EFFECT OF NITROGEN AND PHOSPHORUS STATUS OF SEED ON SEEDLING TRAITS OF WINTER WHEAT (*TRITICUM AESTIVUM* L.)

by

JOSE LUIS TORRES ROMERO

Agricultural Engineer, Universidad del Zulia, Venezuela, 1973

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Approved by:

Major Professor

Dedicated to:

My wife: Judith

My children: Maria Mercedes and Jose Luis

My nation: Venezuela

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EFFECT OF NITROGEN AND PHOSPHORUS STATUS OF SEED AND SOIL ON SEEDLING VIGOR OF WINTER WHEAT (TRITICUM AESTIVUM L.)

INTRODUCTION

Fertilizer nutrients are used extensively to increase growth and grain yields of wheat and other cereals. Nitrogen fertilizer, for instance, typically increases tiller numbers and size, grain numbers per spike, and total grain yield (Hobbs, 1953; Rhode, 1963; Spratt, 1974; Wahhab and Hussain, 1957). Phosphorus fertilizer, on the other hand, is essential for cold hardiness and rapid spring recovery of fall-seeded cereals (Knapp and Knapp, 1978; Freyman and Kaldy, 1979).

Increasing the nitrogen content of grain enhances seedling vigor and, possibly, grain yield of the succeeding generation (Lopez and Grabe, 1973; Lowe et al., 1972; Schweizer and Ries, 1969). Use of nitrogen fertilizer on the preceding crop and selection of large seed for sowing both increase seedling vigor (Lowe et al., 1972). Seedling size and grain yield are positively related to seed protein content regardless of the method used to increase seed protein (Lopez and Grabe, 1973).

The adverse effects of late seeding of fall-seeded cereals contrast with beneficial effects of nitrogen and phosphorus fertilization. Late seeding, for instance, decreases tiller number and size (Flower and Gusta, 1979), increases winterkilling (Worzella and Cutler, 1941), and decreases grain yield (Knapp and Knapp, 1978).

Seeding of winter wheat is frequently delayed by adverse weather, poor seedbed conditions, late harvest of preceding crops, and conflicts with other tasks. The discovery that increasing seed protein content enhances seedling vigor has not been applied toward counteracting the deleterious effect of late seeding. Likewise, no research to date has determined if increasing seed phosphorus content might promote winterhardiness and spring recovery of wheat. The objective of this study was to compare the effects of increasing nitrogen and phosphorus contents of seed with application of the same nutrients to the soil. Normal and late seeding dates were used to differentially stress the plants.

MATERIALS AND METHODS

The effect of seed content of nitrogen and phosphorus and of fertilization with the two nutrients on wheat seedlings was studied in separate experiments at Manhattan and Hutchinson, Kansas, during the 1980-1981 season. Six lots of 'Newton' wheat (*Triticum aestivum* L.) from a nitrogen phosphorus fertilizer trial at Colby, Kansas, the preceding year were used for the first experiment. The fertilizer rates and resulting seed nitrogen and phosphorus content were: ON-OP (1.95%N-0.49%P), 75 kg/ha N-OP (1.91%N-.43%P), 150 kg/ha N-OP (2.13%N-0.45%P), ON-80 kg/ha P (1.94%N-.52%P), 75 kg/ha N-80 kg/ha P (1.87%N-.48%P), and 150 kg/ha N-80 kg/ha P (2.11%N-.46%P). The seed for the second study was also 'Newton' wheat grown at Colby without added nitrogen or phosphorus fertilizer (ON-OP treatment). Three seeding dates, normal, late, and very late, were used to compare normal and adverse conditions for germination and seedling development.

The experimental design was a split plot with four replications. Planting dates were whole plots for both studies. The six seed lots that differed in nitrogen and phosphorus content were subplots for the first experiment. Six fertilizer levels, ON-80 kg/ha P, ON-160 kg/ha P, 150 kg/ha N-80 kg/ha P, 150 kg/ha N-160 kg/ha P, 150 kg/ha N-OP, and ON-OP, were subplots for the second experiment. Ammonium nitrate (35.5-0-0) and triple superphosphate (0-46-0) fertilizer were applied by hand before final working of the field. Soil tests before fertilization were pH 6.9, 25.6 ppm available nitrogen, and 40 ppm available phosphorus at Manhattan and pH 6.6 and 21.5 ppm available nitrogen and 15 ppm available phosphorus at Hutchinson.

Each subplot contained six rows spaced 20 cm apart and 3 m long. The seeding rate was 66 kg/ha. Normal, late and very late seeding dates for both experiments were October 11, October 31, and November 23, respectively, at Manhattan and October 8, November 6, and November 26, respectively, at Hutchinson.

Effect of the different treatments on cold hardiness was determined on plants collected from the Manhattan experiments in mid-January. One gram of seedling crown tissue for each sample was frozen at -15C for 12 hours, thawed at 2C for 12 hours, and then allowed to exosmose into 10 ml of distilled water at 2C for 24 hours. Hardiness was determined as resistance of the solutions of exosmosed electrolytes at 30C (Dexter, Tottingham and Graber, 1932) and as their free amino acids content (Rosen, 1957).

One-meter row-length of seedlings were cut at ground level for plant vigor determination at Hutchinson and Manhattan March 13 and 17, respectively. Samples were weighed, dried at 70C for 48 hours, and reweighed to determine fresh weights, dry weights, and moisture contents.

Two studies in environmental chambers determined effect of phosphorus fertilizer and phosphorus content of seed on germination and vigor of seedlings at low temperature. In the first experiment, phosphorus as triple superphosphate in amounts equivalent to 0, 25, 50 and 100 kg/ha was added to 16-cm-diameter pots containing a mixture of 40% sand and 60% silt. Fifteen seeds of 'Newton' wheat were planted in each pot. Three replications for each group of pots were randomly located in chambers at two temperatures, 10C and 30C. In the second experiment, the same procedure was followed, but the seed source was 'Newton' wheat from the nitrogen-phosphorus fertilizer trial described above. No fertilizer was applied to the soil for the second experiment.

In both experiments, plants were grown under a 16 hr/8 hr light/dark regime for 60 days. At harvest, plants were cut at ground level and oven-dried at 70C for 48 hours. Dry weight and emergence rate were taken as measurements of seedling vigor. Emergence rate was obtained by the relation (Maguire, 1962):

$$\left(\frac{\text{number of normal seedlings}}{\text{days to first count}} + \text{-----} + \frac{\text{number of normal seedlings}}{\text{days to final count}}\right)$$

Analysis of variance and least significant differences (L.S.D.) were calculated in all the experiments (field and chambers) to determine the difference or significance of treatments.

RESULTS

Fresh and dry weights of wheat plants were decreased markedly by seeding at the late and very late dates compared with the normal date (Tables 1 and 2). Nitrogen fertilizer increased fresh and dry weights of seedlings at normal and late seeding dates, but not at the very late seeding date. Phosphorus fertilizer increased vigor of late-seeded wheat grown with nitrogen fertilizer at Manhattan (Table 1) and of normal-seeded wheat grown with nitrogen fertilizer and of late-seeded wheat grown without nitrogen fertilizer at Hutchinson (Table 2).

Plant water content was increased by nitrogen fertilization of late-planted wheat and by phosphorus fertilization of very late planted wheat grown with nitrogen at Manhattan. At Hutchinson, nitrogen without phosphorus increased water content of late-seeded wheat and the highest rate of nitrogen plus phosphorus increased water content of very late seeded wheat.

Fertilizer treatments had little apparent effect on cold hardiness of wheat at Manhattan (Table 3).

Vigor of wheat seedlings grown from six seed lots also decreased as the seedling date was delayed (Tables 4 and 5). High seed nitrogen content enhanced vigor of late-seeded wheat and seedlings from high phosphorus-low nitrogen seed (ON-80 P treatment) displayed more vigor than seedlings from low phosphorus seed (ON-OP treatment) at all seeding dates at Manhattan (Table 4). Seed nutrient content had no discernible effect on plant vigor at Hutchinson (Table 5).

Water content of plants from the different seed lots were similar at Manhattan (Table 4). At Hutchinson plants from the low N-low P seed lots differed significantly at the normal and very late seeding dates, but the order was reversed in the two cases (Table 5).

Specific resistance was generally lower for plants from six late-seeded seed lots than from the normal seeded seed lots, but seed nutrient content had little effect on winterhardiness (Table 6).

Emergence rate and growth of wheat seedlings at different levels of phosphorus fertilization at 10C and 30C are shown in Table 7. Both emergence rate and seedling dry weight were higher at 30C than at 10C. Phosphorus fertilizer increased emergence rate and seedling growth at both temperatures, but the effect of different increments of phosphorus were not significantly different. Emergences and growth of seedlings from the six seed lots from a fertilizer experiment was also greater at 30C than at 10C (Table 8). Seeds from plants fertilized with nitrogen, phosphorus, or both produced more dry weight at both temperatures than seeds from unfertilized plants.

Table 1. Plant weight and water content of 'Newton' wheat grown under six nitrogen-phosphorus fertilizer levels and three seeding dates at Manhattan, Kansas, during 1980-81.

Treatments N	P	Fresh weight	Dry weight	Water content
kg/ha		- - - - - - - -g/m- - - - - - -		%
		Normal seeding date (October 11)		
0	0	65.2	14.1	78.1
0	80	64.2	13.9	78.2
0	160	85.8	19.1	77.6
150	0	108.2	22.1	79.4
150	80	105.6	21.5	79.7
150	160	103.6	21.3	78.2
L.S.D. (5%)		33.6	6.3	2.3
		Late seeding date (October 31)		
0	0	18.8	4.4	76.2
0	80	20.5	4.6	76.8
0	160	19.9	4.4	77.2
150	0	26.6	5.5	79.4
150	80	34.7	7.1	79.3
150	160	32.6	7.2	77.9
L.S.D. (5%)		5.7	1.1	3.1
		Very late seeding date (November 23)		
0	0	5.6	1.0	83.1
0	80	6.2	1.2	81.9
0	160	7.0	1.4	81.3
150	0	6.7	1.4	79.3
150	80	10.4	1.6	80.3
150	160	6.4	1.0	85.6
L.S.D. (5%)		5.1	0.9	6.1

Table 2. Plant weight and water content of 'Newton' wheat grown under six nitrogen-phosphorus fertilizer levels and three seeding dates at Hutchinson, Kansas, during 1980-81.

Treatments N	P	Fresh weight	Dry weight	Water content
kg/ha		- - - - - - - - -g/m-	- - - - - - -	%
		Normal seeding date (October 8)		
0	0	52.8	13.5	74.2
0	80	78.3	20.9	71.6
0	160	77.8	20.2	73.5
150	0	68.5	16.5	75.9
150	80	127.8	27.6	78.3
150	160	148.2	32.3	78.2
L.S.D.	(5%)	29.9	5.4	6.6
		Late seeding date (November 6)		
0	0	13.5	3.9	70.3
0	80	31.2	8.3	74.0
0	160	29.9	7.9	73.2
150	0	30.6	7.5	75.2
150	80	36.3	8.5	75.8
150	160	35.1	8.0	76.9
L.S.D.	(5%)	12.3	3.5	4.4
		Very late seeding date (November 26)		
0	0	7.4	2.6	65.4
0	80	12.8	3.5	72.3
0	160	11.4	3.2	72.7
150	0	7.4	2.3	69.0
150	80	15.5	4.1	73.0
150	160	11.1	3.0	73.3
L.S.D.	(5%)	9.8	1.9	6.5

Table 3. Cold hardiness as conductivity and free amino acids measurement of 'Newton' wheat plants grown under six nitrogen-phosphorus fertilizer levels and three seeding dates, at Manhattan, Kansas, during 1980.

Treatments N	P	Conductivity	Amino acids
		Specific resistance	Optical density
		Normal seeding date (October 11)	
0	0	2150	0.476
0	80	2670	0.724
0	160	2215	0.558
150	0	2195	0.636
150	80	2295	0.631
150	160	2282	0.610
		Late seeding date (October 31)	
0	0	2407	0.547
0	80	2472	0.510
0	160	2380	0.583
150	0	2037	0.638
150	80	2019	0.637
150	160	2191	0.612

Table 4. Plant weight and water content of 'Newton' wheat grown from six seed lots from a fertilizer trial and three seeding dates at Manhattan, Kansas, during 1980-81.

Seed treatments N	P	Fresh weight	Dry weight	Water content
		- - - - - - - g/m - - - - - -		%
		Normal seeding date (October 11)		
0	0	60.8	12.7	79.1
0	80	84.7	17.0	79.9
75	0	68.3	13.8	79.8
75	80	69.2	14.5	79.3
150	0	68.8	14.1	79.6
150	80	73.6	16.1	80.1
L.S.D. (5%)		15.2	2.5	1.3
		Late seeding date (October 31)		
0	0	18.7	3.8	79.6
0	80	25.2	5.3	79.0
75	0	27.0	5.5	79.7
75	80	28.2	5.7	79.6
150	0	25.3	5.0	80.3
150	80	27.3	5.8	78.7
L.S.D. (5%)		5.9	1.4	2.2
		Very late seeding date (November 23)		
0	0	8.6	1.6	81.0
0	80	12.8	2.7	79.2
75	0	10.3	2.1	79.5
75	80	8.6	1.6	81.3
150	0	9.9	1.8	81.6
150	80	9.4	1.7	82.1
L.S.D. (5%)		2.8	0.3	8.4

Table 5. Plant weight and water content of 'Newton' wheat grown from six seed lots from a fertilizer trial, and three seeding dates at Hutchinson, Kansas, during 1980-81.

Seed treatments N	P	Fresh weight	Dry weight	Water content
		- - - - - - - g/m	- - - - - -	%
		Normal seeding date (October 8)		
0	0	46.4	14.2	69.3
0	80	39.7	12.0	70.0
75	0	50.6	14.5	71.4
75	80	59.4	17.9	70.6
150	0	42.3	12.1	70.5
150	80	48.9	13.4	71.8
L.S.D. (5%)		18.2	5.2	2.4
		Late seeding date (November 6)		
0	0	9.9	3.2	67.9
0	80	13.6	4.4	67.4
75	0	10.1	3.8	61.9
75	80	10.9	3.8	65.8
150	0	11.5	3.6	65.5
150	80	11.9	3.4	70.7
L.S.D. (5%)		6.6	2.3	9.3
		Very late seeding date (November 26)		
0	0	5.3	1.5	71.4
0	80	5.9	2.2	62.7
75	0	5.7	1.9	65.9
75	80	5.9	1.8	68.0
150	0	4.5	1.4	69.2
150	80	6.6	2.3	64.2
L.S.D. (5%)		2.1	.8	6.7

Table 6. Cold hardiness as conductivity and free amino acids measurements of 'Newton' wheat plants grown from six seed lots of a fertilizer trial and three seeding dates at Manhattan, Kansas, during 1980.

Seed treatments N	P	Conductivity	Amino acids
		Specific resistance	Optical density
		Normal seeding date (October 11)	
0	0	2897	0.498
0	80	2645	0.466
75	0	2887	0.490
75	80	2867	0.446
150	0	2792	0.476
150	80	2837	0.508
		Late seeding date (October 31)	
0	0	2150	0.429
0	80	1902	0.436
75	0	2067	0.354
75	80	2200	0.441
150	0	2007	0.447
150	80	2637	0.495

Table 7. Effect of temperature and phosphorus fertilization on seedling vigor of 'Newton' wheat.

Phosphorus treatments	Dry weight	Emergence rate
kg/ha	g/15 plants	
	30C temperature	
0	2.9	3.6
25	4.2	6.5
75	4.3	6.0
100	4.5	6.0
L.S.D. (5%)	.5	2.0
	10C temperature	
0	0.9	2.1
25	1.2	2.8
75	1.4	2.8
100	1.2	3.0
L.S.D. (5%)	.2	.6

Table 8. Effect of temperature on seedling vigor of 'Newton' wheat seedlings from six seed lots from a fertilizer experiment.

Seed treatments N	P	Dry weight	Emergence rate
		g/15 plants	
		30C temperature	
0	0	2.1	4.7
0	80	3.6	4.8
75	0	3.8	6.9
75	80	3.8	6.1
150	0	3.0	6.0
150	80	3.1	5.0
L.S.D. (5%)		.6	1.0
		10C temperature	
0	0	1.1	1.7
0	80	2.3	2.2
75	0	2.3	2.4
75	80	2.3	2.7
150	0	2.0	2.0
150	80	2.6	3.2
L.S.D. (5%)		.8	.6

DISCUSSION

The stimulatory effect of fertilization, particularly with nitrogen, on vigor of field-grown winter wheat seedlings was similar to that seen in other studies (Hobbs, 1953; Wahhab and Hussain, 1957; Rhode, 1963, and Spratt, 1974). The adverse effects of late seeding, however, were not overcome by fertilization. The more pronounced effect of fertilization on normal and late seeded wheat than in very late seeded wheat suggested, instead, that other factors limited growth of very late seeded wheat. Low temperature was probably the main factor affecting growth because the very late seeded wheat did not germinate until early spring. The decreased emergence rate and growth of seedlings grown at low temperature in environmental chambers reinforced that conclusion. In both cases, less vigorous seedlings resulted. The effect of low temperature on retarding growth was also observed in other studies (Paulsen, 1968; Flower and Gusta, 1977).

Fertilizer effect was not directly related to cold hardiness of 'Newton' wheat seedlings because the winter season (1980-81) was not severe enough to distinguish between relatively hardy and less hardy plants. Any effect of fertilizer application or nitrogen-phosphorus status of the seed probably was not critical to cold hardening. However, nitrogen and phosphorus fertilizer significantly affected regrowth and vigor of seedlings in the spring as measured by dry matter production.

Altering the nitrogen and phosphorus contents of wheat seed did not consistently modify the adverse effect of late seeding. The positive effect of seed phosphorus content at all seeding dates at Manhattan, and the consistent effect of seed nitrogen and phosphorus contents in the vigor of seedlings grown under controlled environments suggested, however, that these nutrients had some influence.

REFERENCES

1. Dexter, S. T., W. E. Tottingham, and L. F. Graber. 1932. Investigations of the hardiness of plants by measurement of electrical conductivity. Plant Physiol. 7: 63-78.

2. Flower, D. B., and L. V. Gusta. 1977. Influence of fall growth and development on cold tolerance of rye and wheat. Can. J. Plant Sci. 57: 751-755.

3. Freyman, S., and M. S. Kaldy. 1979. Relationship of soil fertility to cold hardiness of winter wheat crowns. Can. J. Plant Sci. 59: 853-855.

4. Hobbs, J. A. 1953. The effect of spring nitrogen fertilization on plant characteristics of winter wheat. Soil Sci. Soc. Amer. Proc. 17: 39-42.

5. Knapp, W. R., and J. S. Knapp. 1978. Response of winter wheat to date of planting and fall fertilization. Agronomy J. 70: 1048-1053.

6. Lopez, A., and D. F. Graber. 1973. Effect of protein content on seed performance in wheat (Triticum aestivum L.). Proc. Assoc. Seed Anal. 63: 106-116.

7. Lowe, L. B., G. S. Ayers, and S. K. Ries. 1972. The relationship of seed protein and amino acid composition to seedling vigor and yield of wheat. Agronomy J. 64: 608-611.

8. Maguire, J. D. 1961. Speed of germination - aid in selection and evaluation for seedling emergence and vigor. Crop Sci. 2: 176-177.

9. Paulsen, G. M. 1968. Effect of photoperiod and temperature on cold hardening in winter wheat. Crop Sci. 8: 29-32.

10. Rhode, C. R. 1963. Effect of nitrogen fertilization on yield, components of yield and other agronomic characteristics of winter wheat. Agronomy J. 55: 455-458.

11. Rosen, H. 1957. A modified ninydrin colorimetric analysis for amino acids. Arch. Biochem. Biophys. 67: 10-15.

12. Schweizer, C. J., and S. K. Ries. 1969. Protein content of seed; increase improves growth and yield. Science 165: 73-75.

13. Spratt, E. D. 1974. Effect of ammonium and nitrate forms of fertilizer-N and their time of application on utilization of N by wheat. Agronomy J. 66: 57-61.

14. Wahhab, A., and I. Hussain. 1957. Effect of nitrogen on growth, quality, and yield of irrigated wheat in West Pakistan. Agronomy J. 49: 116-119.

15. Worzella, W. W., and G. H. Cutler. 1941. Factors affecting cold resistance in winter wheat. J. Amer. Soc. Agron. 33: 221-230.

EFFECT OF SEED PROTEIN CONTENT AND SOWING DEPTH
ON SEEDLING VIGOR OF WHEAT (TRITICUM AESTIVUM L.)

INTRODUCTION

Seeding depth of wheat (triticum aestivum L.) is usually increased when soil surface moisture is deficient, a common occurrence in major production areas. Seedlings from deep-planted seeds are usually weak and frequently fail to emerge, resulting in poor plant stands and low grain yields. The problem is particularly severe in semi-dwarf wheat varieties because of their generally shorter coleoptile (Allan et al., 1962; Sunderman, 1963; Evans and Bhatt, 1977).

The greater seedling vigor and yield potential of wheat plants from large seeds compared with plants from small seeds was recognized early by Kiesselboch (1924) and more recently by Austenson and Walton (1970) and Grabe (1976). The effect of seed size on seedling vigor from deep-planted seeds has been studied in other crops (Rogler, 1954; Beveridge and Wilsie, 1959; Harper and Obeid, 1967). Evans and Bhatt (1977) also reported that seed size influenced seedling vigor in several bread wheat cultivars regardless of seeding depth or harvesting method.

Recent studies related seed protein content with both seedling vigor and grain yield (Lopez and Grabe, 1971; Lowe et al., 1972; Lowe and Ries, 1972, 1973). A direct relationship between seed size and seed protein content was also established. Ries and Everson (1973) indicated that large seeds produced larger seedlings because they contained more protein. It is clear that seed source, particularly as it affects protein content, is important to stand establishment of seedlings. No research to date, however, has determined if increased protein content of wheat seeds can improve the emergence of seedlings from deep planting. The objective of this study was to determine the relationship of seed protein content and depth of seeding on the seedling vigor of three wheat varieties.

MATERIALS AND METHODS

Effect of seed protein content on emergence of wheat seedlings from different planting depths was studied in three wheat (*Triticum aestivum* L.) varieties obtained from a fertilizer field trial with three nitrogen rates conducted during the 1979 season (Table 1). Two studies in environmental chambers and one study in a greenhouse were conducted. Each of the nine seed lots was planted at four different seeding depths, 4, 8, 12 and 16 cm, for each of the three studies. The experiments in environmental chambers were conducted under a 16 hr/8 hr light/dark regime and an average temperature of 24C. Seedlings were grown in plastic containers 22 cm deep and 40 cm square; sand was the growth medium in one experiment and a mixture of 40% sand and 60% silt was the medium in the other experiment. Seeds for each protein-depth treatment for each variety were planted 10 per row, 1.5 cm apart in rows 10 cm apart. No fertilizer was used.

The third experiment, conducted in the greenhouse, also had a 16 hr/8 hr light/dark regime but temperature was not controlled. The growing medium was a mixture of 40% sand and 60% silt fertilized with ammonium nitrate at the rate of 200 kg/ha. Each 9-cm-diameter pot contained 20 seeds of one variety.

The experimental design used in all experiments was a split-plot with three replications; varieties were whole plots and protein content and seeding depth were subplots. Plants were harvested 35 days and 60 days after planting in environmental chambers and the greenhouse, respectively, by cutting them at ground level and oven-drying them at 70C for 48 hours. Dry weight of shoots and emergence rate (Maguire, 1962) were used to evaluate seedling vigor. Emergence rate was calculated as:

$$\left(\frac{\text{number of normal seedlings}}{\text{days to first count}} + \text{-----} + \frac{\text{number of normal seedlings}}{\text{days to final count}}\right)$$

Analysis of variance was used to examine effect of seed protein and seedling depth. Least significant differences (L.S.D.) were calculated to detect differences in dry weight and emergence rate among treatments at the 10% probability level.

RESULTS

Emergence rate and dry weight of seedlings of all three varieties decreased markedly as seeding depth increased (Table 2). Differences were greatest in 'Eagle' and 'KS73256' varieties. Only a few seedlings of any of the varieties emerged from 12- or 16-cm depths; they were extremely chlorotic, weak, and died soon after emerging.

Seedling dry weight increased as the amount of nitrogen fertilizer applied to parent plants increased from 0 to 120 kg/ha in all the varieties except 'KS73256' at the 8-cm depth. Fertilizing parent plants with nitrogen had little effect on germination rate, decreasing it in one case in 'Eagle' and increasing it in 'Clark's Cream' at the 4- and 8-cm depths and in 'Eagle' at the 8-cm depth.

The tendency of germination rate and seedling dry weight to decrease as seeding depth increased was also observed in all varieties in the second study (Table 3). Seedling dry weight increased in some cases as the amount of nitrogen fertilizer applied to the parent plants increased: 'Clark's Cream' and 'Eagle' at the 8-cm depth and all three varieties at the 4-cm and 12-cm depths. Germination rates of 'Eagle' and 'KS73256' at the 4-cm and 12-cm depths and 'Clark's Cream' at the 8-cm depth were increased by applying nitrogen fertilizer to the parent plants.

The negative effect of seeding depth and the positive effect of protein content on seedling weights after emergence from 4-cm and 8-cm depths were also evident in the third experiment (Table 4). 'Clark's Cream' seedlings failed to emerge from the 12-cm depth and protein content had no effect on dry weight of seedlings of 'KS73256' varieties that emerged from that depth. None of the varieties emerged from the 16-cm depth.

Table 1. Seed protein content of 'Clark's Cream,' 'Eagle' and 'KS73256' wheat varieties from three nitrogen fertilizer rates.

	Varieties		
N	Clark's Cream	Eagle	KS73256
kg/ha	- - - - - - - - - - - % protein - - - - - - - - - - -		
0	11.2	10.4	10.6
60	13.0	12.0	12.8
120	13.0	13.1	13.4

Table 2. Dry weight and emergence rate of 'Clark's Cream,' 'Eagle' and 'KS73256' wheat seedlings grown under two seeding depths (seed source from three nitrogen levels of a fertilization trial).

Seed Protein Content	4 cm Depth		8 cm Depth	
	Dry weight	Emergence rate	Dry weight	Emergence rate
%	g/10 plants		g/10 plants	
		Clark's Cream		
11.2	0.97	5.89	1.08	3.57
13.0	1.33	6.95	1.31	5.32
13.0	1.85	6.77	1.37	5.60
		Eagle		
10.4	1.32	6.84	0.70	1.69
12.0	1.42	5.49	0.88	1.65
13.1	1.67	6.85	1.19	2.74
		KS73256		
10.6	1.22	5.48	0.62	0.94
12.8	1.47	6.32	1.02	1.41
13.4	1.54	5.78	0.83	1.71
L.S.D. (10%)	.19	.90	.22	1.04

Table 3. Dry weight and emergence rate of 'Clark's Cream,' 'Eagle,' and 'KS73256' wheat grown of seed source from a fertilizer trial. Means from three nitrogen fertilizer levels at three seeding depths.

	4 cm Depth		8 cm Depth		12 cm Depth	
Seed Protein Content	Dry weight	Emergence rate	Dry weight	Emergence rate	Dry weight	Emergence rate
%	g/10 plants		g/10 plants		g/10 plants	
			Clark's Cream			
11.2	1.35	5.04	0.96	2.12	0.15	0.23
13.0	1.53	5.01	1.33	2.69	0.14	0.33
13.0	1.52	4.99	1.01	2.83	0.45	0.39
			Eagle			
10.4	1.25	4.67	0.93	2.91	0.17	0.17
12.0	1.53	4.57	1.06	2.96	0.55	0.55
13.1	1.57	5.37	1.32	3.10	0.90	0.85
			KS73256			
10.6	1.31	3.72	0.66	3.19	0.12	0.98
12.8	1.46	5.23	0.79	2.67	0.35	0.94
13.4	1.52	5.53	0.98	2.65	0.57	1.57
L.S.D. (10%)	.18	.59	.27	.65	.20	.59

Table 4. Dry weight of 'Clark's Cream,' 'Eagle' and 'KS73256' wheat seedlings grown under three seeding depths (seed source from three nitrogen levels of a fertilization trial).

Seed Protein Content	4 cm depth Dry weight	8 cm depth Dry weight	12 cm depth Dry weight
%	g/20 plants	g/20 plants	g/20 plants
	Clark's Cream		
11.2	3.14	3.13	--
13.0	4.54	3.03	--
13.0	4.67	3.14	--
	Eagle		
10.4	3.93	2.78	0.57
12.0	4.62	3.34	1.09
13.1	4.89	3.80	1.11
	KS73256		
10.6	3.00	2.53	0.55
12.8	4.39	3.87	0.79
13.4	5.30	4.96	1.04
L.S.D. (10%)	.58	.53	.50

DISCUSSION

Dry weight and emergence rate were significantly reduced by increasing depth of seeding of wheat as previously demonstrated with other crops (Erikson, 1946; Lawrence, 1956; Beveridge and Wilsie, 1960; Harper and Obeid, 1967). Conversely, high protein content frequently positively influenced seedling vigor as indicated by higher dry weight. In most cases, seedlings from seed with the highest protein content had higher dry weight, showing that detrimental effects of deep seeding can be counteracted. Thus, the results of Schweizer and Ries (1967), Lowe, Ayres and Ries (1972), Lopez and Grabe (1973), Lowe and Ries (1973) and Ries and Everson (1973), which were obtained at only one seeding depth, are applicable to deep seeding. Moreover, seedlings from high protein seeds often emerged as well from 8-cm as seedlings from low protein seeds emerged from 4-cm.

The effect of protein content of seed on the rate of emergence was less pronounced, but still substantial. It seemed to be associated also with genetic factors (Lawrence, 1956; Allan et al., 1962), and it was observed mainly in'KS73256,' a semi-dwarf variety, in contrast to the tall stature of the other varieties. Semi-dwarf varieties generally emerge poorly when planted deeply due to their short coleoptile (Allan et al., 1962; Evans and Bhatt, 1977). Undoubtedly, rapid germination aids establishment after deep seeding because fewer seed reserves are expended in respiration.

These investigations suggest that adverse situations that necessitate deep seeding might be alleviated by producing seed under conditions that increase its ability to germinate and emerge as vigorous seedling. Nitrogen fertilization of parent plants is a relatively economic way of producing this improved seed.

REFERENCES

1. Allan, R. E., O. A. Vogel, and C. J. Peterson Jr. 1962. Seedling emergence rate of fall-sown wheat and its association with plant height and coleoptile length. Agronomy J. 54: 347-350.

2. Austenson, H. M., and P. D. Walton. 1970. Relationships between initial seed weight and mature plant characters in spring wheat. Can. J. Plant Sci. 50: 53-58.

3. Beveridge, J. L., and C. P. Wilsie. 1959. Influence of depth of planting, seed size, and variety on emergence and seedling vigor in alfalfa. Agronomy J. 51: 731-734.

4. Erickson, L. C. 1946. The effect of alfalfa seed size and depth of seeding upon the subsequent procurement of stand. J. Amer. Soc. Agron. 38: 964-973.

5. Evans, L. E., and G. W. Bhatt. 1977. Influence of seed size, protein content, and cultivar on early seedling vigor in wheat. Can. J. Plant Sci. 57: 929-935.

6. Grabe, D. 1976. Bigger is better . . . in wheat seed. Oregon's Agricultural Progress 23(1): 15.

7. Harper, J. L., and M. Obeid. 1967. Influence of seed size and depth of sowing on the establishment and growth of varieties of fibre and oil seed flax. Crop Sci. 7: 527-532.

8. Kiesselbach, T. A. 1924. Relation of seed size to the yield of small grains. Agronomy J. 16: 670-682.

9. Lawrence, T. 1957. Emergence of intermediate wheat grass lines from five depths of seeding. Can. J. Plant Sci. 37: 215-219.

10. Lopez, A., and D. F. Grabe. 1973. Effect of protein content on seed performance in wheat (Triticum aestivum L.). Proc. Assoc. Seed Anal. 63: 106-116.

11. Lowe, L. B., G. S. Ayers, and S. K. Ries. 1972. The relationship of seed protein and amino acid composition to seedling vigor and yield of wheat. Agronomy J. 64: 608-611.

12. Lowe, L. B., and S. K. Ries. 1972. Effects of environment on the relationship between seed protein and seedling vigor in wheat. Can. J. Plant Sci. 52: 157-164.

13. Lowe, L. B., and S. K. Ries. 1973. Endosperm proteins of wheat seed as a determinant of seedling growth. Plant Physiol. 51: 57-60.

14. Maguire, J. D. 1961. Speed of germination - Aid in selection and evaluation for seedling emergence and vigor. Crop Sci. 2: 176-177.

15. Ries, S. K., and E. H. Everson. 1973. Protein content and seed size relationship with seedling vigor of wheat cultivars. Agronomy J. 65: 884-886.

16. Rogler, G. A. 1954. Seed size and seedling vigor in crested wheat grass. Agronomy J. 46: 216-220.

17. Schweizer, C. J., and S. K. Ries. 1969. Protein content of seed; increase improves growth and yield. Science 165: 73-75.

18. Sunderman, D. W. 1963. Seedling emergence of winter wheats and its association with depth of sowing, coleoptile length under various conditions and plant height. Agronomy J. 55: 23-25.

APPENDIX

Table I. Analysis of variance table for the dependent variable, dry weight, from six nitrogen-phosphorus fertilizer levels and three seeding dates experiment at Manhattan.

Source	DF	SS	F Value	PR F
Nit	1	135.35	22.12	0.0001
Phos	2	12.77	1.04	0.3604
Nit*Phos	2	13.70	1.12	0.3351
SDate	2	3960.22	323.64	0.0001
Nit*SDate	2	102.69	8.39	0.0008
Phos*SDate	4	21.38	0.87	0.4871
Nit*Phos*SDate	4	33.21	1.36	0.2637
Rep (SDate)	9	196.98	3.58	0.0020
Error	45	275.32		

Table II. Analysis of variance table for the dependent variable, dry weight, from six nitrogen-phosphorus fertilizer levels and three seeding dates experiment at Hutchinson.

Source	DF	SS	F Value	PR F
Nit	1	5833.9	35.2	0.0001
Phos	2	6829.9	20.5	0.0001
Nit*Phos	2	514.2	1.5	0.2242
SDate	2	86240.7	259.9	0.0001
Nit*SDate	2	6542.9	19.7	0.0001
Phos*SDate	4	5860.7	8.8	0.0001
Nit*Phos*SDate	4	2582.0	3.8	0.0089
Rep (SDate)	9	2437.2	1.6	0.1373
Error	42			

Table III. Analysis of variance table for the dependent variable, dry weight, from six seed lots from a fertilizer trial and three seeding dates experiment at Manhattan.

Source	DF	ANOVA SS	F Value	PR F
Nit	2	0.8	0.3	0.7372
Phos	1	21.9	16.5	0.0002
Nit*Phos	2	13.5	5.1	0.0100
SDate	2	2113.7	797.7	0.0001
Nit*SDate	4	9.2	1.7	0.1564
Phos*SDate	2	15.4	5.8	0.0056
Nit*Phos*SDate	4	3.6	0.6	0.5997
Rep10 (SDate)	9	29.1	2.4	0.0231
Error	45	2267.2		

Table IV. Analysis of variance table for the dependent variable, dry weight, from a fertilizer trial and three seeding dates experiment at Hutchinson.

Source	DF	ANOVA SS	F Value	PR F
Nit	2	21.6	2.2	0.1202
Phos	1	5.7	1.1	0.2819
Nit*Phos	2	4.6	0.4	0.6230
SDate	2	2055.4	210.8	0.0001
Nit*SDate	4	36.4	1.8	0.1322
Phos*SDate	2	0.7	0.0	0.9306
Nit*Phos*SDate	4	29.9	1.5	0.2072
Rep10 (SDate)	9	68.5	1.5	0.1559
Error	45	2086.8		

Table V. Analysis of variance table for the dependent variable, dry weight, from a phosphorus fertilizer-temperature experiment at controlled environment.

Source	DF	ANOVA SS	F Value	PR F
Temp	1	44.9	538.7	0.0001
Rep (Temp)	4	0.2	0.7	0.5738
Phos	3	3.2	12.9	0.0005
Phos*Temp	3	0.6	2.4	0.1177
Error	12	50.0		

Table VI. Analysis of variance table for the dependent variable, dry weight, from a six seed lot from a fertilizer trial and two temperatures at controlled environment.

Source	DF	ANOVA SS	F Value	PR F
Nit	2	3.5	11.70	0.0004
Phos	1	2.9	19.88	0.0002
Nit*Phos	2	3.1	10.48	0.0008
Temp	1	11.9	79.62	0.0001
Nit*Temp	2	0.8	2.76	0.0872
Phos*Temp	1	0.0	0.12	0.7376
Nit*Phos*Temp	2	0.2	0.70	0.5093
Rep (Temp)	4	1.2	2.16	0.1104
Error	21	26.9		

Table VII. Analysis of variance tables for the variable, dry weight, of three varieties with three nitrogen levels from a fertilization trial and four seeding depths in controlled environments.

VII-1.

Source	DF	ANOVA SS	F Value	PR F
Variety	2	0.3	2.1	0.1303
Protein	2	1.6	9.5	0.0005
Variety*Protein	4	0.3	0.8	0.4847
Depth	1	2.3	28.1	0.0001
Variety*Depth	2	0.5	3.3	0.0460
Protein*Depth	2	0.1	0.7	0.4733
Variety*Protein*Depth	4	0.2	0.6	0.6205
Rep	2	9.9	58.1	0.0001
Error	34	18.4		

VII-2.

Source	DF	ANOVA SS	F Value	PR F
Variety	2	0.3	2.3	0.1085
Protein	2	1.5	10.1	0.0002
Variety*Protein	4	0.2	0.6	0.6101
Depth	2	15.5	100.9	0.0001
Variety*Depth	4	0.4	1.5	0.1916
Protein*Depth	4	0.0	0.2	0.9275
Variety*Protein*Depth	8	0.1	0.2	0.9901
Rep	2	0.9	6.0	0.0043
Error	51	19.3		

VII-3.

Source	DF	ANOVA SS	F Value	PR F
Variety	2	4.8	5.6	0.0062
Protein	2	14.7	17.1	0.0001
Variety*Protein	4	3.6	2.1	0.0934
Depth	2	192.2	223.5	0.0001
Variety*Depth	4	12.6	7.3	0.0001
Protein*Depth	4	3.9	2.2	0.0722
Variety*Protein*Depth	8	2.8	0.8	0.5893
Rep	2	3.7	4.4	0.0171
Error	52	22.3		

EFFECT OF NITROGEN AND PHOSPHORUS STATUS OF SEED ON SEEDLING TRAITS OF WINTER WHEAT (*TRITICUM AESTIVUM* L.)

by

JOSE LUIS TORRES ROMERO

Agricultural Engineer, Universidad del Zulia, Venezuela, 1973

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Fields and controlled environment studies were conducted to determine the effect of nitrogen and phosphorus status of seeds and of fertilization with the two nutrients on seedling vigor of winter wheat. Six lots of 'Newton' wheat seeds from a nitrogen x phosphorus fertilizer trial the preceding year and six nitrogen and phosphorus fertilizer levels were used as treatments in separate experiments at Manhattan and Hutchinson, Kansas, during 1980-1981. Normal and late seeding dates were used to differentially stress the plants.

Vigor of seedlings decreased as seeding date was delayed. Fertilization with nitrogen and/or phosphorus and increasing the seed content of these nutrients frequently, but inconsistently, counteracted the deleterious effect of late planting. Phosphorus and nitrogen fertilizer, however, positively affected regrowth and vigor of seedlings in the spring. Seed phosphorus content also enhanced spring growth at all seeding dates at Manhattan.

In controlled environments, phosphorus fertilizer increased emergence rate and growth of wheat seedlings at both low and normal temperatures. Similarly, increasing the nitrogen and phosphorus content of the seed frequently increased seed emergence rate and seedling vigor. In both cases, the effect was more pronounced at 30C than at 10C.

In the second part of this research, the relationship of seed protein content and depth of seeding on emergence rate and seedling vigor was studied in three wheat varieties, 'Clark's Cream,' 'Eagle' and 'KS73256,' obtained from a fertilizer trial with three nitrogen rates the previous year. Four different seeding depths, 4, 8, 12 and 16 cm, were used for each study.

Two experiments in environmental chambers and one experiment in a greenhouse indicated that emergence rate and dry weight of seedlings decreased markedly as seeding depth increased. At 4-cm depth, seedling dry weight increased as the amount of nitrogen fertilizer applied to parent plants increased from 0 to 120 kg/ha in all varieties. In some cases, high protein content seed improved emergences of seedlings from 8-cm depth. Seed nutrient content did not affect emergence from 12-cm depth; seedlings did not emerge in any case from 16-cm.