Effect of Planting Depth on Seedling Growth of Russian Wildrye (*Elymus junceus* Fisch.)

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Highlight: *Planting depth of Russian wildrye (*Elymus junceus* Fisch.) influenced seedling growth during the seedling year. In field plantings over 4 years at two locations, plants from 2.5- and 3.8-cm planting depths were significantly taller than plants from the 1.3-cm depth. In greenhouse plantings, plants from 3.8-cm planting depth were consistently taller than plants from the 1.3-cm depth, but the plants from the 1.3-cm depth generally produced more tillers. Transplants with crowns set 1.3 cm deep produced more tillers than those with crowns set 3.8 cm deep. Depth of transplanting had no effect on height of plants. The height difference between plants planted at different depths apparently resulted from some form of seedling selection at greater depths, but the number of tillers probably was determined by crown depth alone. Grass breeders using planting depth to evaluate seedling vigor may be inadvertently selecting for taller plants. Weight per plant tended to be higher for the 1.3-cm planting depth than for the 3.8-cm depth, but this effect was not consistent.*

The effects of planting depth on subsequent growth of the grass plant have received little attention. Planting depth affects the number of seedlings that emerge and become established (Plummer, 1943; McGinnies, 1973), and the effect of planting depth on emergence has been used as a measure of vigor (Rogler, 1954). Depth of the crown, growth habit, and number of tillers are influenced by planting depth in several grasses and cereal grains (Evans, 1958; Taylor and McCall, 1936).

While conducting a previously reported study of the effect of planting depth on seedling establishment (McGinnies, 1973), I observed that the height of seedlings measured in the fall increased as the planting depth increased. Because planting depth also affected seedling numbers and because the density of the seedlings in turn could have affected seedling height, additional studies of planting depths were conducted in a greenhouse where growing space per plant could be kept constant. This paper reports results from the field study and the three greenhouse studies. In all cases, data have been limited to those obtained with Russian wildrye (*Elymus junceus* Fisch.) because it remained vegetative and did not produce any seedstalks during the seedling year. In species that produced seedstalks in the seedling year (crested wheatgrass [*Agropyron desertorum* (Fisch.) Schult.] and pubescent wheatgrass [*A. trichophorum* (Link) Richt.]), some individual plants produced seedstalks whereas others did not, and this increased the variability of the data so much that statistically meaningful conclusions concerning the two wheatgrasses would be difficult to obtain. However, the general effect of planting depth on plant height appeared to be the same for the two wheatgrasses as for Russian wildrye.

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Field Planting

Methods and Materials

"Vinall" Russian wildrye was planted at depths of 1.3, 2.5, and 3.8 cm (.5, 1.0, and 1.5 inches) on five dates each spring, 1967 through 1970, at the Fort Collins Experimental Range north of Fort Collins, and on four dates each spring at Central Plains Experimental Range (CPER) north of Nunn, Colorado. At Fort Collins, the soil is a Larimer gravelly loam and precipitation averages 38 cm annually; at CPER the soil is a Vona sandy loam and precipitation averages 30 cm. All planting was at a rate of 50 live seeds/m of row in rows 6.1 m (20 ft) long and 46 cm (18 inches) apart. Seedling counts of 3.05 m (10 ft) of row and height measurements of the tallest plants were made in September of the year of seeding. There were six replications at Fort Collins and 4 at CPER.

Results and Discussion

At both CPER and Fort Collins, seedlings from the 2.5-cm planting depth were significantly taller than those planted 1.3 cm deep (Table 1). There was no difference in number of seedlings/m between these two planting depths at either location. Seedlings from the 3.8-cm planting depth were significantly taller than those from the 1.3-cm planting depth, and the number of seedlings/m from the 3.8-cm planting depth was significantly lower than the number from the 1.3-cm depth. The difference in height between plants

Table 1. Field Planting. Height (cm) and number (no/m of row) of Russian wildrye seedlings in September of the seedling year when planted at three depths.

Location and year of seeding		Plant height by planting depth (cm) 1.3	2.5	3.8	$LSD_{.05}$	Number of seedlings by planting depth (cm) 1.3	2.5	3.8	$LSD_{.05}$
Fort Collins	1967	22.9	25.6	24.6		19.7	19.0	10.5	
	1968	16.2	19.6	21.8		13.4	13.8	6.9	
	1969	11.4	14.7	17.3		17.7	16.1	9.8	
	1970	20.1	23.4	24.1		9.8	11.5	5.6	
	Mean	17.7	20.8	21.9	1.8	15.1	15.1	8.2	2.0
CPER[1]	1967	10.7	12.2	13.2		18.0	14.8	7.9	
	1968	8.6	10.9	13.5		12.1	16.4	9.8	
	1969	7.4	9.4	12.7		14.4	11.8	4.9	
	1970	11.4	13.2	14.7		10.8	10.8	4.6	
	Mean	9.5	11.4	13.5	1.2	13.8	13.4	6.8	3.5

[1] Central Plains Experimental Range.

from the 1.3- and 3.8-cm planting depths could have been either the result of more growing space per plant in the less dense stands at 3.8 cm (McGinnies, 1970 and 1971) or some other factor associated with the deeper planting depth. However, because planting depth caused the plants to be taller from the 2.5-cm than from the 1.3-cm depth and because there were no differences in seedling densities between these two depths, planting depth alone probably caused the differences in plant height.

Table 2. Greenhouse Study No. 1. Plant height (cm), number of tillers, and plant weight (g) of Russian wildrye planted at 2 depths (cm).[1]

Date of harvest	Planting depth 1.3	3.8	$LSD_{.05}$
Plant height			
Oct. 15[2]	49.6	51.7	
Dec. 1	45.9	55.8	
Jan. 12	48.7	55.2	
Feb. 3	49.5	52.7	
Apr. 22	49.3	56.1	
Jun. 2	55.5	60.2	
Mean	49.8	55.3	3.0
Number of tillers			
Dec. 1	23.4	17.3	
Jan. 12	22.9	15.4	
Feb. 3	26.8	21.0	
Apr. 22	32.1	27.6	
Jun. 2	44.4	34.4	
Mean	29.9	23.1	2.6
Plant weight			
Dec. 1	2.0	1.9	
Jan. 12	2.1	2.3	
Feb. 3	3.7	3.5	
Apr. 22	6.7	6.6	
Jun. 2	10.3	9.5	
Mean	5.0	4.8	ns

[1] Planted May 20.
[2] Height of tallest plant in pot on October 15. Plants thinned to 1 plant per pot by removing all but the tallest plant on Oct. 15.

Greenhouse Planting No. 1

Methods and Materials

To eliminate the effects of competition between individual plants that resulted from differences in plant density in field plantings, a greenhouse study was made with one Russian wildrye plant per pot. Twenty 20-cm-diameter plastic pots were filled with a soil-peat mix. Ten pots were planted with five seeds each at a 1.3-cm depth, and 10 pots were planted with five seeds each at a 3.8-cm depth on May 20, 1970. On October 15, plants were thinned to one plant per pot; the tallest plant was retained in each pot. Maximum plant heights, active tiller counts, and weights per plant were obtained on December 1, 1970, January 12, February 3, April 22, and June 2, 1971.

Results and Discussion

Plants from the 3.8-cm planting depth were consistently taller than those from the 1.3-cm depth, and the average difference in height was significant (Table 2). The number of active tillers per pot was consistently greater for the 1.3-cm planting depth than for the 3.8-cm depth. Weight per plant was slightly higher for the 1.3-cm planting depth than for the 3.8 cm depth, but the differences between planting depths were not consistent and the average yields did not differ significantly.

This greenhouse planting showed that planting depth did indeed affect plant height, and also the number of tillers.

Greenhouse Planting No. 2

Methods and Materials

Because Rogler (1954) and others have suspected planting depth of exerting a geneticially selective action on seedling vigor, I needed to eliminate any effects depth of planting might have had on the selection of the genotypes that emerged and became established. To do this, I used a "two-stage" planting system in which the seed was planted 1.3 cm deep, the seedlings were permitted to grow for about 1 month until they averaged 10 cm tall, and then an additional 2.5 cm soil was added to the pots so that the original seed location was now 3.8 cm below the soil surface. Plantings also were made 1.3 and 3.8 cm deep. Ten 20-cm pots were planted with five seeds each at each depth (1.3 cm, 3.8 cm, and two-stage) on January 22, 1971. All treatments were thinned on one plant per pot on March 12. Plant heights, number of tillers, and weights per plant were obtained from all pots on April 21, June 28, September 3, October 18, and December 13.

Results and Discussion

Plants from the 3.8-cm planting depth were consistently taller than those from the 1.3-cm depth (Table 3). On the average, plants from the two-stage planting were taller than those from the 1.3-cm depth, but differences were not so consistent as from the 3.8-cm depth. The number of tillers per plant was significantly greater for the 1.3-cm planting depth than for the other two depths on the first three sampling dates, but the

Table 3. Greenhouse Study No. 2. Plant height (cm), number of tillers, and plant weight (g) of Russian wildrye planted by 3 treatments.

Date of harvest	Treatment A[1]	B[1]	C[1]	$LSD_{.05}$
Plant height				
Apr. 21	42.8	47.6	46.5	ns
Jun. 28	42.6	46.8	49.6	5.6
Sep. 3	32.8	37.7	37.9	3.7
Oct. 18	26.0	24.7	27.6	ns
Dec. 13	34.8	36.6	37.3	ns
Mean	35.8	38.7	39.8	2.9
Number of tillers				
Apr. 21	10.3	6.5	6.6	2.4
Jun. 28	25.9	15.9	18.0	5.3
Sep. 3	130.0	72.8	85.4	24.0
Oct. 18	168.2	139.6	152.7	ns
Dec. 13	158.1	127.1	140.6	ns
Mean	98.5	72.4	80.7	19.9
Plant weight				
Apr. 21	1.5	0.9	1.1	0.2
Jun. 28	4.3	3.1	3.6	0.5
Sep. 3	11.6	9.3	9.9	1.4
Oct. 18	12.7	10.6	11.7	0.8
Dec. 13	10.8	9.8	11.0	ns
Mean	8.2	6.7	7.5	1.2

[1] Planted Jan. 22, 1971.
Treatment A = seed planted 1.3 cm deep.
Treatment B = seed planted 1.3 cm deep; on Feb. 22 after seedling emergence, another 2.5 cm of soil added.
Treatment C = seed planted 3.8 cm deep.

differences became relatively less on the last two dates. When the five harvest dates were averaged, the number of tillers differed significantly between the 1.3-cm and two-stage depths, but not between the 1.3- and 3.8-cm depths. Weight per plant from the 1.3-cm planting depth was significantly higher than from the other two planting depths for the first four dates of measurement; but when all dates were averaged, weight per plant differed significantly between the 1.3-cm depth and the two-stage depth, but not between the 1.3- and the 3.8-cm depth.

The data, particularly from the October 18 and December 13 sampling dates, preclude definite conclusions concerning genetic selection resulting from planting depth. The plants from the two-stage depth did not differ significantly from plants from the 3.8-cm depth in average plant height, number of tillers, or weight per plant. Height, number of tillers, and weight per plant of plants from the two-stage depth were much nearer to those from the 3.8-cm-depth plants than to those from the 1.3-cm-depth plants. Plants from the two-stage depth emerged initially from a 1.3-cm depth but then behaved more like the plants that emerged from a 3.8-cm depth than those that remained growing at a 1.3-cm depth. I assumed that either (1) planting depth (final depth, in the case of the two-stage depth) had influenced height, number of tillers, and weight per plant more than any genetic selection that might have resulted from planting depth, or (2) some type of selection took place after the additional 2.5 cm of soil was added to the two-stage depth.

In general, the relative differences in height, number of tillers, and weight per plant became smaller on the last two measurement dates. This indicates that as the plants became older, the effect of planting depth on the individual plants was gradually reduced.

Greenhouse Planting No. 3

Methods and Materials

In another approach toward eliminating any effects on genetic selection that planting depth may have had, clones from 1-year-old field-grown plants were transplanted into 20-cm pots in the greenhouse on December 21, 1971. The clones were set in the pots so that the tillering buds (crowns) were either 1.3 or 3.8 cm below the soil surface. (The planting depth in the field had been 2.5 cm.) Ten pots were used for each depth, one clone per pot, and each plant was divided so that an equal number of clones were placed in each depth treatment. Plant height, number of active tillers, and weight per plant were measured March 28, May 26, July 12, and August 24, 1972.

Table 4. Greenhouse Study No. 3. Plant height (cm), number of active tillers, and plant weight (g) of Russian wildrye transplants planted with crowns placed at 2 depths (cm).[1]

	Crown depth		
Date of harvest	1.3	3.8	$LSD_{.05}$
Plant height			
Mar. 28, 1972	57.6	59.4	
May 26, 1972	69.4	67.0	
Jul. 12, 1972	74.7	67.2	
Aug. 24, 1972	70.7	69.9	
Mean	68.1	65.9	ns
Number of tillers			
Mar. 28, 1972	61.0	38.4	
May 26, 1972	100.4	66.3	
Jul. 12, 1972	187.2	91.7	
Aug. 24, 1972	221.0	110.4	
Mean	142.4	76.7	32.2
Plant weight			
Mar. 28, 1972	4.9	3.8	
May 26, 1972	21.0	18.1	
Jul. 12, 1972	29.3	24.8	
Aug. 24, 1972	25.4	21.3	
Mean	20.1	17.0	ns

[1] Transplanted Dec. 21, 1971.

Results and Discussion

There were no significant differences in maximum plant height or weight per plant attributable to the depth at which the tillering buds (crowns) were located (Table 4). Although the differences were not significant, weight per plant tended to be higher for the 1.3-cm depth. This result agrees with trends observed in the other greenhouse studies. The number of tillers per plant averaged 78% more for those plants with crowns set 1.3 cm deep than those with crowns set 3.8 cm deep.

Conclusions

A method commonly used by grass breeders to test plant materials for high seedling vigor is to plant the seed at a greater than optimum depth. The assumption is that the greater the seedling vigor, the higher the number of seedlings that will emerge and become established. However, the results of the studies reported here indicate that greater depths of planting tend to select toward taller plants. Thus, it is possible that if a grass breeder has used deep planting to screen for seedling vigor, he may also be selecting for taller plants. This may explain in part why some grass varieties that were developed for high seedling vigor have also shown excellent growth characters as mature plants.

Field stands of grass planted at a greater depth (3.8 cm, for example) will probably produce stands of taller plants, but the deeper planting will also produce sparser stands and the seeding rate will have to be increased to compensate. On the other hand, shallower planting depths produce denser stands that have more tillers per plant and in turn may produce more ground cover during the early life of the seeded stand.

Plant height and number of tillers are commonly used as measures of vigor in seeded stands. Because both of these measures can be affected by planting depth, they probably should not be used as a measure of vigor for any seeded stand where depth of planting is intentionally or accidentally a variable.

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