Does the presence of the gene for glabrous hull in annual canarygrass affect the response to chloride fertilizer?

W. E. May[1], C. B. Holzapfel[2], G. P. Lafond[1], and J. J. Schoenau[3]

[1]Agriculture and Agri-Food Canada, Indian Head Research Farm, RR#1 Gov Rd, P.O. Box 760, Indian Head, Saskatchewan, Canada S0G 2K0 (e-mail: william.may@agr.gc.ca); [2]Indian Head Agricultural Research Foundation, RR#1 Gov Rd, Box 156, Indian Head, Saskatchewan, Canada S0G 2K0; and [3]University of Saskatchewan, Department of Plant Sciences, 51 Campus Drive, Saskatoon, Saskatchewan, Canada S7N 5A8.
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May, W. E., Holzapfel, C. B., Lafond, G. P. and Schoenau, J. J. 2013. **Does the presence of the gene for glabrous hull in annual canarygrass affect the response to chloride fertilizer?** Can. J. Plant Sci. **93**: 109–118. Annual canarygrass is an important cereal crop in western Canada with a unique niche market as feed for caged birds. Chloride (Cl) fertilizer has been shown to increase seed yield in annual canarygrass; however, the response was only tested in one glabrous cultivar. Currently, glabrous cultivars created through mutagenesis, are lower yielding than cultivars with trichomes on their lemma, palea and glumes. The objective of this study was to determine if the mutagenic process which created cultivars that lack trichomes on their lemma, palea and glumes also affected the response of annual canarygrass to chloride fertilizer. A two-way factorial study was conducted across 7 site-years. The first factor was Cl applied at two rates (0 and 18.2 kg Cl ha^{-1}) and the second factor was four cultivars (Keet, Cantate, CDC Togo (glabrous) and CDC Bastia (glabrous). The application of Cl increased the seed yield of annual canarygrass by 25% and most of this increase was due to a 21% increase in seeds per panicle. Kernel weight also contributed to increased seed yield. Chloride did not interact with the presence or absence of trichomes and therefore growers can expect to receive a yield increase from the application of Cl regardless of the annual canarygrass cultivar grown. Growers should apply 9 kg ha^{-1} of Cl when growing annual canarygrass. In conclusion, Cl is not involved in the physiology of the lower yield in glabrous cultivars compared with cultivars with trichomes, and Cl could not explain the seed yield differences between the two types of annual canarygrass.

Key words: Canaryseed, annual canarygrass, environmental conditions, seed yield, yield stability

May, W. E., Holzapfel, C. B., Lafond, G. P. et Schoenau, J. J. 2013. **La présence du gène de la cosse glabre chez l'alpiste roseau affecte-t-elle la réaction aux engrais contenant du chlore?** Can. J. Plant Sci. **93**: 109–118. L'alpiste roseau est une importante céréale annuelle dans l'ouest du Canada. Cette culture occupe un créneau unique, qui est celui de la nourriture pour les oiseaux en cage. On sait que les engrais à base de chlore (Cl) accroissent le rendement grainier de l'alpiste, cependant, cette réaction n'a été testée que sur un cultivar glabre. Or, à l'heure actuelle, les variétés glabres, qui résultent de la mutagénèse, s'avèrent moins productifs que les cultivars présentant des trichomes sur leur lemme, leur paléole et leurs glumelles. L'étude devait établir si le processus de mutagénèse à l'origine des cultivars sans trichomes sur le lemme, le paléole et les glumelles modifie aussi la réaction de l'alpiste roseau annuel aux engrais renfermant du chlore. À cette fin, les auteurs ont procédé à une expérience bifactorielle pendant 7 années-sites. Le premier facteur consistait en deux taux d'application de l'engrais Cl (0 et 18,2 kg de Cl par hectare) et le second, en quatre cultivars [Keet, Cantate, CDC Togo (glabre) et CDC Bastia (glabres)]. L'application d'engrais Cl augmente le rendement grainier de l'alpiste roseau annuel de 25 % et la majeure partie de cette hausse résulte d'une hausse de 21 % du nombre de graines par panicule. Le poids des graines concourt aussi à accroître le rendement grainier. Le chlorure n'interagit pas avec la présence ou l'absence de trichomes, de sorte que les producteurs peuvent s'attendre à une hausse de rendement s'ils appliquent de l'engrais Cl, quelle que soit la variété d'alpiste cultivée. Les producteurs devraient appliquer 9 kg de Cl par hectare aux cultures d'alpiste roseau annuel. En conclusion, le Cl n'intervient pas dans les mécanismes physiologiques responsables du rendement plus faible des cultivars glabres, comparativement à celui des cultivars pourvus de trichomes, et le Cl n'explique pas l'écart du rendement grainier entre ces deux types d'alpiste roseau.

Mots clés: Alpiste roseau, alpiste roseau annuel, conditions environnementales, rendement grainier, stabilité du rendement

The major use of canaryseed or annual canarygrass (*Phalaris canariensis* L.) has been as a feed for caged birds. Approximately 69 to 79% of the world's annual canarygrass is produced in Canada, centered in the province of Saskatchewan (FAOSTAT 2008). The first recorded test of annual canarygrass as a grain crop in Saskatchewan was at Indian Head, SK, in 1906 (MacKay 1907). In Canada, 800 ha of annual canarygrass was first grown commercially in 1971. Seeded area has ranged from 95 000 to 350 000 ha over the past 20 yr, with 89 to 98% of the production in Saskatchewan (Saskatchewan Ministry of Agriculture 2009). Annual canarygrass growers reported in an informal survey that their greatest concern was spatial and temporal

Abbreviation: **NDVI**, normalized difference vegetation index variability in seed yield, especially the production of very large amounts of biomass accompanied by very low seed yield (May 1998). Research into this problem has identified several factors that can contribute to yield variability but do not entirely account for the problem. May et al. (2012a) and Miller (2000) reported that seeding date affected seed yield and could account for some but not all of the annual variability reported by growers. Control of septoria leaf mottle, a major disease in annual canarygrass, also appears to account for some of this yield variability (May et al. 2002).

Recently, chloride has been identified as an important nutrient for reducing yield variability in annual canarygrass. The application of chloride increased seeds per panicle thereby directly impacting seed yield, while potassium had little effect on canaryseed in this study (May et al. 2012b). There was no measurable effect of the chloride on annual canarygrass before seed filling. The exact mechanism of how chloride increases the number of seeds that develop on each annual canarygrass panicle is not known. When researchers observed an effect of chloride in other crops they have attributed the response to several factors including, osmoregulatory functions, interactions with other nutrients, interaction with diseases and alteration of crop development (Fixen 1993). Many studies could not identify how chloride actually increased seed yield (Fixen et al. 1986; Engel 1994; Gaspar et al. 1994; Diaz-Zorita et al. 2004). Several studies did identify that in wheat and barley, chloride response varied across cultivars (Mohr et al. 1995a, 1995b; Grant et al. 2001; Evans and Riedell 2006). Research on other crops rarely report a strong response to chloride as observed for annual canarygrass, especially during seed filling.

Previous testing of annual canarygrass' response to chloride was conducted using one cultivar, CDC Togo, a glabrous (hairless) cultivar free of trichomes on the palea, lemma and glumes (May et al. 2012b). Cultivars free of trichomes were developed from a single cultivar, Keet, through mutagenesis using sodium azide (Hucl et al. 2001). The reasons for the development of glabrous cultivars was to reduce the skin irritation that producers and handlers experience during harvest and processing and to address concerns surrounding the effects of trichome hairs, consisting mainly of silica, on human health. The inheritance of the glabrous trait in annual canarygrass was identified as a single recessive gene (Matus-Cadiz et al. 2003). Unfortunately, current cultivars developed with this mutation have lower seed yield than non-mutated cultivars (Saskatchewan Ministry of Agriculture 2012). The reason for a lower seed yield is not understood at this time. It is also not known if the mutagenic event used to produce glabrous annual canarygrass altered the sensitivity of annual canarygrass to chloride. Therefore, the objective of this study was to determine if the mutagenic process which created glabrous cultivars altered the response of annual canarygrass to chloride fertilizer.

MATERIALS AND METHODS

A field experiment was conducted at Indian Head (lat. 50°33′08.37″N, long. 103°38′39.82″W, elevation 579 m) and Carry The Kettle (two sites: lat. 50°24′56.59″N, long. 103°34′47.13″W, elevation 642 m and lat. 50°24′46.98″N, long. 103°35′39.29″W, elevation 616 m) in 2008 and 2009 and Riceton (lat. 50°08′13.17″N, long. 104°21′41.51″W, elevation 580 m) in 2009. The soil series were Indian Head heavy clay (Orthic Vertisol or Haplocryert) at Indian Head, an Oxbow loam (Orthic Black Chernozem or Udic Boroll) and Ellisboro (Rego Black Chernozem or Udic Boroll) at Carry The Kettle, and Regina heavy clay (Orthic Vertisol or Haplocryert) at Riceton. To differentiate between the two sites near Carry The Kettle they will be referred to as CTK ellisboro and CTK loam.

The experiment consisted of a two-way factorial randomized complete block design with four replications. The first factor involved two rates of chloride, 0 and 18.2 kg Cl ha^{-1}, in the form of KCl fertilizer applied at the time of seeding in a side-band, 2.5 cm to the side and 3 to 5 cm below the seed. In a related study, the annual canarygrass was proven to be responding to Cl and not K at all the sites where this current study was carried out (May et al. 2012b). The second factor consisted of four cultivars, Keet, Cantate, CDC Togo, and CDC Bastia. Keet and Cantate have trichome hairs on the lemma palea and glumes while CDC Togo and CDC Bastia are glabrous (hairless).

Additional nutrients were side banded to all plots at a rate of 60 kg N ha^{-1}, 11 kg P ha^{-1} and 12 kg S ha^{-1} to all treatments in the form of urea (46–0–0), monoammonium phosphate (11–51–0) and ammonium sulfate (21–0–0–24). All the cultivars were seeded at a rate of 35 kg ha^{-1} using 2.5-m-wide knife opener, a row width of 30.5 cm, and a plot size of 10.7 $\times$ 4.0 m. The seeder was custom built by Vale farms, Indian Head, SK, using independent lift openers. Seed and fertilizer were delivered to the openers using a Valmar metering and air delivery system (Valmar Airflo Inc., Elie, MB). The plots were managed as a no-till, continuously cropped production system. Glyphosate was applied before seeding and all in-crop broadleaf herbicide applications were determined separately for each site-year depending on the weed species and density encountered. Only recommended herbicides and rates were applied (Saskatchewan Ministry of Agriculture 2010).

Data Collection

Soil tests were carried out at each site for N, P, K, S and Cl. Spring soil test levels of NO_3-N, SO_4-S and Cl were measured to a depth of 60 cm; soil residual phosphate (PO_4-P) and potassium (K) were measured to a depth of 15 cm. A $NaHCO_3$ extraction procedure (Hamm et al. 1970) was used to estimate residual soil N (NO_3), P, and K. Available Cl was determined by extraction of 5 g of soil with 50 mL of water followed by filtration and