The Effect of Seeding Depth on Crown Location, Plant Development, Cold Hardiness and Yield in Winter Wheat.

Heather Loeppky and Guy Lafond
Indian Head Experimental Farm
Indian Head, Saskatchewan SOG 2KO

Brian Fowler
Crop Development Centre
University of Saskatchewan
Saskatoon, Saskatchewan S7N OWO

1.0 Introduction

Seeding depth affects yield of winter wheat through its influence on both emergence and plant development. According to the literature, optimum seeding depth varies with moisture availability but in general, deep planting results in lower emergence rates, reduced tillering per plant, increased disease incidence and winter injury (Ashrof and Taylor, 1974; Hadjichristodoulou et al., 1974; Tinline, 1981). Crown location in relation to the seed and soil surface is an important factor (Taylor and McCall, 1936) thus the effect of seeding depth on yield may be modified by variations in the length of the subcrown internode.

The subcrown internode is the internode between the seed (or basal attachment of the coleoptile) and the first node of the crown. The first node of the crown generally corresponds to the first foliar leaf but it may correspond to the second, third or even fourth (Taylor and McCall, 1936). In shallow seeded plants this internode may remain unextended and as a result, the crown develops adjacent to the seed. As seeding depth increases, the subcrown internode length increases so that crown depth increases with seeding depth but not proportionately (Ashrof and Taylor, 1974). The subcrown internode has sometimes been referred to as the mesocotyl. The mesocotyl, by definition, is the internode between the scutellar node and the coleoptile (Esau, 1977) and it occurs in many grasses including corn and oats. Salisbury and Ross (1978) claim that members of the Festucoideae subfamily such as wheat have no detectable mesocotyl and our observations substantiate their claim with regard to wheat.

There is evidence which suggests that subcrown internode length is genetically controlled (Chowdry and Allan, 1966; Hunt et al., 1983; Sallans, 1961) but influenced by seeding depth and environment. Increasing temperature, increasing seeding depth and reducing light intensity have all resulted in greater subcrown internode length (Ashrof and Taylor, 1974; Ferguson and Boatwright, 1968; Hunt et al., 1983; Taylor and McCall, 1936).

2.0 Materials and Methods

Two winter wheat cultivars, Norstar (tall) and Norwin (short) were hand seeded on summerfallow on two seeding dates (August 29 and September 18, 1986) at six different depths (Table 1). Culled seed of a uniform size was used. Water was applied to the plots after seeding so that moisture would not be a limiting factor. Plants were dug and washed on November 4, 1986 and the following measurements made: actual planting depth, plant development (using Haun's scale), number of tillers, subcrown internode length and crown depth. A subsample of these plants was subjected to a freeze test using a procedure similar to one used by Fowler and Carles (1979). Survival and regenerative ability of the plants were scored after a six week regrowth period.

The effects of seeding depth and cultivar on winter survival and yield were investigated at four locations (Clair, Saskatoon (2 sites) and Indian Head). The plots were seeded shallow (0-2.5 cm) and deep (2.5-5.0 cm). Winter survival and yield were recorded at all locations. At Indian Head the number of heads per unit area was also determined for the various treatments.

3.0 Results and Discussion

The actual seeding depth varied from the expected seeding depth and the actual seeding depth was deeper on the first seeding date (Table 1). This was taken into account when the results were analyzed.

Subcrown internode length generally increased with increasing depth of seeding but was more apparent at depths greater than 2.0 cm on both seeding dates. However, the increase in subcrown internode length in relation to seeding depth was greater on the first than the second seeding date. This confirms the observations of other researchers (Ferguson and Boatwright, 1968; Hunt et al., 1983; Taylor and McCall, 1936) that subcrown internode length is positively correlated to temperature. The result is that crowns of plants seeded on the second seeding date were deeper than those seeded on the first seeding date.

Tiller number and Haun's scale were used as indicators of plant development. A general decline in plant development was observed as crown depth increased. However, any possible advantage derived from shallow crown placement due to subcrown internode elongation was lost if the crown was associated with a deep seed. This may be due to the fact that much of the seed's energy reserves were depleted during the period of emergence and subcrown internode elongation. Plants originating from deep seeds generally developed into weak plants which have an etiolated appearance. This means that crown depth alone is not an adequate indicator of the potential of the winter wheat seedling. Presence or absence of a subcrown internode should be considered in order to get an indication of the health of the winter wheat stand.

Although seeding depth had a significant effect on plant development, seeding date had a far greater effect. Plant development as characterized by Haun's scale and tiller number (Table 2) are evidence of the advantage of early seeding. Seed sown on the first date germinated more readily and developed more rapidly than those seeded on the second date. The fact that, on average, plants at the second seeding date had more than 4 leaves at the shallow depth of seeding is an indicator that growing conditions were optimal. Under field conditions, seldom do you observe more than 3 leaves when the seeding operation is delayed. Survival rates and regenerative ability following exposure to artificial freezing temperatures are also more dependent on seeding date than seeding depth. Under field conditions where plants are exposed to freezing temperatures for longer periods of time, more sub lethal injury may occur as a result of deeper planting than we observed in the artificial freeze test. Plants seeded on the first date survived low temperatures better than plants from the second seeding (Table 3) date and generally maintained their growth advantage over plants from the second seeding date. The temperature at which 50% of the plants were killed (LT50) was reached at -17 degrees C for the first seeding date and at -10 degrees C on the second seeding date (Table 3). Plants from the cultivar Norstar survived the exposure to low temperatures better than Norwin (data not included). It is well known that the cold hardiness potential is greater in Norstar than Norwin (Fowler, personal communcation).

The effects of freezing temperature on the ability of the plants to regenerate new roots and new tillers were also investigated. Plants were exposed to an artificial freeze test (-3, -10, -17, -19, -21, -23 degrees C). The number of roots and tillers present before the freeze test are given in Table 4 for the various seeding dates and seeding depths. Once again, the effect of seeding date was much more pronounced than that of seeding depth. The number of roots and tillers regenerated after the freeze test are given in Table 5. The first observation is that the number of roots and tillers produced after a period of regrowth was greater following exposure to -10 degrees C than -3 degrees C. There is no explanation for this observation.

The next observation is that the percent reduction in the number of roots regenerated after six weeks is greater for the second seeding date than for the first seeding date (Table 6). (Survival rates for plants subjected to temperatures lower than -17 degrees C were so low that only those plants subjected to -3, -10 and -17 degrees C were considered in Tables 5 and 6). However, the percent reduction in the number of tillers was greater on the first seeding date than the second seeding date (Table 6). Legge et al. (1983) have found that primary tillers are generally more successful in surviving freezing than secondary and tertiary tillers. A greater number of secondary and tertiary tillers present on the first seeding date than on the second seeding date would result in more tiller deaths on the first rather than the second seeding date. The percent reduction was lower on the second seeding date because most of the tillers were primary tillers.

The effect of seeding depth on yield was measured in four cultivars at three locations. Yield was not determined at the fourth location because of extensive winter kill. In two of the three locations there was a significant yield increase due to shallow seeding (Table 7). These results support previous observations in the field regarding seeding depth on yield (Lafond, Hultgreen and Fowler, personnal communcation). Some of the yield reduction can be attributed to a reduction in the number of heads per meter square when seeds are planted deeply as was observed at Indian head (Table 8).

In summary, the importance of seeding on the optimum date cannot be overemphasized given the effects of plant development and tiller production. The ability of the plants to survive and regenerate roots after exposure to freezing temperatures was not as great when seeding was delayed. Seeding depth significantly delayed the time to emergence as reflected in Haun's scale. This was observed on both seeding dates. The subcrown internode tends to be shorter when seeding is delayed as a result of lower soil temperatures. Therefore, for any given planting depth, greater than approximately 2.0 cm, winter wheat crowns tend to be deeper when seeding is delayed. Plants with deeper crowns tend to tiller less and be more prone to infection from soil borne diseases than shallow planted material.

4.0 Bibliography

Ashraf, M. and O. A. Taylor. 1974. Morpho-developmental factors related to winter survival of wheat. I Association of characteristics of dark grown seedlings and winter survival. Crop. Sci. 14: 499-502.

Chowdry, A. R. and R. E. Allan. 1966. Culm length and differential development of the coleoptile, root and sub-crown internode of near-isogenic wheat lines. Crop Sci. 6: 49-51.

Duczek, L. J. and L. J. Piening. 1982. Effect of seeding depth, seeding date and seed size on common root rot of spring barley. Can. J. PH. Sci. 62: 885-891.

Easu, K. Anatomy of seed plants. New York, John Wiley. 1977. 2nd Ed. p. 515.

Ferguson, H. and G. O. Boatwright. 1968. Effects of environmental factors on the development of the crownnode and adventitious roots of winter wheat (Triticum aestivum). Agron. J. 60: 258-260.

Fowler, D. B. and R. J. Carles. 1979. Growth, development and cold tolerance of fall-acclimated cereal grains. Crop Sci. 19: 915-922.

Hadjichristodoulou, A., A. Della and J. Photiades. 1977. Effect of sowing depth on plant establishment, tillering cpacity and other agronomic characteristics of cereals. J. Agric. Sci. 89: 161-167..

Haun, J. R. 1973. Visual quantification of wheat development. Agron. J. 65: 116-119.

Hunt, L. A., B. D. McKersie and D. G. Tanner. 1983. Crown depth in eastern soft white winter wheats. Crop Sci. 23: 613-614.

Legge, W. G., D. B. Fowler and L. V. Gusta. 1983. Cold Hardiness of Winter Wheat Tillers Acclimated under Field Conditions. Can. J. Plant Sci. 63: 879-888.

Salisbury, F. B. and C. W. Ross. Plant Physiology. 2nd Ed. p. 297. Belmont, California Wadsworth Publishing Co. 1978.

Sallans, B. J. 1961. Inherent differences in depth of crown in wheat and barley. Can. JU. Plant Sci. 41: 493-498.

Taylor, J. W. and M. A. McCall. 1936. Influence of temperature and other factors on the morphology of the wheat seedling. J. of Agric. Res. 52: 557-568.

Tinline, R. D. 1981. Effect of depth and rate of seeding on common root rot of wheat in Saskatchewan. Phytopath. 71: 909.

Table 1. Actual Seed Depth and Crown Depth for Two Seeding Dates. Each value represents the mean of 24 observations.

Expected Seeding Depth (cm)	Date I: Actual Seeding Depth (cm)	Date I: Crown Depth (cm)[1]	Date II: Actual Seeding Depth (cm)	Date II: Crown Depth (cm)[1]
1.3	1.13	1.12	1.05	1.05
2.5	1.53	1.44	2.05	2.05
3.8	2.36	2.07	2.50	2.38
5.0	3.45	2.60	3.23	3.23
7.5	5.50	2.56	5.57	4.83
10.0	7.42	3.59	6.27	4.46
Mean	3.56	2.23	3.44	3.00

[1] Means within these columns which differ by more than .50 cm are significantly different according to L. S. D. .05.

Table 2. The effect of seeding depth and seeding date on plant development (Haun's scale) and tiller numbers. Each value represents the mean of 24 observations.

	Plant Development		Tiller Number	
Depth	Date I	Date II	Date I	Date II
1	7.61	4.73	11.63	2.4
2	7.31	4.72	9.77	2.5
3	7.05	4.53	10.0	2.2
4	6.82	4.20	9.7	1.6
5	6.67	3.58	8.3	1.0
6	6.63	3.31	8.0	0.8
Mean	7.01	4.18	9.6	1.8

Table 3. Survival (%). Effect of seeding date.

Temp. (^{o}C)	Date Aug. 29/86	Date Sept. 18/86
-3	100	100
-10	100	100
-17	52.5	10
-19	41.6	0
-21	0	2.08
-23	0	0

Table 4. The effects of seeding date and seeding depth on the number of roots and tillers at fall freeze-up. Each value was averaged over cultivars.

	# of Roots		# of Tillers	
Depth	Date I	Date II	Date I	Date II
1	19.0	13.3	6.3	1.5
2	21.1	12.1	6.1	1.2
3	18.6	15.2	5.8	1.1
4	18.9	13.9	4.8	1.5
5	19.8	11.8	4.9	0.8
6	17.7	9.5	4.6	0.4
Mean	19.2	12.6	5.4	1.1

Table 5. The effects of artificial freezing temperatures, seeding date and seeding depth on root regeneration and tiller number. Each value was averaged over cultivar.

		# of Roots		# of Tillers	
Temp.	Depth	Date I	Date II	Date I	Date II
-3	1	16.0	6.7	2.4	0.2
	2	15.3	7.7	1.7	0.5
	3	14.0	7.9	1.1	0.8
	4	17.1	7.7	1.6	0.4
	5	17.1	7.6	1.5	0.2
	6	13.4	8.1	1.9	0.3
	Mean	15.5	7.6	1.7	0.4
-10	1	18.2	10.8	2.6	1.2
	2	16.6	10.7	2.3	1.0
	3	17.5	11.8	2.8	1.3
	4	18.9	10.2	3.8	0.9
	5	18.9	10.1	3.2	0.7
	6	16.9	7.9	2.7	0.7
	Mean	17.9	10.2	2.9	0.9
-17	1	5.6	-	0.5	-
	2	6.9	5.3	1.5	0.3
	3	6.2	7.5	0.4	0.5
	4	7.9	-	13.3	-
	5	4.4	3.5	0.3	0.3
	6	8.6	-	0.7	-
	Mean	6.7	4.1	0.8	0.3

Table 6. Percent reduction in the number of roots and tillers regenerated after regrowth following the artificial freeze test.

	# of Roots		# of Tillers	
Temp.	Date I	Date II	Date I	Date II
-3	19.3	39.6	68.5	64.0
-10	7.0	19.0	46.2	18.0
-17	65.0	67.0	85.2	73.0

Table 7. Effect of seeding depth on yield (kg/ha) for three locations and four winter wheat cultivars.

	Saskatoon		Clair		Indian Head	
Cultivar	Shallow	Deep	Shallow	Deep	Shallow	Deep
Norstar	1185	1429	2553	2406	3535	3169
Alabaskaya	1409	1493	2417	2374	3100	2672
83-192	1441	1351	2287	2240	2859	2282
Norwin	1233	1515	2117	1987	2646	2410
Mean	1317	1447	2344	2252	3036	2633
Level of Significance	ns		*		*	

Table 8. The effect of seeding depth on heads per meter square for four winter wheat cultivars at Indian Head.

Cultivar	Shallow	Deep
Norstar	425	359
Alabaskaya	569	407
83-192	469	364
Norwin	414	355
Mean	469	371