21. Flooding effects on wheat growth and yield

Project Duration

- 2019-2021

Collaborators

- Canadian Agricultural Partnership funding
- Curtis Cavers, AAFC Portage la Prairie

Objectives

– to evaluate the effects of early and late flooding on four commonly grown wheat varieties in Manitoba. Plots were also grown under no flooding conditions as control for comparisons.

Results

Flooding influenced plant height, days to maturity, lodging and the yield of wheat varieties tested at Arborg site (Table 21.1). Wheat plots flooded at early crop stage had taller plants than in control plots. On the contrary, late-flooded plots has shorter plants and took less days to mature. Late flooding also resulted in greater lodging in the plants. Early flooding increased grain yield, whereas late flooding had adverse effect on the grain yield. Grain protein content was higher when the plots were flooded.

Table 21.1. Effect of flooding on wheat growth and grain yield at Arborg site.

Treatment	Plant height	Days to maturity	Lodging	Yield	Protein content
	inches		*1-5 scale*	*bu /acre*	*%*
Early Flooding	28.2c	81.0b	1.00a	51.7c	15.40b
Late Flooding	23.5a	77.3a	1.91b	17.7a	15.58b
No Flooding	26.4b	81.2b	1.00a	40.7b	15.13a
P -value	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
CV (%)	5.2	2.2	25.4	13.5	1.2
Sig. diff.	Yes	Yes	Yes	Yes	Yes

Project findings

Continuous flooding at 2-3 leaf stage benefitted wheat resulting in significant yield increase. This was not a surprise in a drought year like 2021, when the soil moisture was deficit during the entire crop season (Fig. 6.1 and Fig*. 6.2*). Flooding actually benefitted the crop rather than imposing any stress. Flooding at the later crop stage, however, reduced grain yield. The grains were shriveled and had less bushel weight in the late-flooded plots.

Background / References / Additional resources

Wet soils cause an oxygen deficiency and reduction in nutrient uptake. Early flooding can significantly have reduced tillering, plant height, delayed head emergence significantly affecting the grain yield. Excessive soil moisture also delays agronomic operations. The impact of these losses on farm net income is significant. During 1966-2015, excess moisture accounted for 38% of all crop losses in Manitoba (MASC).

Manitoba crop insurance data from 1965-1972 showed clay soils subjected to excess moisture in July experienced the highest yield loss (2-6 bu/ac/day) for barley, oats, wheat and flax crops (Rigaux and Singh,1977).

Additionally, farmers experience loss of nutrients due to extreme moisture as well as loss of soil. Excess water conditions may influence the ability of a plant to take up inorganic nutrients due to the effects on processes associated with solute movement across membranes (Barrett-Lennard 2003). Uptake of essential nutrients such as N, P, and K takes place against gradients of chemical and electrical potential, which requires energy inputs from aerobic respiration; respiration is inhibited under anaerobic conditions making nutrient uptake energetically unfavorable (Greenway and Gibbs 2003). For example, Huang et al. (1995) reported reduced concentrations of N, P, K, Mg, and Zn in wheat shoots under waterlogged conditions (and an increased concentration of these same elements in the wheat roots).

References

Barrett-Lennard, E. G. 2003. The interaction between waterlogging and salinity in higher plants: causes, consequences and implications. Plant Soil 253: 35-54.

Greenway, H. and Gibbs, J. 2003. Mechanisms of anoxia tolerance in plants. II. Energy requirements for maintenance and energy distribution to essential processes. Func. Plant Biol. 30: 999-1036.

Huang, B. R., Johnson, J. W., Nesmith, D. S. and Bridges, D.C. 1995. Nutrient accumulation and distribution of wheat genotypes in response to waterlogging and nutrient supply. Plant Soil 173: 47-54.

Rigaux, L. R. and Singh, R. H. Benefit-cost evaluation of improved levels of agricultural drainage in Manitoba, Volume 1-3, Research Bulletin No. 77-1, Department of Agricultural Economics and Farm Management, University of Manitoba, June 1977.

Materials and methods

Experimental design – Randomized complete block design

Plot size – 8.22 m^2

Varieties –AAC Brandon, AAC Cameron, AAC Viewfield and Cardale

Treatments – 3

- Early flooding (2-3 leaf stage)
- Late flooding (soft dough stage)
- No flooding (control)

Four wheat varieties were grown in flooded (early- and late-crop stage) and non-flooded set ups. Early flooding plots were flooded four times between June 21- 28 and a total of 5 inches of flooding was applied in addition to natural precipitation. Flooding was started, when the wheat crop was at 2-3 leaf stage.

Flooding was started in late-flooded plots on July 21, when the crop was at soft dough stage. Flooding continued until July 27 and a total of 7.5 inches of flooding was applied in addition to natural rainfall.

Data collected

Plant stand, Plant height, days to maturity, lodging, grain yield

Agronomic information

Stubble, soil type – Fallow, Heavy clay

Fertilizer applied –

- Early/Late flooding sets: N-55: P-20 (lb /acre)
- Control set: N-:55 P-20 (lb /acre)

Pesticides applied –

- Pre-emergence burn off using glyphosate @ 0.67L/ac
- Silencer @ 34ml/acre on July 8 (Only no flooding plots) and on July 29 for the control of grasshoppers (Only early flooding plots)

Seeding date

- May 28, 2021

Harvesting date

- No flooding: Aug 19, 2021
- Early flooding: Aug 27, 2021,
- Late flooding: Sep 1, 2021