DRY MATTER ACCUMULATION AND GRAIN YIELD OF WINTER WHEAT AS AFFECTED BY SEEDING DATE

by

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INTRODUCTION

Kansas contributes nearly one-fifth of the annual wheat production of the United States. The production during 1963 was 184 million bushels. Hoover and McCoy (13) stated that the factors contributing to such a high production are the climatic and soil conditions coupled with the topography. The average acre yields increased from 15.8 bushels in the 1940's to 22 bushels during 1958-62. This increase in yield is partly due to the introduction of new varieties, with improved resistance to diseases, insects, etc. (31). Besides varieties, improved cultural and soil management and climatic factors also will contribute to increased yields. Proper date of seeding is one of the major factors that influences yields in winter wheat, as it may affect the stand, tillering, resistance to cold, maturity, and finally the yield of the crop.

Hence, the present studies were undertaken to determine the effect of different dates of seeding on dry matter accumulation and yield of three varieties of winter wheat.

REVIEW OF LITERATURE

Winter wheat is usually sown in the United States during September or October, except in certain northcentral and southwestern United States. Leonard and Martin (23) and Burtis and Moorhouse (9) stated that medium-season seeding was better than early or late seedings. The work done by Schafer _et al_. (34) at Pullman, Washington indicated that medium-early seedings gave largest yields when compared to very early or late seedings.

If the crop is seeded too early, it exhausts the available soil moisture and reaches the jointing stage in the fall. Thus, it becomes more susceptible to winter injury. Klages (20), Burtis and Moorhouse (9), and Call et al. (10) stated that early seedings were not advantageous, and gave low yields. Leighty and Taylor (22), Schafer et al. (34), and Beutler and Foote (6) stated that seedings earlier than the critical dates produced more straw than grain.

On the other hand, late seedings in November also were not advisable, in general, except for southwestern United States. Late seedings generally produced low yields. Kisselbach (18) and Kisselbach et al. (19) stated that late seedings gave decreased yields and test weight, due to delayed germination and maturity. Locke and Mathews (24), at Woodward, Oklahoma, reported that a delay of one month in seeding beyond the normal decreased yields. Stephens et al. (35, 36) reported that yields of winter wheat were significantly decreased when sown in November in the dry lands of western United States. Miller et al. (27), from southwestern United States, reported that seeding in November and December was better than late seedings in January or March. Richardson (32), from Austria, also reported that very late sowings were disadvantageous. Jones (17) stated that yields were much reduced, especially when seedings were delayed in poorly drained soils of Ohio. Work done at the Agricultural Experiment Station at Wooster (3) for 20 years also showed that late planting was unfavorable to high quality wheat as measured by test weight. Heyne et al. (12) reported that late-sown wheat develops a shallow root system and thus is subjected to injury from drought and hot winds. They also mentioned that late-sown wheat often winterkills badly. The results of experiments conducted at the Kansas Agricultural Experiment Station (2) also indicated that late-sown crops tillered very little, gave a thin stand, and ripened late. Martin (25) summarized trials that were conducted to determine the optimum date of seeding for different varieties in various locations of the Great Plains and Great Basin area. Hughes and Henson (14), Suneson and Kisselbach (38), Chilcott and Cole (11), Morgan and Bell (28), and Moss (29) observed that a number of factors control the optimum date of seeding.

The optimum seeding date is determined mainly by the length of the growing season, moisture content of the soil at the time of seeding, and the mean daily temperatures at the time of sowing.

When the growing season (frost-free period) is short, as in the northern states, earlier sowings than those of the southern states are favored in order to provide enough time for growth and development (25). The results given by Martin (25) indicated that where the growing season was comparatively short, the early seedings gave higher yields. He stated that higher yields were obtained with early seedings of September 1 and 15 in Montana, Wyoming, and Idaho in the northwestern region, respectively, whereas highest yields were obtained with the October 15 seeding date in Oklahoma and Texas. This is in agreement with the results reported by Hughes and Henson (14). Chilcott and Cole (11) reported that relatively early seeding from August 15 to September 15 was better for the northern parts of the Great Plains such as

Montana, Wyoming, western South Dakota, and portions of western Nebraska. They also stated that September 15 to October 1 was optimum for central parts of the Great Plains.

Experiments conducted at Bozeman, Montana (1, 28) indicated that August and early September seedings gave better yields than later seedings. The yields were in favor of August and September seedings. Quayle and Nelson (30) reported that Kanred wheat gave better yields when drilled on September 1, under Wyoming conditions. Stephens _et al_. (35, 36) stated that September 15 to October 1 is the better time to seed winter wheat under Nephi, Utah conditions. Moss (29) reported that the September 1 seeding date gave high yields under eastern Idaho conditions.

Robertson _et al_. (33) stated that September 1 and 15 seedings are best for obtaining higher yields in Colorado. Under Michigan conditions, higher yields were obtained when seeding was between September 18 and 22 (7). Williams and Welton (43) and Jones (17) stated that September 22 is the best date to sow winter wheat in Ohio. Atkinson (5) and Burnett (8) reported that early September was satisfactory for Iowa. Call _et al_. (10) stated that the best time to seed in northeast Kansas was September 25 to October 3, and for southcentral Kansas, September 25 to October 7. Jardine (16) stated that it was unsafe to sow before October 5 in southern Kansas, because of the Hessian fly. Kisselbach (18) and Kisselbach _et al_. (19) stated that September 15 to October 1 was the optimum date in Nebraska. The maximum grain yields were obtained with September 22 seedings.

As we proceed to the south, the seeding date is further delayed. Burtis and Moorhouse (9) reported that October 10 to 20 seedings were better when compared to September 10 to 20 or November 10 to 20 seeding dates, under Oklahoma conditions.

Suneson and Briggs (39), Suneson and Parsons (40), Miller *et al*. (27), and Leonard and Martin (23) stated that November-December seedings were better in southwestern United States.

The time of seeding also changes, depending upon the latitude and altitude. Swanson (41) stated that the time should be earlier with increased altitude and latitude. Miller and Hackleman (26) stated that for northern Missouri, September 15 to October 1 was better, whereas for southern Missouri, 10 to 15 days later was optimum. Leighty (21) reported that, in general, for each 10-mile difference in latitude or 200-foot increase in elevation, there was a difference of one day in seeding date, this date being earlier as one goes north and later as one goes south from a given point. Wiancko (44) reported that the third week of September was better for northern Indiana, whereas early October was optimum for southern Indiana.

METHODS AND MATERIALS

The experiment was conducted at the Agronomy Farm, Kansas Agricultural Experiment Station, Manhattan, Kansas, during the fall of 1963 and spring of 1964.

The previous crop was oats. The soil is a Geary silt loam. The plots were given a 50-20-0 (N-P-K) treatment prior to seeding.

Experimental Design

The experimental design was a modified split-plot, with each treatment being replicated five times. Seeding dates were main plot-treatments to facilitate various cultural operations. The sub-plot treatments, i.e., varieties, were randomized within each date of seeding. Approximate seeding dates were: September 1, September 15, October 1, October 15, November 1, and November 15.

The sub-plot treatments were Triumph, Ottawa, and Pawnee, varieties which are well adaptcd to northeast Kansas.

Seeding and Sampling

After the fertilizer was applied, the seeds were planted with a Planet Jr. 300-A seeder. Plot size was 4-12-inch rows 12 feet in length. At the end of each main plot treatment, four border rows were included. The seeder was calibrated in order to have a uniform seed rate for the three varieties.

Samples were taken from two replications on March 27, April 25, May 16, May 30, and June 13 to determine dry matter content and protein percentage. Wherever possible, samples were taken from the two central rows. Samples from a three-foot length of two rows were taken. The plants were cut near the ground, leaving a one-half to one inch stubble.

Dry Matter and Nitrogen

For determining dry matter accumulation, samples were dried in the oven at 150^{o}F for four to five days and the weights were recorded. From these samples, nitrogen percentage in the whole plant was determined by the Kjeldahl method, using boric acid to receive the ammonia.

Population Counts

Population counts were taken from the samples of the first cutting. For this purpose, the actual number of plants established in an area of six square feet was counted.

Yield and Yield Components

Data on grain yield and yield components were obtained from replications 2, 3, and 4. For this study, (1) number of head-bearing tillers in an area of six square feet, (2) number of grains per head, and (3) weight of 200 grains per sample were determined.

Finally, the yield of grain and straw was determined by taking the weight from 22 square feet. After cutting, samples were bundled, labeled, and dried at 140°F for four days. Immediately after drying, the weights of the whole plants were recorded and the grain was threshed. The grain was cleaned and redried in the laboratory for four days at 150°F. The samples were then ground for nitrogen determination.

From the clean grain after weights were recorded, 200 seeds at random were picked up and their weights per sample were recorded.

The number of seeds per head was calculated by first dividing the grain yield of 22 square feet area by the number of head-bearing tillers in order that the weight of grain per head be known. Then, based on the weight of 200 grains of that particular sample, the number of grains per head could be determined.

Statistical Analysis

The data were statistically analyzed by following a suitable analysis of variance to account for the modification from a normal split-plot design. The source of variation and degrees of freedom for the analysis of variance of the data for yield and yield components, percentage protein in grain, population counts, dry matter accumulation, and percentage of protein in the whole plant are given in Tables 1, 2, and 3.

Table 1. Source of variation and degrees of freedom for analysis of variance of data for yield and yield components and percentage protein in grain.

Source of variation	Degrees of freedom
Main plots:	
Dates (D)	5
Rep. within dates (Error A)	12
Sub plots:	
Varieties (V)	2
D x V	10
Error (B)	24
Total	53

Table 2. Source of variation and degrees of freedom for analysis of variance of data for population counts.

Source of variation	Degrees of freedom
Main plots:	
Dates (D)	5
Rep. within dates (Error A)	6
Sub plots:	
Varieties (V)	2
D x V	10
Error (B)	12
Total	35

Table 3. Source of variation and degrees of freedom for analysis of variance of dry matter accumulation and percentage protein in whole plant.

Source of variation	Degrees of freedom
Main plots:	
Rep.	1
Dates (D)	5
Dates x Reps. (Error A)	5
Sub plots:	
Varieties (V)	2
D x V	10
V x R)) (Error B) D x V x R)	12
Cuttings (C)	4
C x R (Error C)	4
C x D	20
C x D x R (Error D)	20
C x V	8
C x V x D	40
C x V x R)) (Error E) C x V x D x R)	48
Total	179

EXPERIMENTAL RESULTS

Plant Stand

The average number of plants per six feet of row, as influenced by seeding date and variety, is given in Table 4 (Appendix)* and Fig. 1. Statistical analysis showed that both seeding dates and varieties significantly affected spring stands. Ottawa differed significantly from Pawnee and Triumph. The number of plants of Triumph and Ottawa increased gradually from September 1 to October 15 seeding, and then decreased. In case of Pawnee, the same pattern was observed except for a decrease in the October 1 seeding date.

Among the various seeding dates, October 15 produced the maximum number of plants, which differed significantly from other dates. Next to the October 15 seeding, October 1 and November 1 seedings ranked high. September 1, the earliest seeding date, produced the lowest stand. The seeding date x variety interaction was significant at the 1 per cent level, due to the inconsistent behavior of the varieties.

Grain Yield

The average grain yields as influenced by seeding dates and varieties are given in Table 5. Statistical analysis showed that seeding dates and varieties differed significantly within themselves at the 1 per cent level. Triumph yielded more than Pawnee

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* Tables 4 to 15, inclusive, are shown in the Appendix.

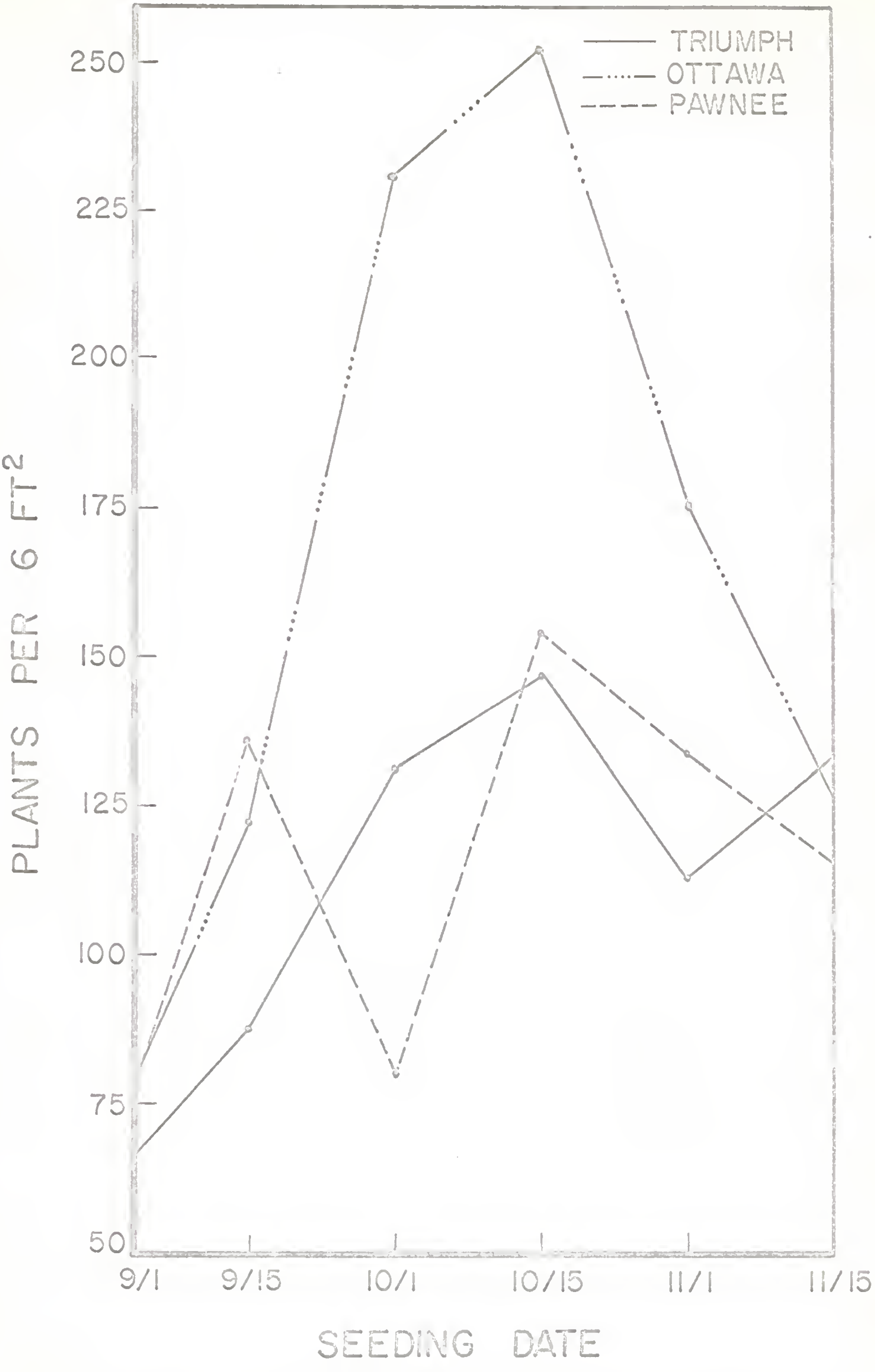

Fig. 1. Number of plants per six square feet as influenced by variety and seeding date.

and Ottawa. Ottawa produced the lowest yield.

October 1 seeding produced the highest mean yield, but this was not significantly greater than that from October 15 and November 1 seeding dates. The yield of these three seeding dates differed significantly from that of the others. The September 1 seeding date produced the lowest yield. Triumph produced the highest yield with the October 15 seeding, whereas Pawnee and Ottawa produced maximum yields with the October 1 seeding. Yields in all three varieties gradually increased up to the October 1 or October 15 seeding, but gradually decreased with later dates of seeding.

Straw Yield

Straw yields are given in Table 6. Analysis of variance indicated highly significant (1 per cent level) differences among seeding dates. Differences among varieties or varieties x seeding dates were not significant. The October 15 seeding date produced the maximum amount of straw per acre. The differences in the yields of October 15 and the next highest yield obtained with October 1 and November 1 seeding dates were not significant. It was significantly different, however, from the September 15, November 15, and September 1 seeding dates. The September 1 seeding date gave the lowest straw yield.

Total Dry Matter (grain plus straw)

Information on total yield (straw plus grain) is presented in Table 7 and Fig. 2. Statistical analysis indicated that

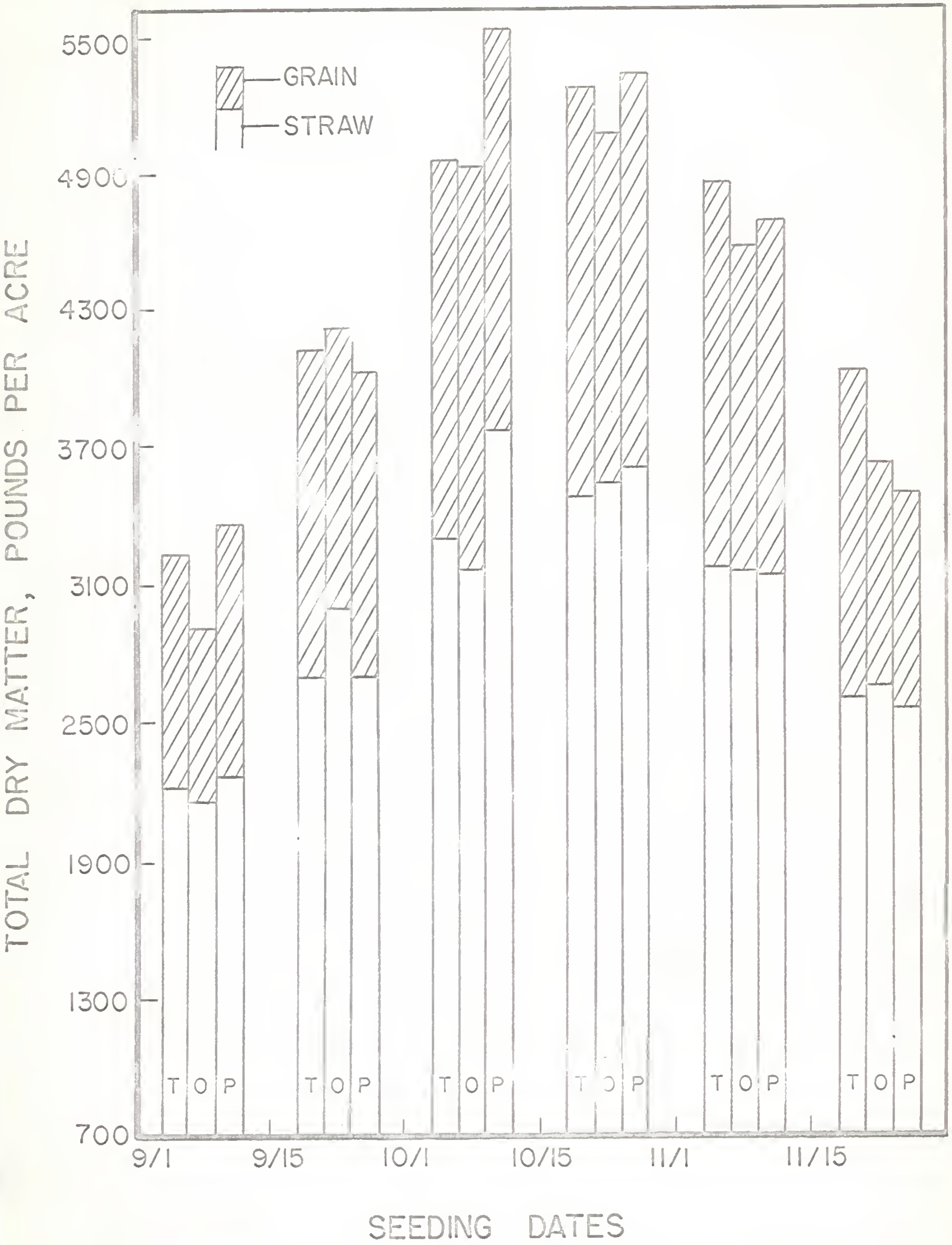

Fig. 2. Total dry matter (grain + straw) as influenced by variety and seeding date.

differences among seeding dates were significant at the 1 per cent level. Varieties did not differ significantly.

Differences among seeding dates were significant. The October 15 date produced the highest total yield, but this was not significantly different from yields obtained from October 1 and November 1 seedings. Lowest yields were obtained with the September 1 seeding which was the earliest. The mean yields of the last two dates of seeding were slightly higher.

Number of Heads Per Unit Area

The data are presented in Table 8 and Fig. 3. Analysis of variance indicated that differences among seeding dates and varieties were significant at the 1 per cent level, and the interaction between varieties x seeding dates was significant at the 5 per cent level. Ottawa produced the maximum number of heads, which differed significantly from Pawnee and Triumph. Triumph produced the fewest heads per square foot. Differences among seeding dates were significant, and the maximum number of heads was obtained with the October 15 seeding. The lowest was with the November 15 seeding. In all three varieties, the number of heads produced gradually increased from the September 1 to the October 15 seeding and decreased thereafter.

Number of Seeds Per Head

Analysis of variance (Table 9) showed that the number of seeds per head did not differ significantly neither with varieties nor with the interaction between varieties x seeding dates.

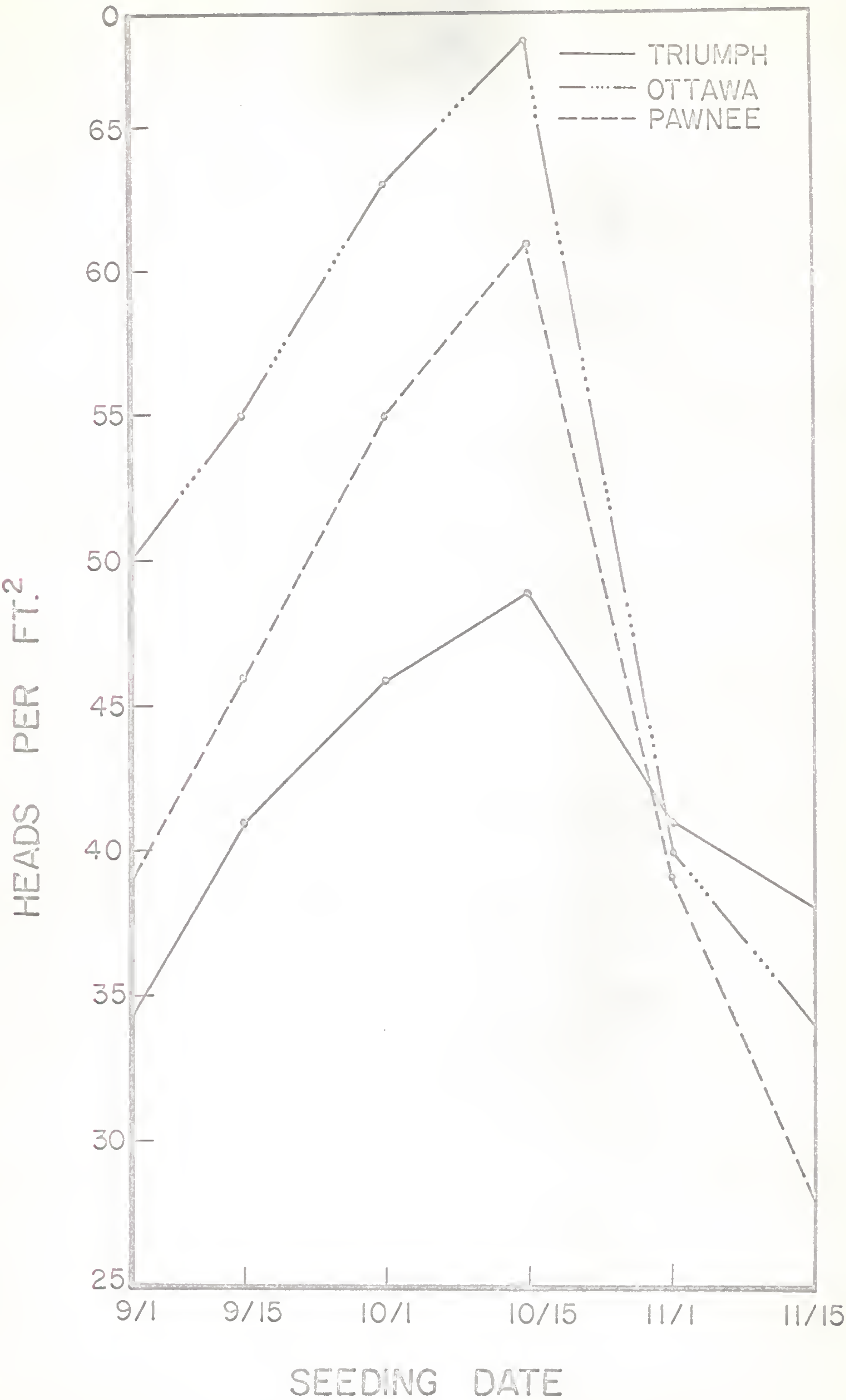

Fig. 3. Number of heads per square foot as influenced by variety and seeding date.

The differences among the seeding dates were significant at the 10 per cent level.

Seed Weight

The average weight of 200 seeds is given in Table 10 and Fig. 4. Analysis of variance indicated that the seeding dates and varieties differed significantly within themselves at the 1 per cent level. The interaction among the seeding dates x varieties also was significant at the 1 per cent level of probability. Among the varieties, Triumph had the greatest seed weight, which was significantly more than that of Ottawa. Among the seeding dates, the maximum seed weight was obtained with the November 1 seeding. This did not differ significantly from that of the November 15 and September 1 and 15 seeding dates, but differed significantly from all others.

The interaction between varieties and seeding dates was significant due to the inconsistent behavior of varieties.

Grain Protein Percentage

Information on protein percentage, as influenced by variety and seeding date is presented in Table 11 and Fig. 5. Analysis of variance indicated that differences amont the varieties and seeding dates were significant at the 1 per cent level. The interaction of variety x seeding date also was significant at the 1 per cent level. Among seeding dates, November 15 gave the highest protein percentage. Ottawa showed the highest amount of protein, followed by Triumph and Pawnee, respectively. Triumph

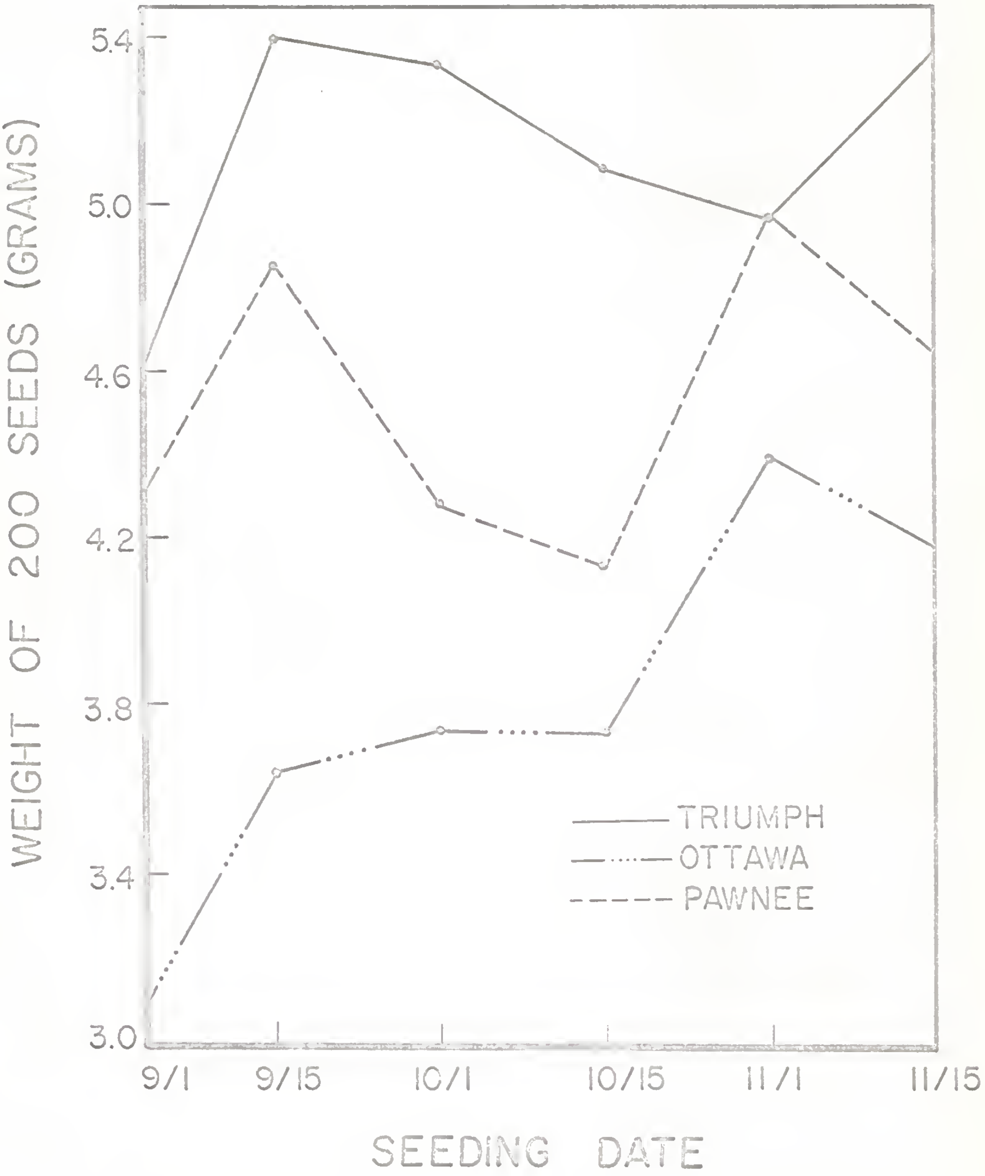

Fig. 4. Weight of 200 seeds (grams) as influenced by variety and seeding date.

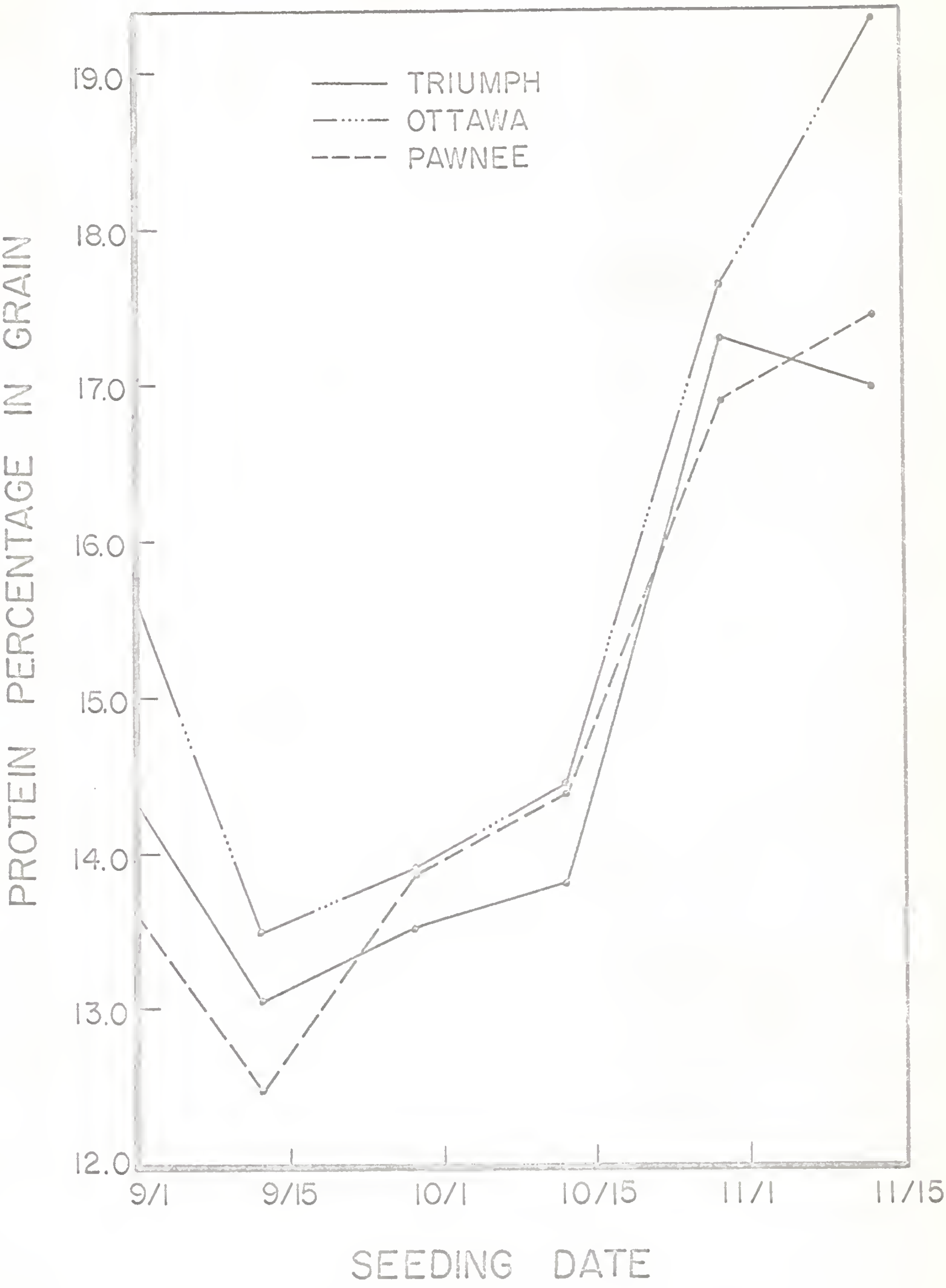

Fig. 5. Protein percentage in grain as influenced by variety and seeding date.

and Pawnee did not differ significantly. The lowest protein percentage in all three varieties was obtained with the September 15 seeding date, and it increased gradually up to the November 15 seeding date except for Triumph. In the case of Triumph, it increased up to the November 1 seeding date, then decreased. In all varieties, the protein percentage obtained with the September 1 seeding date was higher than the protein percentage from September 15. Differences among September 1, October 1, and October 15 seeding dates were not significant.

Dry Matter Accumulation

Information on dry matter accumulation is presented in Tables 12 and 13 and Figs. 6 and 7. Analysis of variance indicated that the differences within the various seeding dates and cutting dates were significant at the 1 per cent level. The October 1 seeding produced the maximum amount of dry matter, whereas the lowest amount was obtained with the November 15 seeding. Next to October 1, the October 15 seeding date produced the maximum amount of dry matter, and the difference between these two was not significant. As expected, the maximum amount of dry matter was accumulated with the last cutting date. In general, dry matter increased from the March 27 cutting date to the June 13 cutting date. Triumph produced more dry matter than Pawnee or Ottawa, but differences were not significant.

Dry matter accumulated by different varieties also followed the same pattern over different cutting dates. All varieties

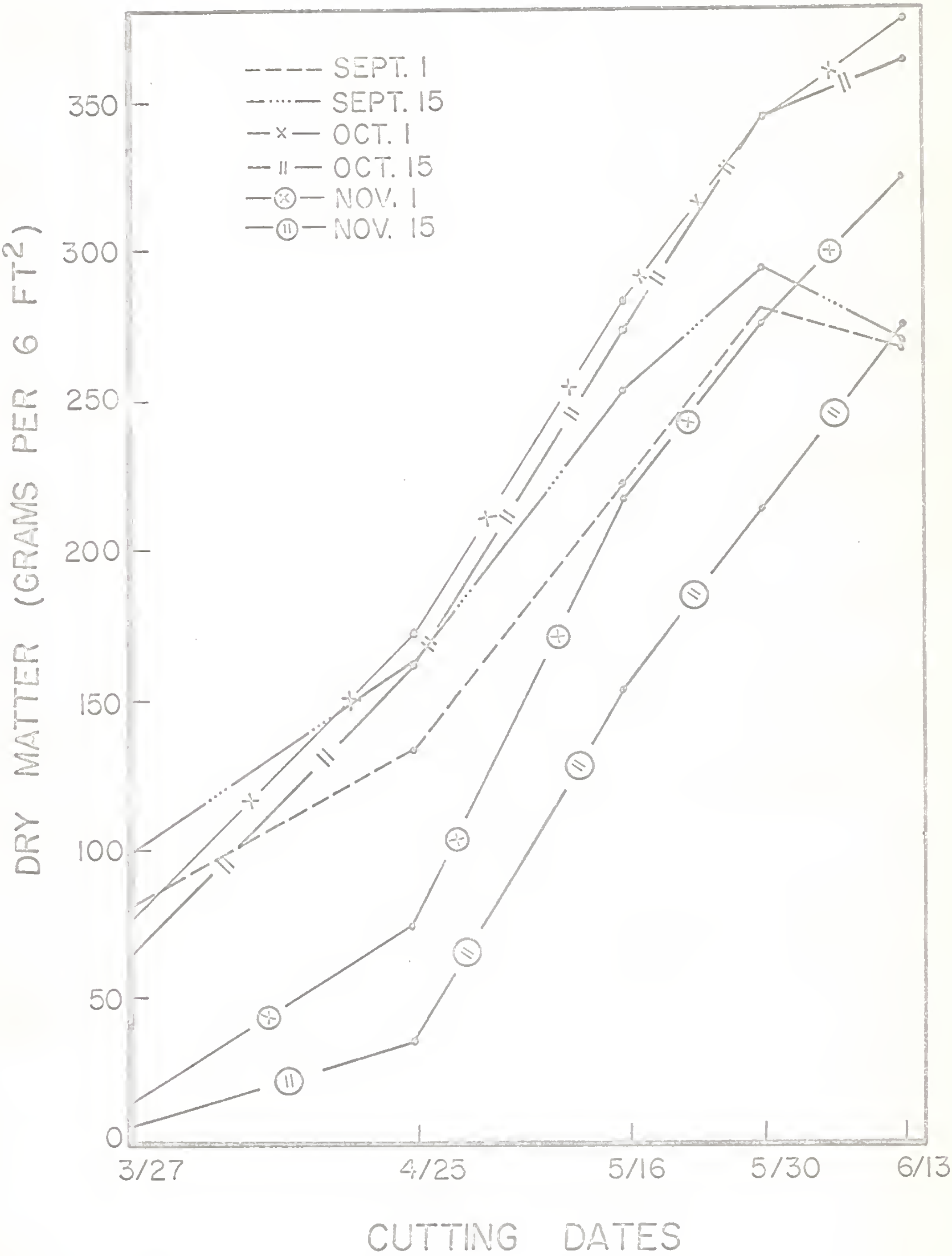

Fig. 6. Amount of dry matter (grams/6 ft.^{2}) as influenced by cutting date and seeding date.

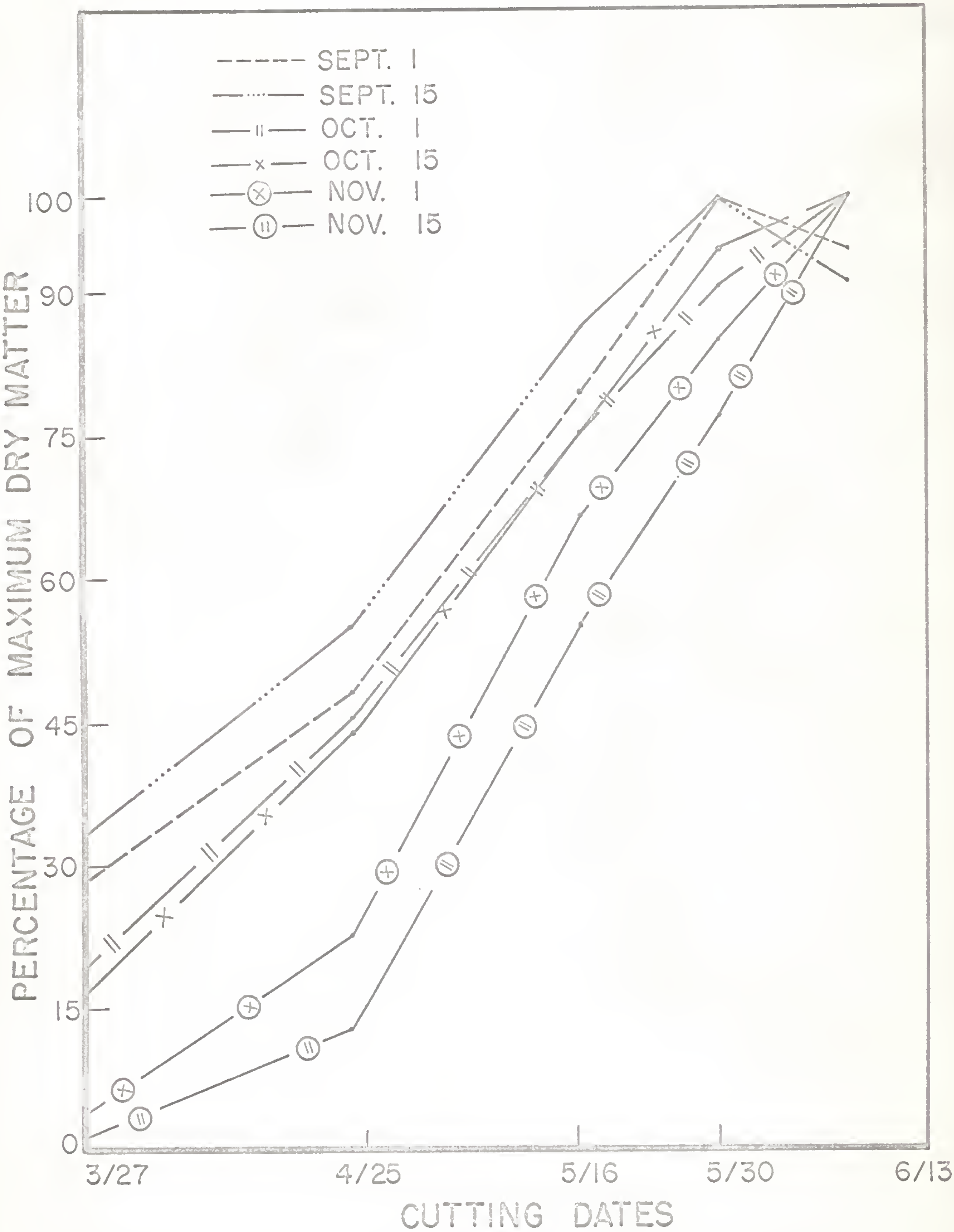

Fig. 7. Amount of dry matter (expressed as percentage of maximum) as influenced by cutting and seeding dates.

produced maximum dry matter with the June 13 cutting date, and a minimum amount with the March 27 cutting date.

Protein Percentage in Whole Plant

Data on protein percentage as influenced by seeding date and cutting date are given in Table 14 and illustrated in Fig. 8. Analysis of variance revealed that differences among the seeding dates and cutting dates were significant at the 1 per cent level of probability. The interaction among the cutting dates and seeding dates also was significant at the 1 per cent level. The interaction among cutting dates and varieties was significant at the 5 per cent level.

The percentage protein in the whole plant was highest with the November 15 seeding date. In general, it decreased gradually with earlier seeding. The September 1 seeding date showed a higher protein percentage than the September 15 seeding date. As expected, the March 27 cutting contained more protein than the others. The lower percentages of protein were obtained with May 30 and June 13 cutting dates, which differed significantly from the others. With all the seeding dates, the percentage protein decreased and leveled off as the cutting dates proceeded from March 27 to June 13.

Nitrogen Uptake

The uptake of nitrogen was highest with the June 13 cutting date and gradually decreased with the earlier cutting dates, as shown in Table 15 and Fig. 9. Thus, the lowest uptake of nitrogen

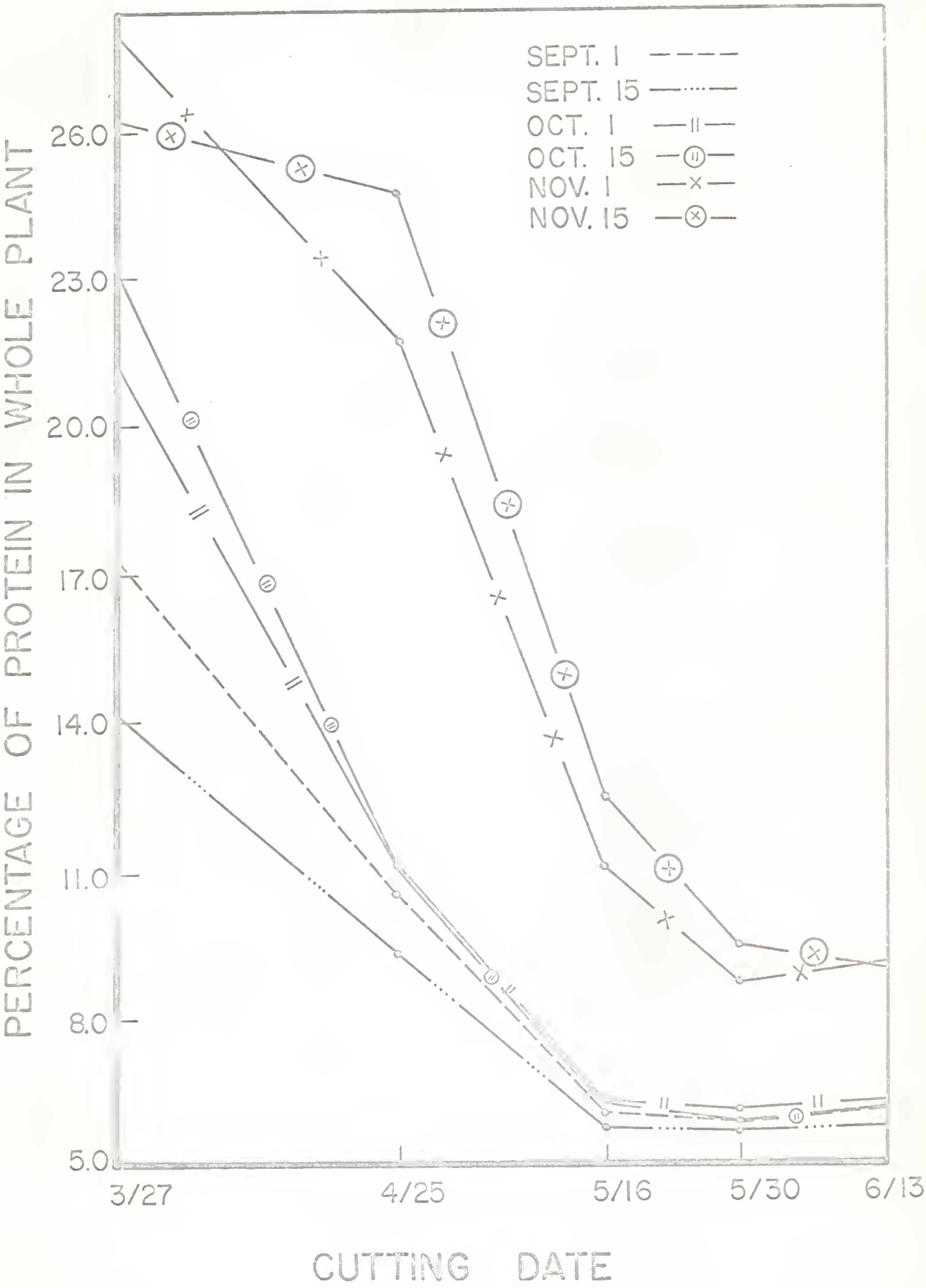

Fig. 8. Protein percentage in whole plant as influenced by seeding date and cutting date.

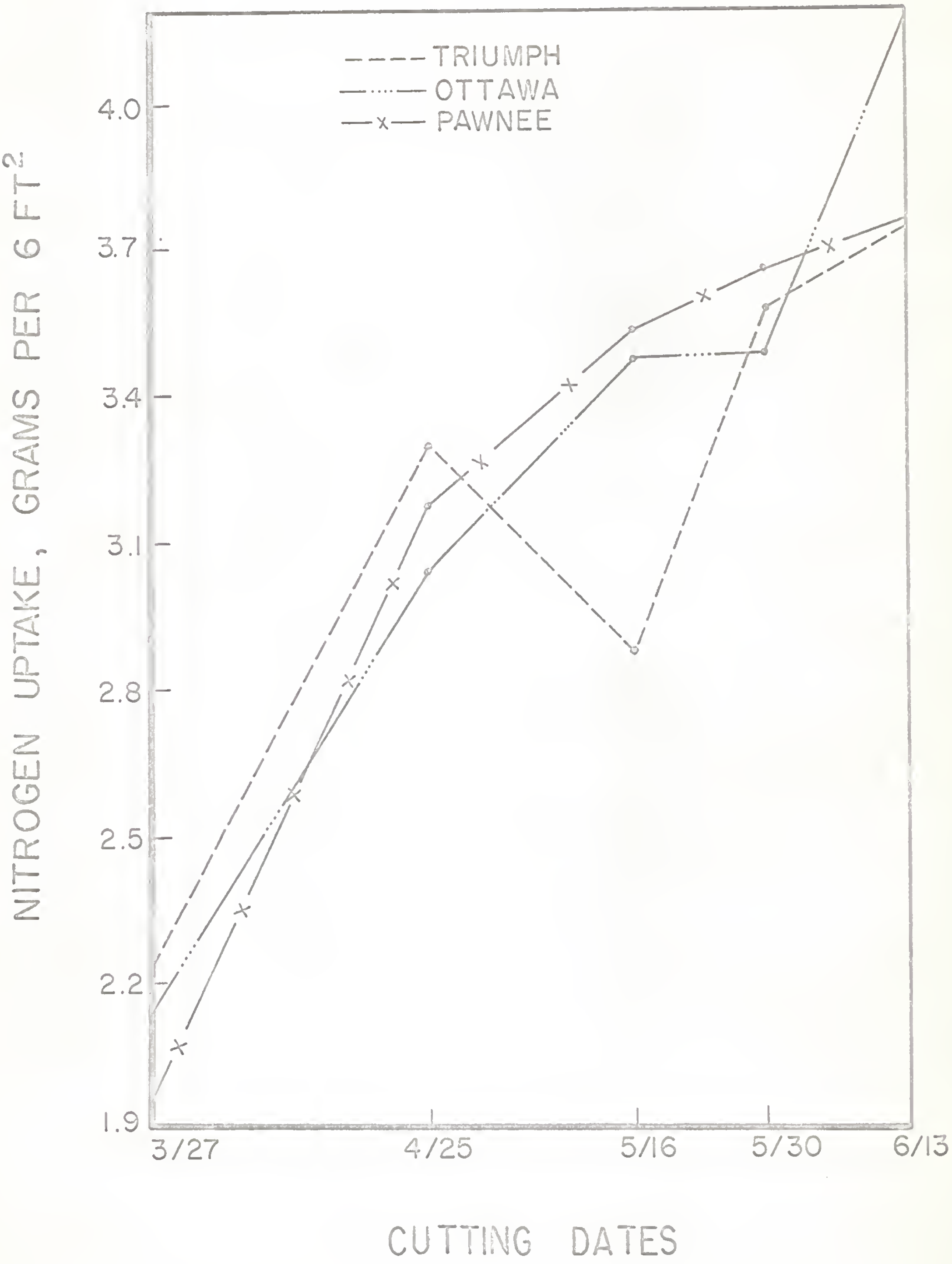

Fig. 9. Nitrogen uptake (grams/6 ft.^{2}) as influenced by cutting date and variety.

was seen with the March 27 cutting date. The varieties Pawnee and Ottawa showed a similar trend in the uptake of nitrogen, i.e., the nitrogen uptake gradually increased from the earlier cutting date to the last cutting date. In the case of Triumph, there was a depression in the May 16 cutting date. Except for this, the trend of nitrogen uptake by Triumph was similar to the above two varieties. This difference might be due to the fact that the percentage nitrogen during the May 16 cutting date decreased to nearly 50 per cent of that of the April 25 cutting date.

DISCUSSION

Both seeding date and variety contributed to the stand density of the crop. Ottawa ranked high, with a population of 164 plants per 6 square feet, followed by Pawnee and Triumph. The October 15 seeding showed the maximum number of 184 plants, against the lowest of 74 plants produced by the September 1 seeding. These results indicated that environmental conditions with the October 15 seeding were conducive to best stand establishment.

The highest grain yield per acre was obtained with Triumph, succeeded by Pawnee and Ottawa. The yields of the three varieties were 1482, 1390, and 1265 pounds per acre, respectively. A similar ranking of the varieties, with regard to yield, was reported by Walter (42) from the results obtained at Hutchinson, Kansas. The October 1 seeding gave the highest grain yield of 1733 pounds per acre, compared with the lowest of 941 pounds per acre given by the September 1 seeding. The next lowest yield was obtained with the November 15 seeding. These results indicated that both early and late seeding gave low yields. Several investigators (9, 10, 20) stated that early seedings of winter wheat gave low yields. It was also reported by various workers (2, 12, 18, 19, 24, 35) that late seedings resulted in low yields and poor grain quality. These findings confirm the studies cited above. In the present study, October 1 to 15 seedings gave higher yields than seedings made on other dates. These results are in accordance with the recommendations of Heyne et al. (12) and Call et al. (10), who stated that late September or early October seedings were better for the Manhattan, Kansas area.

With respect to number of heads per square foot, the October 15 seeding showed the highest with 59, whereas the lowest were found with the November 1 and 15 seeding dates. Ottawa produced the highest number of heads, whereas Triumph produced the lowest. The number of grains per head did not differ significantly with varieties or interaction between seeding dates and varieties. It differed among seeding dates at the 10 per cent level. Triumph had the maximum seed weight of 5.13 grams per 200 seeds, which differed significantly from that of Pawnee and Ottawa. Among seeding dates, the lowest seed weight was recorded with the earliest seeding, i.e., September 1. This suggests that earlier seedings are not advisable when averaged over dates. Triumph, with the heaviest seed weight, produced the maximum grain yield of 1492 pounds per acre, whereas Ottawa, with the lowest seed weight, gave the lowest grain yield of 1265 pounds per acre. Pawnee was intermediate. From this, it was seen that grain yield was associated with seed weight. The results reported by Ahmed (4) from a seeding rate experiment were in agreement with the present findings. The differences among varieties with regard to straw yield were not significant.

The June 13 cutting date showed the greatest dry matter in the case of October and November seedings. September 1 and 15 seeding dates showed maximum dry matter with the May 30 cutting date. However, the differences among these two cutting dates were not significant. This suggested that dry matter increased as the growth of the plants proceeded in spring until they approached maturity. September seedings accumulated more dry matter in the fall than October and November seedings. September seedings produced nearly 30 per cent of their maximum dry matter in the fall and reached the maximum by the end of May, whereas October seedings produced about 20 per cent of maximum dry matter in the fall, and had rapid development in the spring and continued growth in June also. November seedings produced nearly 96 per cent of dry matter during April to June. Late seedings continued their growth in June also, whereas early seedings reached the maximum by the end of May.

October seedings with comparatively less fall growth than September seedings, showed rapid growth and development in the spring and thus finally produced higher amounts of dry matter. November seedings produced the lowest amounts. These findings suggested that October 1 to 15 is the better period to sow, as the seedlings have optimum fall growth. This might facilitate better winter survival and later spring development.

The grain protein percentage of Ottawa was significantly greater than that of Triumph or Pawnee. Ottawa, with the lowest yield, had the highest protein percentage of 15.76, whereas Triumph and Pawnee had 14.85 and 14.80, respectively. This finding was in agreement with the statement made by Stuber (37) that high protein content occurred with low head weight and late flowering date. Wheat seeded November 1 and 15 had higher protein percentages. This is in agreement with the statement made by Janssen (15). The percentage protein in the whole plant decreased gradually from March 27 to May 30 cutting as the plant developed and reached maturity. This reduction in protein percentage was due to a greater accumulation of dry matter than protein. Therefore, the nitrogen percentage decreased even though there was an actual increase in total nitrogen uptake by the plant. A similar trend was observed with variety means. The nitrogen uptake increased as the cutting date proceeded from March 27 to June 13. These results indicated that an increase in protein percentage or nitrogen uptake was associated with decreased grain yield. Ottawa, with the lowest grain yield, showed the highest percentage of protein or nitrogen uptake, whereas Triumph, with the highest grain yield, gave the lowest percentage of the above two components.

SUMMARY AND CONCLUSIONS

A study involving different seeding dates for three varieties of winter wheat was conducted at the Agronomy Farm, Kansas Agricultural Experiment Station, Manhattan, Kansas, during

1963-64. Six seeding dates, i.e., September 1 and 15, October 1 and 15, and November 1 and 15, were selected. The three varieties selected for the study were Triumph, Ottawa, and Pawnee.

Differences among varieties were significant with regard to number of plants per unit area, grain yield, number of heads per square foot, weight of 200 seeds, nitrogen percentage, and nitrogen uptake. Ottawa differed significantly from Triumph and Pawnee, and ranked highest regarding the number of plants per unit area, number of heads per square foot, protein percentage, and nitrogen uptake. Triumph had the highest seed weight and total yield, followed by Pawnee.

In this study, varietal grain yield was determined to a greater extent by seed weight than by number of heads per unit area or number of grains per head. Differences among varieties were not significant with respect to straw yield, total dry matter (grain plus straw), and number of grains per head.

Among the various seeding dates, October 15 and 1 ranked higher with regard to number of plants, total yield, number of heads per square foot, and dry matter per unit area. The differences between October 1 and October 15 seeding dates, with regard to grain yield, straw yield, total yield, and amount of dry matter per unit area, were not significant. In most cases, the earliest seeding, i.e., September 1, ranked lowest. The next lowest results were obtained with the last date of seeding, i.e., November 15. The above results indicated that October 1 and 15 were optimum. The maximum grain weights and the protein percentages were found with November 1 and 15 seedings. The differences among seeding dates, with reference to number of grains per head, were significant at the 10 per cent level.

Dry matter accumulation was determined by harvesting total plant samples periodically. Among the cutting dates, June 13 ranked higher than the others with regard to dry matter yield and nitrogen uptake. The protein percentage decreased as the cutting dates proceeded from March 27 to June 13.

These results indicated that, in general, all three varieties responded similarly to seeding dates. Among the varieties, Triumph ranked higher than Pawnee and Ottawa with regard to the components of yield and total yield per acre. Regarding seeding dates, October seedings were better, with October 15 leading slightly over October 1. Among the cutting dates, March 27 ranked highest with regard to protein percentage, and dry matter content was highest with June 13.

It is concluded that October 1 to 15 is the proper time to seed winter wheat in the Manhattan, Kansas area. Present-day varieties could be expected to respond similarly.

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APPENDIX

Table 4. Number of plants per six square feet as influenced by variety and seeding date.*

Variety	Seeding date						Variety mean
	Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	
Triumph	66	88	131	147	113	133	113
Ottawa	79	122	231	252	176	127	164
Pawnee	77	135	80	154	134	116	116
Seeding date mean	74	115	147	184	141	125	

L.S.D. at 5%

Seeding date = 22.82
Variety = 16.90

Seeding date Ranking	Oct.15	Oct.1	Nov.1	Nov.15	Sept.15	Sept.1
	184	147	141	125	115	74

Variety Ranking	Ottawa	Pawnee	Triumph
	164	116	113

* Means underscored by the same line do not differ significantly (5% level).

Table 5. Grain yield (pounds per acre) as influenced by variety and seeding date.

Variety	Seeding date						Variety mean
	Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	
Triumph	1006	1401	1658	1806	1673	1409	1492
Ottawa	721	1246	1776	1522	1359	965	1265
Pawnee	1096	1321	1765	1730	1504	923	1390
Seeding date mean	941	1233	1733	1686	1512	1099	

L.S.D. at 5%

Seeding date = 266.23
Variety = 84.34

Seeding date Ranking	Oct.1	Oct.15	Nov.1	Sept.15	Nov.15	Sept.1
	1733	1686	1512	1233	1099	941

Variety Ranking	Triumph	Pawnee	Ottawa
	1492	1390	1265

Table 6. Straw yield (pounds per acre) as influenced by variety and seeding date.

Variety	Seeding date						Variety mean
	Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	
Triumph	2228	2729	3311	3672	3196	2616	2925
Ottawa	2184	2992	3173	3558	3194	2664	2961
Pawnee	2269	2705	3779	3615	3180	2574	3020
Seeding date mean	2227	2809	3421	3548	3190	2618	

L.S.D. at 5% Seeding date = 528.59
Variety = 186.08

Seeding date Ranking	Oct.15	Oct.1	Nov.1	Sept.15	Nov.15	Sept.1
	3548	3421	3190	2809	2618	2227

Variety Ranking	Pawnee	Ottawa	Triumph
	3020	2961	2925

Table 7. Total dry matter (grain + straw) as influenced by variety and seeding date.

Variety	Seeding date						
	Sept.1 S + G*	Sept.15 S + G	Oct.1 S + G	Oct.15 S + G	Nov.1 S + G	Nov.15 S + G	Variety mean S + G
Triumph	2228 1006 3234	2730 1401 4131	3311 1658 4969	3473 1806 5279	3197 1673 4870	2617 1409 4026	2926 1492 4418
Ottawa	2185 721 2906	2993 1246 4239	3173 1776 4949	3559 1522 5081	3195 1359 4554	2664 965 3629	2961 1265 4226
Pawnee	2269 1096 3365	2705 1321 4026	3779 1765 5544	3615 1730 5345	3180 1504 4684	2574 923 3497	3020 1390 4410
Seeding date mean	2227 941 3168	2809 1323 4132	3421 1773 5194	3549 1686 5235	3190 1512 4702	2618 1099 3717	

L.S.D. at 5%

Seeding date = 528.59 + 266.23 = 794.82
Variety = 186.08 + 84.34 = 270.42

Seeding date Ranking	Oct.15	Oct.1	Nov.1	Sept.15	Nov.15	Sept.1
	5235	5194	4702	4132	3717	3168

Variety Ranking	Triumph	Pawnee	Ottawa
	4418	4410	4226

* S = Straw yield in pounds per acre
G = Grain yield in pounds per acre

Table 8. Number of heads per square foot as influenced by variety and seeding date.

Variety	Seeding date: Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	Variety mean
Triumph	34	41	46	49	41	38	41
Ottawa	50	55	63	68	40	34	52
Pawnee	39	46	55	61	39	28	45
Seeding date mean	41	47	55	59	40	33	

L.S.D. at 5% — Seeding date = 0.540; Variety = 0.318

Seeding date Ranking	Oct.15	Oct.1	Sept.15	Sept.1	Nov.1	Nov.15
	59	55	47	41	40	33

Variety Ranking	Ottawa	Pawnee	Triumph
	52	45	41

Table 9. Analysis of variance for number of seeds per head.

Source	D.F.	Ss	Ms	F value: Calculated	10%	5%	1%
Dates	5	81.70	16.36	2.52	2.39	3.11	5.06
Rep: Dates (Error A)	12	77.78	6.48				
Varieties	2	4.93	2.46	0.45	2.56	3.44	5.72
D x V	10	44.85	4.48	0.82	1.90	2.30	3.26
Error B	24-2 =22	119.56	5.43				

Table 10. Weight of 200 seeds (grams) as influenced by variety and seeding date.

Variety	Seeding date: Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	Variety mean
Triumph	4.62	5.40	5.35	5.10	4.95	5.37	5.13
Ottawa	3.10	3.64	3.75	3.74	4.41	4.19	3.80
Pawnee	4.33	4.87	4.28	4.14	4.98	4.67	4.54
Seeding date mean	4.01	4.63	4.46	4.32	4.78	4.74	

L.S.D. at 5% Seeding date = 0.274
Variety = 0.119

Seeding date	Nov.1	Nov.15	Sept.15	Oct.1	Oct.15	Sept.1
Ranking	4.78	4.74	4.63	4.46	4.32	4.01

Variety	Triumph	Pawnee	Ottawa
Ranking	5.13	4.54	3.80

Table 11. Protein percentage in grain as influenced by variety and seeding date.

Variety	Seeding date: Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	Variety mean
Triumph	14.4	13.5	13.6	13.8	17.3	17.0	14.8
Ottawa	15.6	13.5	14.0	14.5	17.7	19.4	15.8
Pawnee	13.6	12.5	13.9	14.4	16.9	17.4	14.8
Seeding date mean	14.5	13.0	13.8	14.2	17.3	17.9	

L.S.D. at 5% Seeding date = 0.7410
Variety = 0.3306

Seeding date	Nov.15	Nov.1	Sept.1	Oct.15	Oct.1	Sept.15
Ranking	17.9	17.3	14.5	14.2	13.8	13.0

Variety	Ottawa	Triumph	Pawnee
Ranking	15.8	14.8	14.8

Table 12. Amount of dry matter (grams/6 ft.^{2}) as influenced by cutting date and seeding date.

Cutting date	Seeding date: Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	Cutting date mean
March 27	80.1	97.6	74.8	63.0	13.0	4.0	55.4
April 25	134.0	161.8	170.6	160.5	73.6	33.6	122.3
May 16	221.8	252.5	283.3	272.8	215.0	151.0	232.7
May 30	279.0	293.3	341.3	342.3	275.3	211.8	290.5
June 13	264.5	266.6	377.1	362.6	323.3	274.8	311.4
Seeding date mean	195.8	214.3	249.4	240.2	180.0	135.0	202.4

L.S.D. at 5% Seeding date = 15.06
Cutting date = 25.31

Seeding date Ranking	Oct.1	Oct.15	Sept.15	Sept.1	Nov.1	Nov.15
	249.4	240.2	214.3	195.8	180.0	135.0

Cutting date Ranking	June 13	May 30	May 16	April 25	March 27
	311.4	290.5	232.7	122.3	55.4

Table 13. Amount of dry matter (expressed as percentage of maximum) as influenced by cutting date and seeding date.

Cutting date	Seeding date: Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	Cutting date mean
March 27	28.6	33.4	19.8	17.3	4.0	1.4	17.4
April 25	48.0	55.2	45.3	44.0	22.9	12.3	37.9
May 16	79.5	86.0	75.0	75.2	66.5	54.9	72.8
May 30	100.0	100.0	90.4	94.2	85.1	77.0	91.1
June 13	94.6	91.1	100.0	100.0	100.0	100.0	97.6
Seeding date mean	70.1	73.1	66.1	66.1	55.7	49.1	

Table 14. Protein percentage in whole plant as influenced by seeding date and cutting date.

Cutting date	Seeding date: Sept.1	Sept.15	Oct.1	Oct.15	Nov.1	Nov.15	Cutting date mean
March 27	17.4	14.1	21.3	23.2	28.0	26.3	21.7
April 25	10.5	9.3	11.3	11.2	21.8	24.7	14.8
May 16	6.1	5.8	6.3	6.2	11.3	12.5	8.0
May 30	5.9	5.8	6.2	5.9	8.8	9.6	7.0
June 13	6.2	5.9	6.3	6.2	9.1	9.1	7.1
Seeding date mean	9.2	8.1	10.2	10.5	15.8	16.4	

L.S.D. at 5% Seeding date = 0.5415
Cutting date = 1.4706

Seeding date	Nov.15	Nov.1	Oct.15	Oct.1	Sept.1	Sept.15
Ranking	16.4	15.8	10.5	10.2	9.2	8.1

Cutting date	Mar.27	Apr.25	May 16	June 13	May 30
Ranking	21.7	14.8	8.0	7.1	7.0

Table 15. Nitrogen uptake (grams/6 $ft.^2$) as influenced by cutting date and variety.*

Cutting date	Variety: Triumph	Ottawa	Pawnee	Cutting date mean
March 27	2.23	2.14	1.95	2.10
April 25	3.29	3.03	3.17	3.16
May 16	2.87	3.47	3.52	3.28
May 30	3.57	3.48	3.65	3.56
June 13	3.73	4.18	3.75	3.88
Variety mean	3.13	3.26	3.20	

Cutting date	June 13	May 30	May 15	Apr.25	Mar.27
Ranking	3.88	3.56	3.28	2.16	2.10

Variety	Ottawa	Pawnee	Triumph
Ranking	3.26	3.20	3.13

* These data were not analyzed statistically.

DRY MATTER ACCUMULATION AND GRAIN YIELD OF WINTER WHEAT AS AFFECTED BY SEEDING DATE

by

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An experiment involving six seeding dates and three varieties of winter wheat was conducted at the Agronomy Farm, Kansas Agricultural Experiment Station, Manhattan, Kansas.

Significant differences were observed among varieties with regard to plant stand, number of heads per unit area, weight of seeds, grain yield, protein percentage, and nitrogen uptake. Triumph, with heaviest seeds, gave the highest total yield. Ottawa, with low seed weight, gave low yield, even in spite of having the maximum number of plants and head-bearing tillers per unit area.

The grain protein percentage was highest with the low yielding variety (Ottawa), whereas Triumph, with its high yield and early maturity, had the lowest protein.

Varieties did not differ significantly with regard to straw yield, total dry matter, and number of grains per head.

October 1 and 15 seeding dates produced higher yields than other seeding dates. The differences between these two dates regarding total yield and dry matter were not significant. The earliest seeding date (September 1) ranked lowest with regard to plant stand and the yield components except for the number of heads per unit area. The last seeding date (November 15) ranked lowest with regard to number of heads per unit area and dry matter content. These results indicated that neither early nor late seedings are advisable, but October 1 to 15 is the suitable period to sow winter wheat in the Manhattan, Kansas area. The maximum grain weights and highest protein percentages were obtained with the last seeding dates, i.e., November 1 and 15.

Dry matter accumulation was highest with October 1 and 15 seedings. October seedings had less dry matter accumulation in fall than September seedings, but had better spring growth and development and thus produced highest amounts of dry matter than other seeding dates. November seedings accumulated nearly 96 per cent of their maximum dry matter during April to June. This indicated that October seedings have the optimum fall growth, which might have facilitated better winter survival and later spring development. Late seedings produced the lowest amount of dry matter.

The last cutting date showed highest amounts of dry matter and nitrogen uptake, whereas the first cutting date (March 27) had the lowest amounts, but had the highest protein percentage.

These results suggested that October 1 to 15 is the proper time to seed winter wheat in the Manhattan, Kansas area. Present-day varieties could be expected to respond similarly.