POST-HARVEST MANAGEMENT OF TIMOTHY HAY FOR SURVIVING ANOTHER 100-YEAR DROUGHT[1]

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ABSTRACT

Timothy (*Phleum pratense*) is a highly productive cool-season grass grown mainly for hay in the west. When it comes to timothy hay: high quality = high value for either the domestic or export markets. In good years this goal is a challenge to meet and in drought years it maybe impossible. Timothy growers in the Kittitas Valley normally make 2 hay cuttings per season. Little information exists to make recommendations on the best way to handle this crop under droughty conditions. This research was conducted during the 2005 drought year in the major timothy growing area of Kittitas Valley in WA State. The fundamental questions we asked involved plant responses to zero or limited irrigation after first cutting. We monitored timothy plant survival of two varieties each at two maturities and three drought treatments. We measured changes in plant dry weight and concentration of carbohydrates in timothy stubble and corms during the summer and fall of the drought.

Too often, western timothy growers face a drought at sometime during the life of a stand. Kittitas Valley Washington timothy growers have earned the reputation of producing some of the highest quality hay grown in the world. Much of their business (estimated > $60 million per year) is based on exports. When potential export customers visit, the grower wants to show clean, weed-free, green and productive fields. During the latest drought in 2005 growers asked how to better manage timothy fields. Traditionally during a drought event irrigation water is available to produce the first hay cutting but not enough for a second. To meet the needs of exporters for bright green fields during the growing season, growers will irrigate once or twice, even though a full second cutting is not produced. Experiences reported from growers using this management is it leads to less productive and thinner stands during and after a drought. With the partial financial support of the Kittitas County Conservation District in Kittitas County, WA we conducted a field and laboratory study to determine if applying but limiting irrigation water application after first cutting would change the important concentrations of storage sugars in the timothy stubble and corms and if there would be any effect on the survival of new plants and tillers during and after the drought.

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PROCEDURES

Four timothy fields from two commercial growers were selected for sampling during the 2005 drought in Kittitas County. The fields are: 1) seedling (fall seeded and less than1 year old) Clair, 2) established (more than 3 years old) Clair, 3) seedling Richmond, and 4) established Richmond. Soil samples were collected from each field site for nutrient analysis. Drought management treatments imposed were: 1) dry, where no additional irrigation water was applied after first cutting hay, 2) 1X, where irrigation water was applied once after first cutting hay, and 3) 2X, where irrigation water was applied twice after first cutting hay. We collected four half-square meter quadrants from each field and drought treatment on July 1, August 1, August 29 and September 26, 2005. Additionally, we collected samples on February 9, 2006. Quadrant timothy samples were hand washed to remove any debris or dead plant material then dried in forced air ovens at 150°F until dry. Samples were weighed in and out of ovens then hand separated into stubble, corms and roots. Each component was oven dried again and reweighed. Components were ground through a 1-mm Wiley mill screen and we measured water soluble carbohydrates (WSC) using the procedure of Dubois etal. (1956). To determine timothy survival we transplanted 20 washed tillers per 8" greenhouse pot containing soil tested field soil from the WSU-Prosser research and extension center where they were grown. Each field and drought treatment at each collection date was replicated four times. Pots were watered as needed and 'harvested' (destroyed) within 60 days of transplanting. At harvest transplanted tillers that were alive and grew new leaves and roots were counted as surviving. Percent timothy survival was calculated as: % survivors = number tillers survive / number tillers transplanted * 100. All data were analyzed using ANOVA with a randomized complete block design and four replications.

RESULTS AND DISCUSSION

MAIN TREATMENT RESPONSES: Variety differences were found for corm dry weight and % survival but not for WSC, Table 1. Stubble weight and sugar concentrations were not different between these varieties. Clair corms were heavier but produced fewer live plants than Richmond when averaged over maturities and collection dates. The advantage of heavier corms did not also translate into more stored sugars for Clair compared to Richmond. Thus, we did find differences between Clair and Richmond for survival but this cannot be attributed to stored sugar concentration or dry weight of corms. It also makes us wonder how much difference in % survival we might find for other varieties treated similarly.

We found no differences in % survival of timothy when comparing seedling stands to established stands, Table 2. However, timothy stubble and corms differed for dry weight and WSC when comparing maturities. Established stands weighed more and contained more sugars than seedling stands but this did not translate into an advantage for survival. Seedling stands are less than 18 months old and considered to be juvenile so they do not go through root shedding as do established stands. The seedling stands in this study were planted in the fall of 2004 so less than one year old when we started. The sugar

concentrations we measured were adequate to produce a new timothy crop under the drought treatments we imposed.

Differences were found among drought treatments for % survival and sugar concentrations in stubble and corms, Table 3. Sugar is mobilized from both the stubble and corms after irrigation to produce new leaves, stems and harvestable hay yield. If the sugars are not replenished then expect lower % survival of timothy. In this case the 2X treatments never replenished the sugar supplies from either timothy stubble or corms resulting in lower survival. The 1X treatment was similar to the dry for carbohydrates but similar to 2X for survival. Sugar concentration in the stubble and corms is certainly a major reason for declines in timothy survival during and after a drought but there maybe other factors that also need to be further investigated.

Collection dates, averaged over varieties, maturities and drought treatments, differed for survival, live timothy plant weight and sugar concentrations in stubble and corms, Table 4. Survival of timothy plants started at 59.2% on July 1st then declined by August 1st then continued to increase as plants entered into root formation in the fall and did not significantly differ from September to February sampling dates. As the drought extended from July to late September live plant weight yield per acre declined. Water-soluble carbohydrate concentrations in timothy stubble and corms also showed cyclic patterns over time. Stubble WSC was highest on July 1st then declined rapidly and rebuilt likely due to mobilization to start then storage after some leaf tissue had regrown. Corm WSC was highest at the end of the sample collection period in late September, likely due to storage needs for winter survival of delicate growing points. There appears to have been adequate sugar storage for some treatments as noted previously % survival of timothy plants in February was similar to September.

DROUGHT TREATMENT RESPONSES BY MATURITY AND VARIETY: Closer evaluation of the data when separated by individual timothy variety and maturity will answer more detailed questions in how growers may wish to handle specific situations on their farms.

Seedling Clair: Table 5 reports stubble and corms WSC and % survival averaged over collection dates. Plant survival of timothy from the dry treatment was higher than partial irrigation treatments. Stubble WSC followed the same pattern as survival while there were no differences in corm WSC. For a seedling Clair timothy stand a grower should not irrigate after first cutting and allow the sugars in the stubble to support the apical meristems so new growth can be initiated when drought stress conditions have been relieved.

Seedling Richmond: Table 6 provides similar data to seedling Clair. Interesting seedling Richmond results are similar to seedling Clair except stubble sugars were similar for dry and 1X drought treatments and concentrations of sugars in corms are less for Richmond. As reported in Table 1, seedling Richmond appears to produce more live timothy plants than Clair, Table 5.

Established Clair: This field of established Clair was the oldest of all the fields evaluated, approximately 5 years old. Upon washing the roots and crowns clean of debris it was easy to see several years of older corms, almost stacked like plates. This dead plant material was discarded from weighing or WSC in this study. Highest % survival and sugars from stubble or corms in established Clair was found in the dry drought treatment, Table 7.

Established Richmond: This field was approximately 3 to 4 years old. At every collection date we found Billbug (*Sphenophorus* spp.) in the soil or the corms of the plants in this field. We found no differences among drought treatments for survival or corm WSC, Table 8. Stubble WSC was highest for 1X with dry and 2X sugar concentrations lowest. We think the previously unknown and high population of Billbug in this field affected the results. We also found the Billbug in the seedling Richmond field but at a lower population because we did not find them each collection date. Although we are not showing the data, timothy root weights were lower and declined from July to September samplings for the established Richmond field site while timothy from other sites increased in root mass during the fall root regrowth period.

CONCLUSIONS AND RECOMMENDATIONS

The results from this study are based on only the 2005 crop production year. We did not have funding to continue this work. Thus, the recommendations should be considered preliminary until more research is conducted. The study does reveal new data and information that could help western US timothy hay growers make decisions when facing another drought situation.

- Richmond timothy survived the drought better than Clair timothy. We found no differences in stored corm WSC between the varieties. Corm weight was higher for Clair than Richmond and this could be a function of stand age. It would be dangerous to speculate how other timothy varieties will respond to surviving a summers' drought event without further research.
- Seedling and established stands produced similar timothy survival over all treatments and dates. Seedling stands were lower in stubble and corm WSC but their concentrations were adequate to produce timothy growth comparable to longer-lived established stand.
- Keeping timothy plants dormant after first cutting is important for higher plant survival and maintaining high stubble and corms WSC concentrations. Even a single irrigation that produces green timothy growth during the drought period will decrease sugars though remobilization of the storage in stubble and corms to new growing leaf tissues. Unfortunately, there is inadequate time or water for a second cutting with the 1 or 2X treatments resulting in increased timothy plant death.
- Timothy survival and sugar concentrations change over time. About August 1st we found the lowest survival and sugar concentrations in both stubble and corms. Sugar levels increased in the fall as did plant survival. We think this is due in part to changing photoperiod (shortening daylength) that naturally triggers root

regeneration and new apical meristem development. Sustaining timothy survival over winter from late September is good news to growers who have properly managed the crop during the drought.

- Pests, such as the Billbug, can impact timothy plant growth. Even though we did not find differences in plant survival of established Richmond timothy we expect this stand to thin very rapidly. We only selected live timothy tillers and plants for this research but the damage from Billbug and other pests may reduce the total number of live plants per acre resulting in thinner, open stands that are not due to the drought.
- There are actions you can take during a drought to save timothy stands once the drought has ended. Our best advice is to not irrigate and keep off the fields except to control weeds. Weeds are likely to invade during the drought period when timothy is at its weakest point. Annual weeds will steal moisture and rapidly produce a seed crop. Perennial weeds will just increase in size and dominance. Be proactive, be patient, the dead-looking timothy is simply dormant and waiting for better conditions to produce hay again.

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Table 1. Corm dry weight and water soluble carbohydrates and survivors of droughted Clair and Richmond timothy in 2005.

Variety	Dry wt. (g)	WSC (c)	Survivors (%)
Clair	32.7 a	144.0 a	59.6 b
Richmond	27.3 b	141.2 a	68.4 a
$P <_{0.05}$	xx	ns	xx

Table 2. Dry weight and water soluble carbohydrate of stubble and corms and survival of droughted timothy by maturity in 2005.

	Stubble		Corms		
Maturity	Dry wt (g)	WSC (c)	Dry wt (g)	WSC (c)	Survival (%)
Seedling	30.6 a	66.1 b	77.6 b	110.6 b	62.8 a
Established	24.8 b	82.6 a	32.4 a	175.1 a	65.2 a
$P <_{0.05}$	x	x	x	x	ns

Table 3. Timothy stubble and corm water soluble carbohydrates and survivors by drought treatment in 2005.

Treatment[a]	Stubble (c)	Corms (c)	Survivors (%)
Dry	79.3 a	154.4 a	71.8 a
1X	76.7 ab	142.2 ab	60.3 b
2X	66.9 b	131.9 b	58.9 b
$P <_{0.05}$	x	x	xx

[a] Dry plants received no irrigation water after first cutting, 1X plants were irrigated once and 2X were irrigated twice but not enough to produce a second cutting

Table 4. Live weight timothy plant (stubble, corms and roots) and survival by collection date in 2005 and 2006.

Collection Date	Live plant wt. (lbs./acre)	Stubble WSC	Corm WSC	% Timothy Survival
July 1, 05	2805.0 a	130.3 a	129.9 c	59.2 b
August 1, 05	2760.7 a	39.4 d	94.4 d	48.4 c
August 29, 05	2246.4 b	57.7 c	150.4 b	56.9 b
Sept 26, 05	2189.6 b	69.9 b	196.6 a	81.9 a
Feb. 9, 06	-----	-----	xx	78.1 a
$P <_{0.05}$	xx	xx	xx	xx

Table 5. Seedling Clair timothy stubble and corm water soluble carbohydrates and survivors by drought treatment in 2005.

Treatment[a]	Stubble (c)	Corms (c)	Survivors (%)
Dry	80.3 a	132.4 a	65.5 a
1X	68.8 b	133.2 a	52.2 b
2X	64.6 b	125.5 a	48.8 b
$P <_{0.05}$	xx	ns	xx

[a] Dry plants received no irrigation water after first cutting, 1X plants were irrigated once and 2X were irrigated twice but not enough to produce a second cutting

Table 6. Seedling Richmond timothy stubble and corm water soluble carbohydrates and survivors by drought treatment in 2005.

Treatment[a]	Stubble (c)	Corms (c)	Survivors (%)
Dry	71.4 a	95.2 a	76.2 a
1X	64.9 a	88.7 a	66.5 b
2X	46.5 b	88.4 a	65.4 b
$P <_{0.05}$	xx	ns	xx

[a] Dry plants received no irrigation water after first cutting, 1X plants were irrigated once and 2X were irrigated twice but not enough to produce a second cutting

Table 7. Established Clair timothy stubble and corm water soluble carbohydrates and survivors by drought treatment in 2005.

Treatment[a]	Stubble (c)	Corms (c)	Survivors (%)
Dry	93.6 a	195.8 a	74.5 a
1X	80.9 ab	145.9 b	58.3 b
2X	75.6 b	133.7 b	55.2 b
$P <_{0.05}$	x	x	xx

[a] Dry plants received no irrigation water after first cutting, 1X plants were irrigated once and 2X were irrigated twice but not enough to produce a second cutting

Table 8. Established Richmond timothy stubble and corm water soluble carbohydrates and survivors by drought treatment in 2005.

Treatment[a]	Stubble (c)	Corms (c)	Survivors (%)
Dry	72.0 b	194.1 a	71.0 a
1X	96.2 a	211.1 a	64.0 a
2X	76.9 b	179.8 a	66.2 a
$P <_{0.05}$	x	ns	ns

[a] Dry plants received no irrigation water after first cutting, 1X plants were irrigated once and 2X were irrigated twice but not enough to produce a second cutting