat, Triticum aestivum L., and barley, Hordeum vulgare, are annual crops. They are among numerous cereals which, when improved, will partially solve the demand for increased food supply. This is manifested in the ability of these cereals to adapt themselves to a wide range of climatic and soil conditions (34, 35). They produce satisfactory grain yield during most seasons (29).

The Middle East and most countries in the hottest and coldest parts of the world regard these two cereal crops as their basic food crop (11). In the United States of America, 1.47 to 1.59 million metric tons (65 to 70 million bushels)[1] (3, pp xiii) of barley are used annually for producing malt for beer, whiskey and other beverages,

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[1] One bushel of barley (50 lb) = 0.022680 metric tons.

while 2.27 to 4.54 million metric tons (100 to 200 million bushels) (3, pp xiii) are used as food and feed (29, pp 547). About 13.61 million metric tons (500 million bushels)[1] (3, pp xiii) of wheat are annually used for food, in the form of flour for baked products, and as feed (29, pp 547). Other food uses of wheat include breakfast foods, and most recently, for making dextrose (glucose) and alcoholic products (29, pp 459). In the Middle East, these two cereals provide half of the calories required by the entire population (4). An average of 160 kg per caput per annum is consumed by the Near Eastern people as compared to 146 kg for those in the Far East and 70 kg in North America (2, pp 27). Slykhuis (48) observed that about 18.0 million metric tons of wheat were produced on 17.7 million hectares in the Near East in 1962-63, while in the same year, 7.0 million metric tons of barley were produced on 7.2 million hectares.

At present, little information is available on the cultural practices that greatly affect the quantity and quality of these two cereals in Lebanon, hence, the date of planting is considered essential in their production.

The purpose of this investigation is to evaluate the effect of four dates of planting on yield and other agronomic characteristics in winter wheat and barley.

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[1] One bushel of wheat (60 lb) = 0.027216 metric tons.

The study was carried out in 1966-67 under dryland conditions at the Agricultural Research and Education Center (AREC) of the American University of Beirut, Beqa'a, Lebanon.

The determination of an appropriate date of planting coupled with necessary farm management will aid the farmers in the Beqa'a plain to obtain higher yields with good nutritive quality. As a result, the problem of food shortage will be partially solved.

II. REVIEW OF LITERATURE

The cultivation and introduction of wheat and barley vary with changes in agronomic practices and the climatic condition of the locality involved. Seed selection, availability of labor, and adequate scientific and management undertakings on the crops decide the output.

Various investigators have studied wheat and barley varieties in relation to yield and other agronomic characteristics. They observed that time of planting would drastically affect the yielding capacity, susceptibility to diseases, chemical composition, and other characteristics of the crops. Sowing too early or too late may result in poor growth and consequently reduced yield.

Citations relating to the possible effect of date of planting on yield and other agronomic characteristics of wheat and barley will be mentioned in this section.

Planting Date and Yield

A decrease in yield was observed when wheat was seeded too early or too late, while medium planting date produced the best and highest yields (10, 15, 22, 30, 31). Beech and Norman (9) in an experiment in the Ord River Valley in Australia, showed that decrease in yield from

late planting dates was due to the high temperature occurring at the time of maturity. Mooers (33), studying winter barley in Tennessee, U.S.A., observed highest yield in the early date of planting, with subsequent decrease at later dates.

The effect of moisture, temperature, and date of sowing on yield of wheat was studied by Robertson et al. (44) in Akron, Colorado. It was observed that extremely low temperatures and moisture resulted in poor performance of the crop. Thus, under Colorado climatic conditions, the investigators concluded that the highest yield of wheat was obtained when planting was done on a date preceding a three-week period in which the average daily mean temperature was 65.8°F (18.8°C). This occurred usually between September 1 and 15. Woodward (53) observed that small grains sown late would help to control weeds and diseases. He also observed a 64 percent increase in yield from early date of planting, while the medium date averaged 32.7 percent higher yields than the later dates.

Martin (30) reported that heavy growth in the fall exhausted the available plant food and soil moisture. As a result spring recovery of the crop became less favorable. He observed that very late seeding usually would produce even poorer yields than the extremely early planting, because of poor development and late maturity. However, after very severe winters, spring emergence would escape

winter-killing and have higher yield than crops which emerge in the fall and are partly winter-killed (30). When wheat is planted early, emergence is slow in the fall and the plants are sometimes killed in the winter. Seedlings from very late dates of planting do not emerge until spring, and thus mature so late that the crops are exposed to drought, hot wind, and rust (29, 30, 32). Wheat and barley which do not emerge until the spring usually yield less than those which emerge in the fall. Knoch (26), investigating in Germany three sowing dates of winter barley, noted that the plants sown earliest gave the highest yields of grain. Mohsini (32), working in the Beqa'a, Lebanon, observed that the highest yield of wheat and barley was obtained from November 15 and November 30.

Planting Date and Protein Percentage

Protein, which forms the chief part of gluten, is one of the most important nutritional ingredients in wheat and barley (43). Florell (15) stated that the protein percentage of cereal grains is intimately associated with the nitrogen nutrition of the crop during the later stages of development. He correlated protein percentage with grain yield. Lower protein percentage was usually associated with high grain yields. The higher protein percentage of grains from the later dates of planting was due to lower yield either of grain or straw or both. In Utah, U.S.A., the

protein percentage of wheat grain was 11.63 percent when grown under 22 to 24 inches of rainfall and 12.63 percent under 25 inches of irrigation (15). Ramon and Laird (40) in Central Mexico found that protein percentage of wheat grains was lowest in excess moisture treatment. Moist warm climatic regions result in heavy deposits of starch in the grains, and decrease in the protein percentage (42). On the other hand, hot dry climates shorten the time for starch transference, making the grains richer in proteins and lower in carbohydrates (15, 32, 43). Florell (15) observed that early sown wheats ordinarily are starchy and low in protein. Bailey (7), working in Minnesota, observed that a long ripening period of wheat after heading gave rise to plump kernels with a low percentage of protein, while higher protein percentage was observed in shorter ripening period.

Planting Date and Weight of 1000 Kernels

A study of the weight of 1000 grains gives an idea of weight per bushel and shrivelling of the grain caused by lodging and diseases (51). Jevtic (20) found that later date of planting resulted in delayed emergence, decreased tillering, ear-size, and decrease in yield and 1000-grain weight.

Planting Date and Straw Yield and Plant Height

Beutler and Foote (10) observed that straw yield decreased as seeding date is delayed. Early planting date produced taller plants and consequently increased the straw yield (10, 31, 32).

Planting Date and Heading

Temperature and length of growing period and heading of winter wheat are interdependent. The higher the temperature, the shorter the period required from emergence to heading of winter wheat and vice versa (35). The heading of winter barley occurred earlier during relatively cooler temperature. The milk stage of the grains was reached from 12 to 15 days after heading. It is at the milk stage that cereals become very sensitive to temperature, and lack of soil moisture (34, 35). Nuttonson (34) observed that satisfactory production of winter barley and wheat was obtained at 60°F to 62°F (15.6°C to 16.7°C) in the central regions of the U.S.A. In Eastern Canada 48°F to 58°F (8.9°C to 14.4°C) was found to result in satisfactory growth.

Planting Date and Maturity

The maturity of winter wheat and barley is judged by the date of heading (21, 34, 35). Florell (15) pointed

out that the time of maturity shortens in accordance with the different dates of seeding. He observed about 18 days difference in the date of maturity of wheat from early and late plantings. Pittman and Andrews (38), working at Southern Alberta, Canada, observed that maturity of winter wheat was delayed when planted after the optimum time or when stands were thinned by winter killing.

III. MATERIALS AND METHODS

The investigation involving the effect of dates of planting winter wheat and barley was performed at the AREC of the American University of Beirut in the Beqa'a plain, Lebanon, under dryland condition for one season, 1966-67. The soil at this Center as reported by Salib (46, pp 65-66) was fine in texture, calcareous, and alkaline in reaction with a pH of 8.0. It was generally very low in phosphorus, total nitrogen, and organic matter, but not deficient in potassium. The experimental site was under fallow for one year. Fertilizers were added each year at the rate of eight kilograms of nitrogen per dunum in the form of ammonium sulfonitrate and eight kilograms of phosphorus (P_2O_5) in the form of superphosphate. The superphosphate was broad-casted and disked into the soil before planting was done. Nitrogen was top-dressed on the soil surface early in March. To reduce the hazards from rodents in the experimental site, a small area affected on the field was fumigated manually with calcium cyanide in February 1967, while close observation was made to prevent a re-occurrence.

Three varieties of wheat: Florence Aurore, FAO-8685, and Senator Capelli; and three varieties of barley: Athinais, Baladi, and Beecher, were employed in this study.

In selecting the winter wheat and barley varieties, emphasis was placed on their variations in maturity and performance at the experimental station in the Beqa'a. FAO-8685 is known to be an early variety, Florence Aurore is intermediate, while Senator Capelli is late in maturation. In barley, Athinais is early, while Baladi and Beecher are intermediate in maturity. Weeds were controlled by hand and by hoeing throughout the growing season.

Birds caused damage to the Athinais variety of the first date of planting during the early heading stage. Damage to other varieties was prevented by laborers who kept the birds away from the plots, and by erecting "scare-crows".

The plots were seeded on November 1, November 15, November 30, and December 30. The longer period between the third and the last dates of planting was due to rain and wet soil conditions which made it impossible to sow on December 15. Seeding was done with a Planet Junior planter. Irrigation by sprinkler was used only once on the second date of planting. This was to permit immediate germination of the seeds as the moisture content of the soil was considered low. Condition of the soil at other dates of planting was moist enough for emergence, hence there was no irrigation. The weather data from the experimental area for the seasons 1965-66 and 1966-67 are presented in Table 15 in the Appendix.

The experimental lay-out was based on a split-plot

design in a Latin square with four replications. The dates of planting were the main-plots, while the wheat and barley varieties were the sub-plots. Each of the sub-plots was made up of three rows, each 4.5 meters long and 25 centimeters apart. Twenty-two rows were in each plot. The size of each main plot was 4.5 m x 5.6 m, each block was 4.5 m x 23.7 m, and the area of the total experiment was 23 m x 23.7 m.

Data for grain and straw yield, protein content, plant height, weight of 1000 kernels, number of days from planting to heading, and maturity were recorded. Varieties in the plots were examined for lodging and winter injuries.

To determine the grain and straw yield, four meters from each central row of each sub-plot were harvested, leaving a quarter of a meter on both ends to avoid border effects. Cutting of the plants was done by hand sickle. Samples from each sub-plot were kept separately in cloth sacks and sun-dried for two to three weeks. Threshing and cleaning were done with nursery equipment. The clean seeds were weighed for grain yield, and the difference between the total grain-straw weights and grain weights gave the straw weights. The protein content of the grains was determined using the modified Kjeldahl method (17, pp 12-13). A representative sample from each sub-plot was ground, stored in a screw-top bottle, and oven dried at 60°C for a minimum of 48 hours. Two grams of sample were weighed from each bottle on a moisture-free basis for analysis. The nitrogen

values for each sample were multiplied by the factors 5.7 for wheat and 5.83 for barley to get the protein percentage. Plant height was measured from the ground level to the uppermost spikelet at the time of full maturity. One thousand sound kernels were selected at random from each variety and weighed to obtain the weight of 1000 kernels. The number of days between planting, heading, and maturity of each variety was calculated. Lodging percentage and winter injury were estimated by observation and comparing the degree of affected and unaffected stand.

The varieties Florence Aurore in wheat and Athinais in barley were taken as the check. The November 1 date was considered as the check for the dates of planting.

Data analysis was performed by statistical methods appropriate to split-plot-design in a Latin square design according to LeClerg et al. (27). Analysis of variance was then made with the calculation of the "F" and "t" tests to determine the difference between the different treatment combination.

IV. RESULTS AND DISCUSSION

The investigation was conducted for one season, 1966-67, at the AREC of the American University of Beirut in the Beqa'a plain, Lebanon. Data were collected on the effect of four dates of planting on the grain and straw yield, protein percentage, plant height, weight of 1000 kernels, and the number of days from planting to heading and maturity of wheat and barley varieties. Reaction of these two crops to winter injury and lodging was also recorded. The data for the characteristics studied are indicated in Tables 1, 2, 3, 4, 5, 6, and 7. The analysis of variance and the L.S.D. figures for treatments significant at the five and one percent levels are reported in the Appendix in Tables 8, 9, 10, 11, 12, 13, and 14.

Grain Yield of Wheat and Barley

The average grain yield of wheat and barley varieties was high in comparison to yields obtained from previous years under dryland condition in the Beqa'a plain (double in wheat and 45 percent higher in barley (54)). This was due to the favorable climatic condition occurring during the present study. The annual rainfall recorded for 1966-67 season was 674.2 mm at AREC (Table 15), as compared to an

average of 430 mm recorded for the 1955 to 1967 seasons.

The average grain yields expressed in kg per dunum are presented in Table 1.

In wheat, plantings made on November 1 produced the highest grain yields in all varieties studied. As the plantings were delayed, the yields gradually decreased from 319 kg per dunum for wheat planted on November 1 to 163 kg for that planted on December 30. The average high yields established for the November 1 date of planting were probably due to the larger and sturdier plants developed in the fall. Mohsini (32) also working at the Beqa'a plain obtained the highest yields from the November 15 and 30 plantings. However, adverse freezing temperatures of $-4^{o}C$ to $-7^{o}C$ which occurred in March of 1965 and 1966 in Mohsini's trials were observed to have drastically reduced grain yields of some of the varieties planted on November 1 of both years. The early varieties were headed during the occurrence of the low temperatures and produced many sterile flowers and fewer seeds.

There was no significant difference between the yields of the individual wheat varieties. However, FAO-8685 yielded 266 kg per dunum as compared to 239 kg for Florence Aurore. Senator Capelli produced the lowest average grain yield. The relative yielding performance of the wheat varieties at the various planting dates was fairly consistent.

Various dates of planting significantly influenced

Table 1. Effect of dates of planting on the average grain yield in kg per dunum[+] of winter wheat and barley during 1966-1967 in the Beqa'a plain, Lebanon.

Varieties	Date of planting				
	November 1	November 15	November 30	December 30	Mean
Wheat					
Florence Aurore	297	293	209	159	239
FAO-8685	364	265	281	154	266
Senator Capelli	295	217	154	177	211
Mean	319	258*	215**	163**	
Barley					
Athinais	356	507	396	274	383
Baladi	485	607	477	413	495**
Beecher	427	630	445	291	448**
Mean	423	581**	439	326*	

* Indicates difference significant at the 5% level.
** Indicates difference significant at the 1% level.
[+] One dunum is taken as 1000 square meters or 1/4 of an acre.

the average grain yield of barley as indicated in Table 1. Highest grain yield of 581 kg per dunum was obtained from planting made on November 15. Due to some damage caused by birds during heading of varieties planted on November 1, the average yield for this date was reduced. However, yields from delayed plantings decreased from the November 15 planting to 326 kg per dunum for the December 30 planting date. In general, the early planting dates of barley produced higher grain yields. These results are in close agreement with the observation of Mooers (33) and Mohsini (32).

Varietal differences in barley were found to be highly significant. On the average, Baladi and Beecher produced higher grain yields than Athinais. These results conform favorably with the findings of Mohsini (32) and Worzella (55) for the varieties grown at AREC.

Protein Percentage of Wheat and Barley

The data in Table 2 indicate the average protein percentages of wheat and barley planted on various dates.

In wheat, the percentage of protein in the seeds was not significantly influenced by the various dates of planting. However, high protein percentages were obtained in seeds with plantings made on November 1 and December 30.

Varietal differences in protein percentage were observed to be highly significant. The highest percentage

Table 2. Effect of dates of planting on average protein percentage of wheat and barley during 1966-1967 in the Beqa'a plain, Lebanon.

Varieties	Date of planting				Mean
	November 1	November 15	November 30	December 30	
Wheat					
Florence Aurore	14.1	12.7	12.3	15.6	13.7
FAO-8685	13.3	11.5	11.2	13.3	12.3
Senator Capelli	12.9	10.1	11.5	12.7	11.8*
Mean	13.4	11.4	11.7	13.9	
Barley					
Athinais	13.1	11.0	10.5	12.3	11.7
Baladi	12.6	10.1	9.1	11.0	10.7**
Beecher	12.3	10.9	10.4	12.5	11.5
Mean	12.7	10.7**	10.0**	11.9**	

* Indicates difference significant at the 5% level.
** Indicates difference significant at the 1% level.

of 13.7 was observed in seeds of Florence Aurore, followed closely by FAO-8685 with 12.3 percent protein, and 11.8 percent for Senator Capelli.

In barley, the various dates of planting significantly influenced the protein percentages of the grains as indicated in Table 2. Seeds produced from plantings made on November 1 contained a higher percentage of protein (12.7 percent) than those from the November 15, 30, and December 30 plantings which contained 10.7, 10.0, and 11.9 percent of protein, respectively.

Athinais and Beecher varieties of barley contained higher protein percentages than did Baladi.

Weight of 1000 Kernels of Wheat and Barley

The data for the weight of 1000 kernels of wheat and barley varieties are shown in Table 3.

There was a slight influence of the various dates of planting on the grain weights of wheat. The second date of planting (November 15) produced significantly heavier grains than the November 1 plantings. The higher amount of rainfall recorded during this season produced well-filled grains which were heavier in weight as compared to seasons with lower amount of rainfall as reported by Mohsini (32).

Senator Capelli produced the largest seed of the varieties studied. The average weight of 1000 seeds of Senator Capelli was 43.6 grams and that for Florence Aurore

Table 3. Effect of dates of planting on the average weight in grams of 1000 kernels of winter wheat and barley during 1966-1967 in the Beqa'a plain, Lebanon.

Varieties	Date of planting				Mean
	November 1	November 15	November 30	December 30	
Wheat					
Florence Aurore	43.1	42.1	39.4	41.5	41.5
FAO-8685	39.7	45.3	42.1	39.3	41.6
Senator Capelli	42.6	42.9	40.6	48.4	43.6**
Mean	41.8	43.4*	40.7	43.1	
Barley					
Athinais	40.8	42.3	47.9	45.6	44.1
Baladi	38.4	49.2	53.6	52.3	48.4**
Beecher	49.0	52.9	54.4	51.2	51.9**
Mean	42.7	48.1**	52.0**	49.7**	

* Indicates difference significant at the 5% level.
** Indicates difference significant at the 1% level.

was 41.5 grams.

There were significant interactions observed between weight of seeds planted on various dates. Small differences in seed weight were obtained between the wheat varieties planted on November 30, while great differences occurred in seed size between Senator Capelli and the other two varieties planted on December 30.

Significant differences were observed in the average 1000-kernel weight of barley due to the various planting dates as indicated in Table 3. Average weights of grains were higher from the November 15, 30, and December 30 than from the November 1 plantings.

Barley varieties showed significant differences in their seed weights. The seed size in all varieties increased as the plantings were delayed from November 1 to November 30. The varieties Beecher and Baladi (51.9 and 48.4 grams, respectively) had heavier seeds than Athinais which weighed 44.1 grams.

The interaction between seed weight of varieties and the various planting dates was highly significant. Large differences in seed size were obtained between Baladi and Beecher when planted on November 1. However, only small differences in seed size were produced between these two varieties when planted on the other three dates. Also, delayed plantings increased the size of the seed to a greater extent in the variety Baladi than in Athinais or

Beecher.

Straw Yield of Wheat and Barley

Average straw yields of wheat and barley, expressed in kg per dunum, were influenced greatly by the various dates of planting. Data for this study are presented in Table 4.

In wheat, earlier plantings showed consistently more straw yield than later plantings. On the average, November 1 seedings produced 600 kg per dunum of straw as compared to only 359 kg from December 30 plantings. For the November 15 and November 30 plantings, average straw yields of 477 kg per dunum and 452 kg per dunum, respectively, were produced. These trends were also observed from the trials of Mohsini (32) in the Beqa'a, Lebanon, and Beutler and Foote (10) in Eastern Oregon, U.S.A., who showed that straw yields decreased as planting dates were delayed.

Straw yields from varieties of wheat were consistent but not statistically significant. However, Florence Aurore produced 495 kg per dunum followed by FAO-8685 and Senator Capelli which produced 468 kg and 453 kg per dunum, respectively.

The average straw yields of barley were affected by the various dates of planting as indicated in Table 4. Plantings made on November 1 produced the highest straw yields in all varieties studied. As the plantings were

Table 4. Effect of dates of planting on the average straw yield in kg per dunum[+] of winter wheat and barley during 1966-1967 in the Beqa'a plain, Lebanon.

Varieties	Date of planting				Mean
	November 1	November 15	November 30	December 30	
Wheat					
Florence Aurore	615	503	456	407	495
FAO-8685	596	447	450	380	468
Senator Capelli	589	481	451	290	453
Mean	600	477**	452**	359**	
Barley					
Athinais	661	425	384	261	433
Baladi	684	605	409	380	519**
Beecher	543	509	416	430	475
Mean	629	513**	403**	357**	

** Indicates difference significant at the 1% level.

+ One dunum is taken as 1000 square meters or 1/4 of an acre.

delayed, the yields gradually decreased from 629 kg per dunum of straw for barley planted on November 1 to 357 kg for that planted on December 30.

Among the barley varieties studied, Baladi producing 519 kg of straw per dunum was significantly higher in yields than the 433 kg produced by Athinais. Beecher yielded 475 kg per dunum and was intermediate in yielding capacity.

A significant interaction was obtained between dates of planting and straw yields of barley varieties. Baladi produced the largest amount of straw from plantings made on November 1 and 15, while Beecher produced greater amounts of straw from the November 30 and December 30 plantings. Also, Athinais produced relatively much less straw than did Beecher from the December 30 plantings as compared to the straw yields from the November 30 plantings.

Plant Height of Wheat and Barley

The effect of different dates of planting on the plant heights of wheat and barley is presented in Table 5.

Various planting dates influenced the plant heights of wheat significantly. Plant heights from seedings made on November 1 and November 15 were higher than those from the November 30 and December 30 plantings. A fairly consistent decrease in plant heights was observed as plantings were delayed from November 1 to December 30.

Table 5. Effect of dates of planting on the average plant height in cm of winter wheat and barley during 1966-1967 in the Beqa'a plain, Lebanon.

Varieties	Date of planting				Mean
	November 1	November 15	November 30	December 30	
Wheat					
Florence Aurore	120	125	110	90	111
FAO-8685	113	118	101	83	104**
Senator Capelli	127	123	104	83	109
Mean	120	122	105**	85**	
Barley					
Athinais	87	83	76	71	79
Baladi	85	85	79	70	80
Beecher	95	97	89	85	91**
Mean	89	88	81**	75**	

** Indicates difference significant at the 1% level.

Wheat sown on November 1 had an average height of 120 cm, while the average height from the December 30 plantings was 85 cm. The findings of Beutler and Foote (10) and Mohsini (32) revealed that early dates of seeding produced taller plants than plantings made on later dates.

The wheat varieties studied varied significantly in their heights. Florence Aurore produced the tallest plants (111 cm), followed by Senator Capelli (109 cm), and then FAO-8685 (104 cm), the shortest variety.

Plant heights of barley varieties as affected by various dates of planting are presented in Table 5.

As in wheat, the sowings made on November 1 produced the tallest plants in all varieties studied. However, with delayed planting, the plant heights gradually decreased from 89 cm for barley seeded on November 1 to 75 cm for that planted on December 30.

Varieties of barley varied in their plant heights. Beecher having an average height of 91 cm, produced the tallest plants as compared to Athinais and Baladi with average heights of 79 cm and 80 cm, respectively.

Days from Planting to Heading of Wheat and Barley

The number of days from planting to heading of wheat and barley as influenced by plantings made on various dates is shown in Table 6.

Dates of seeding significantly affected the number

Table 6. Effect of dates of planting on the average number of days from planting to heading of winter wheat and barley during 1966-1967 in the Beqa'a plain, Lebanon.

Varieties	Date of planting				
	November 1	November 15	November 30	December 30	Mean
Wheat					
Florence Aurore	183	173	163	146	166
FAO-8685	179	170	162	145	164**
Senator Capelli	191	179	166	148	171**
Mean	184	174**	164**	146**	
Barley					
Athinais	157	150	144	144	149
Baladi	172	161	155	134	155
Beecher	163	158	151	133	151
Mean	164	156	150	137*	

* Indicates difference significant at the 5% level.
** Indicates difference significant at the 1% level.

of days from planting to heading. As plantings were delayed, the number of days required to head consistently decreased from 184 days for wheat planted on November 1 to 146 days for that planted on December 30. On the basis of a one-year average, the number of days from planting to heading was reduced by 38 days when planting was delayed from November 1 to December 30. The gradual decrease in the number of days was due to the moisture shortages and higher temperatures occurring in the spring of 1967, which affected the heading of wheat planted at later dates. Several investigators have reported studies showing a similar trend between days of planting and heading (32, 34, 35).

The number of days from planting to heading was significantly different for the three varieties of wheat studied. Senator Capelli required the most time, while FA0-8685 took the shortest time to head. From this study, it was observed that Senator Capelli, Florence Aurore, and FA0-8685 headed on the average in 171, 166 and 164 days after planting, respectively.

The interaction between the heading of wheat varieties and the various dates of planting was highly significant. The differences between varieties for the number of days from planting to heading were greater from seedings made on November 1 (12 days) as compared to those made on November 30 and December 30 (3 days).

In barley (Table 6), plantings made on November 1, required the most time to head in all the varieties studied. There was a general decrease in the number of days from planting to heading as the sowing dates were delayed from November 1 to December 30.

The early variety, Athinais, required 149 days to head, while Baladi and Beecher required 155 and 151 days to head after planting, respectively.

Days from Planting to Maturity of Wheat and Barley

The data for the number of days taken by wheat and barley to mature are shown in Table 7.

The average number of days from planting to maturity in wheat was significantly affected by the four dates of planting. It will be noted that a delay in planting caused a consistent decrease in the number of days to reach maturity of wheat as the planting was delayed from November 1 to December 30.

The number of days between planting and maturity of wheat was 237, 221, 209, and 186 days, when planted on November 1, 15, 30, and December 30, respectively. The decrease in the number of days taken for the crop to reach maturity as planting was delayed was probably due to the influence of the hot and dry weather usually occurring in May and June, which promoted the early maturation of varieties planted late. These results are in agreement with the

Table 7. Effect of dates of planting on the average number of days from planting to maturity of winter wheat and barley during 1966-1967 in the Beqa'a plain, Lebanon.

Varieties	Date of planting				
	November 1	November 15	November 30	December 30	Mean
Wheat					
Florence Aurore	235	217	204	183	210
FA0-8685	233	216	207	183	210
Senator Capelli	244	230	215	193	220**
Mean	237	221**	209**	186**	
Barley					
Athinais	203	199	196	168	191
Baladi	225	206	197	171	200**
Beecher	210	203	198	171	195*
Mean	213	203	197	170**	

* Indicates difference significant at the 5% level.
** Indicates difference significant at the 1% level.

findings of Florell (15) and Mohsini (32).

Florence Aurore and FA0-8685 were early in maturity and were consistent in the number of days required to mature, while Senator Capelli required the longest time to reach maturity.

Barley varieties planted on various dates were slightly different in the length of time required to mature as shown in Table 7. The barley varieties from plantings made on November 1 took the longest time to reach maturity. As the plantings were delayed, the number of days required to reach maturity decreased from 213 days for barley planted on November 1 to 170 days for that planted on December 30. The average number of days required for barley to reach maturity was 213, 203, 197, and 170 days when planted on November 1, 15, 30, and December 30, respectively.

Varieties of barley varied significantly in the number of days required between planting and maturity. Athinais, an early variety, required the shortest time (191 days) to reach maturity, while Beecher and Baladi respectively took 195 and 200 days to mature.

The number of days required between planting and maturity was within three days for the varieties planted on November 30 and December 30. However, when planted on November 1, Athinais required 22 days less to mature than did Baladi.

Earliness, as observed in FAO-8685 and Florence Aurore (wheat) and in Athinais and Beecher (barley), was an important characteristic of these varieties to escape the hot and dry weather occurring in May and June in the Beqa'a plain. This resulted in the production of well-filled and mature grains. Later varieties such as Senator Capelli often produced poor quality and shrivelled grains due to the hot and dry weather occurring during the period of ripening.

Planting Date and Lodging

Lodging was slight and noted in both wheat and barley only in the plots planted on November 1. However, Baladi showed considerable lodging from plantings made on November 1. Plants from this barley were observed to be thin and produced some grains that contained some mold and were discolored. The other plots of wheat and barley did not lodge and were observed to have tall, erect, and stiff-strawed plants during the entire growing season. Pe'ev (37) observed that lodging in barley caused a reduction in grain weight, increased the percentage of chaff, and decreased the protein and fat contents of the grains. Also, others have reported that grain quality was generally low when lodging occurred at the start of ear formation (15, 21, 37).

Planting Date and Winter Injury

Air temperatures as low as -8.5°C that occurred in January of 1967 produced leaf injury in wheat and barley varieties planted on November 1 and 15. However, no winter injury was caused by the temperatures on plants from the seedings made on November 30 and December 30 as the crop had not reached the heading stage. The injury was limited to the tips of the leaves and the varieties recovered rapidly during later part of the growing season.

The findings of Knoch (26) agree with this observation. It was further observed that after very severe winter, late emerging wheat and barley when planted late would escape winter injury (26).

V. SUMMARY AND CONCLUSIONS

Date of planting trials on wheat and barley varieties

were conducted during 1966-1967, under dryland condition at the AREC of the American University of Beirut in the Beqa'a plain, Lebanon. The effect of four dates of planting on grain and straw yield, protein percentage, plant height, weight of 1000 kernels, and the number of days from planting to heading and maturity was investigated. Three varieties of wheat, Florence Aurore, FAO-8685, and Senator Capelli, and three varieties of barley, Athinais, Baladi and Beecher that varied widely in maturity were included in the study. The dates of planting were November 1, November 15, November 30, and December 30.

Plantings of wheat and barley made between November 1 and November 15 produced the highest grain yields. Among the wheat varieties, FAO-8685 produced the highest yield, followed by Florence Aurore. Senator Capelli produced the lowest yield. In barley, Baladi and Beecher produced more grains than Athinais.

The percentage of protein in wheat was not affected by the various dates of planting. However, plantings made on November 1 and December 30 tended to produce seeds with high protein percentages. Florence Aurore produced seeds

with high protein percentage while seeds of Senator Capelli contained significantly low protein percentage. Barley seeds produced from plantings made on November 1 contained higher protein percentage than those from later planting dates. The grain of Athinais and Beecher contained higher protein percentage than did the seeds of Baladi.

Significant differences were observed due to the effect of planting dates on the grain weights of wheat and barley. Wheat planted on November 15 produced grains with significantly heavier weights than did that planted on November 1 or November 30. Senator Capelli produced the heaviest grains as compared to Florence Aurore and FAO-8685. In barley, the weight of the seed increased as the dates of planting advanced from November 1 to December 30. Baladi and Beecher produced heavier grains than Athinais.

Various dates of planting greatly influenced the straw yield of wheat and barley. The first date of planting produced the most straw. As the plants were delayed, the yields of straw decreased. The straw yields of wheat varieties were not significantly different. Among the barley varieties, Baladi produced significantly higher yields than Athinais. Beecher was intermediate in straw yield.

The plant heights of wheat and barley were influenced by the various dates of planting. The tallest plants were obtained from plantings made on the first and second dates, while plants from the third and fourth dates of planting

were shorter in height. FAO-8685, an early variety, produced the shortest plants among the varieties of wheat, while Athinais produced the shortest plants among the barley varieties.

Dates of planting significantly affected the number of days required from planting to heading and maturity of wheat and barley. As the dates of planting were delayed, the number of days to heading and maturity in both crops was reduced. In wheat, Senator Capelli required the longest period of time to head and mature, while FAO-8685 and Florence Aurore were early, and required the shortest number of days to head and reach maturity. In barley, Baladi took the longest time to head and mature, Beecher was intermediate, while Athinais was early and required the shortest time to head and mature.

On the basis of the present study, and that conducted for two years in the Beqa'a plain by Mohsini (32), it appears that optimum yields of wheat and barley can be obtained from plantings made between November 10, and November 30. However, additional date of planting trials are recommended to more adequately represent the varied growing conditions and other hazards in the Beqa'a plain. Small grain crops sown earlier than the middle of November may encounter winter injury and low yields caused by low temperatures in March. Further trials will determine the extent and frequency of the damage caused by the low temperatures in

March. Also, plant diseases and sunni bug infestations, not encountered in these trials, may influence the results and the present recommended dates of planting of wheat and barley in the Beqa'a plain.

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A P P E N D I X

Table 8. Analysis of variance for grain yield of wheat and barley, 1966-1967.

Source	d.f.	Mean square		F-ratio		L.S.D. 5%		L.S.D. 1%	
		Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Columns	3	3056.9	18377.8	1.40	2.01				
Rows	3	4918.1	25387.5	2.26	2.78				
Dates	3	52220.8	133481.9	24.00**	14.64**	46.65	95.50	70.64	144.61
Error (a)	6	2175.7	9115.3						
Varieties	2	12104.7	50767.2	3.23	13.00**	N.S.	52.55	N.S.	71.43
Varieties x Dates	6	5573.4	4136.6	1.49	1.05	N.S.	N.S.	N.S.	N.S.
Error (b)	24	3738.9	3904.7						

** Indicates F-ratio significant at the 1% level.

Table 9. Analysis of variance for protein percentage of wheat and barley, 1966-1967.

Source	d.f.	Mean square		F-ratio		L.S.D. 5%		L.S.D. 1%	
		Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Columns	3	2.93	0.83	0.38	4.15				
Rows	3	8.46	4.36	1.11	21.80**				
Dates	3	18.20	17.26	2.39	86.30**	N.S.	0.42	N.S.	0.63
Error (a)	6	7.60	0.20						
Varieties	2	15.00	4.80	5.37*	18.46**	1.40	0.41	1.90	0.56
Varieties x Dates	6	1.36	0.60	0.48	2.30	N.S.	N.S.	N.S.	N.S.
Error (b)	24	2.79	0.26						

* Indicates F-ratio significant at the 5% level.
** Indicates F-ratio significant at the 1% level.

Table 10. Analysis of variance for 1000-kernel weight of wheat and barley, 1966-1967.

Source	d.f.	Mean square		F-ratio		L.S.D. 5%		L.S.D. 1%	
		Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Columns	3	1.13	2.96	0.44	0.76				
Rows	3	19.60	19.23	7.84*	4.92*				
Dates	3	18.60	183.90	7.44*	47.15**	1.57	1.98	2.37	3.00
Error (a)	6	2.50	3.90						
Varieties	2	22.35	239.50	13.11**	104.13**	1.09	1.28	1.48	1.74
Varieties x Dates	6	33.16	34.16	19.52**	14.86**	2.68	3.13	3.64	4.26
Error (b)	24	1.75	2.26						

* Indicates F-ratio significant at the 5% level.
** Indicates F-ratio significant at the 1% level.

Table 11. Analysis of variance for straw yield of wheat and barley, 1966-1967.

Source	d.f.	Mean square		F-ratio		L.S.D. 5%		L.S.D. 1%	
		Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Columns	3	822.7	2206.6	0.09	0.46				
Rows	3	14547.7	2564.4	1.61	0.54				
Dates	3	118085.2	177012.4	13.13**	37.29**	94.81	68.89	143.58	104.33
Error (a)	6	8988.0	4745.7						
Varieties	2	7393.7	30073.5	1.04	4.87*	N.S.	66.08	N.S.	89.82
Varieties x Dates	6	3855.6	18854.9	0.54	3.05*	N.S.	161.85	N.S.	220.00
Error (b)	24	7090.8	6173.6						

* Indicates F-ratio significant at the 5% level.
** Indicates F-ratio significant at the 1% level.

Table 12. Analysis of variance for plant height of wheat and barley, 1966-1967.

Source	d.f.	Mean square		F-ratio		L.S.D. 5%		L.S.D. 1%	
		Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Columns	3	113.4	23.5	2.59	0.97				
Rows	3	33.1	44.6	0.75	1.84				
Dates	3	3397.6	499.8	77.74**	20.65**	6.61	4.92	10.02	7.46
Error (a)	6	43.7	24.2						
Varieties	2	257.8	756.1	16.74**	30.36**	3.30	4.20	4.48	5.71
Varieties x Dates	6	53.3	17.9	3.46*	0.71	8.07	N.S.	10.98	N.S.
Error (b)	24	15.4	24.9						

* Indicates F-ratio significant at the 5% level.
** Indicates F-ratio significant at the 1% level.

Table 13. Analysis of variance for the number of days from planting to heading of wheat and barley, 1966-1967.

Source	d.f.	Mean square		F-ratio		L.S.D. 5%		L.S.D. 1%	
		Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Columns	3	4.33	50.2						
Rows	3	7.03	94.2	1.54	1.82				
Dates	3	3116.16	1556.1	683.36**	30.15**	2.13	22.71	3.23	34.39
Error (a)	6	4.56	51.6						
Varieties	2	184.60	193.5	143.10**	2.61	0.93	N.S.	1.26	N.S.
Varieties x Dates	6	18.51	153.8	14.34**	2.08	2.35	N.S.	3.19	N.S.
Error (b)	24	1.29	73.9						

** Indicates F-ratio significant at the 1% level.

Table 14. Analysis of variance for number of days from planting to maturity of wheat and barley, 1966-1967.

Source	d.f.	Mean square		F-ratio		L.S.D. 5%		L.S.D. 1%	
		Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Columns	3	53.9	351.5	1.68	1.35				
Rows	3	15.7	255.1	0.49	0.98				
Dates	3	5493.5	4001.9	172.21**	15.38**	5.63	16.15	8.53	24.45
Error (a)	6	31.9	260.2						
Varieties	2	645.3	272.3	52.04**	14.71**	2.99	3.63	4.06	4.93
Varieties x Dates	6	8.8	100.5	0.70	5.43**	N.S.	8.86	N.S.	12.04
Error (b)	24	12.4	18.5						

** Indicates F-ratio significant at the 1% level.

Table 15. Average monthly temperatures, relative humidity and rainfall during 1965-1966, and 1966-1967 at the AUB Agricultural Research and Education Center, Beqa'a plain, Lebanon*

Month	Temperature °C		Relative humidity %		Rainfall mm	
	1965-66	1966-67	1965-66	1966-67	1965-66	1966-67
September	20.2	20.2	48.4	62.2	23.2	0.9
October	13.2	16.1	59.9	64.1	46.8	28.0
November	10.0	14.1	60.4	63.2	24.8	11.0
December	6.7	7.3	77.2	75.5	155.7	187.8
January	5.7	4.1	75.3	72.8	70.9	139.3
February	6.4	4.1	72.8	78.3	68.7	85.1
March	6.6	5.9	67.9	71.5	96.7	167.1
April	11.8	10.5	62.1	58.6	0.0	20.5
May	14.5	15.1	58.0	56.6	2.6	34.5
June	19.6	17.9	53.3	48.3	0.0	0.0
July	22.8	20.7	53.4	45.5	0.0	0.0
August	23.7	20.5	53.6	48.7	0.0	0.0
	-	-	-	-	489.4	674.2

* Meteorological data, collected by Reza Soroush and Fouad M. Malouf, AUB, Agricultural Research and Education Center, Beqa'a plain, Lebanon