Advance Journal of Food Science and Technology 10(8): 597-602, 2016
DOI: 10.19026/ajfst.10.2190
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: May 30, 2015 Accepted: July 8, 2015 Published: March 15, 2016

Research Article

Effects of Salt Stress on Growth and Physiological Characteristics in Dryland Wheat Seedlings

Caiyun Chen, Dandan Kong, Xiaojuan Sun, Huisong Sun and Yan Shi
Dryland-Technology Key Laboratory of Shandong Province, Qingdao Agricultural University, Qingdao, 266109, Shandong Province, China

Abstract: In order to find an appropriate salt stress and improve the resistance to salt stress in dryland wheat. In this experiment, Jimai22 was used as experimental material to study the effects of different salt stress on growth and physiological characteristics in dryland wheat seedlings by the pots in the artificial climate chamber. The results show that different salt stress could have different effects on leaf length, plant height, aboveground and underground fresh weight, POD and SOD activity in dryland wheat seedlings. Within a certain range of salt stress, salt stress could increase leaf length, plant height, POD and SOD activity and promote the accumulation of dry matter, but if the salt stress range was exceeded, excessive salt stress would inhibit the growth of wheat seedlings. In the salt stress range of 0~0.4%, 0.2% salt stress was the most conducive to promote the growth of dryland wheat seedlings.

Keywords: Dry matter accumulation, dryland wheat seedlings, enzyme activity, salt stress

INTRODUCTION

Wheat is one of the major food crops in northern China. There are lots of factors may have an effect on wheat yield, such as water shortage in the northern arable land restricting agricultural development (Zhanli and Yan, 2014). Furthermore, the soil salt stress is an important abiotic stress, which could seriously impact on the metabolic activity of plants and even lead to plant death. As the main environmental factor, excessive salt can cause agricultural disasters and crop yield reduction in worldwide. The salt of high concentrations will reduce the absorption of water and essential nutritional components under the salt stress. Currently, the occurrence of secondary salinization of farmland is growing fast due to unreasonable irrigation and farming and more than 50% of arable land in worldwide is suffering the different degrees harm of salinization. Thus, soil salinization has become a global cultivated land problem. China has more saline-alkali soil, which has about 30 million hm^2 land in different degrees of salinization, accounting for 20% of the arable land (Jinfang and Jingtao, 2015). Salt stress could alter a series of physiological and biochemical processes, cause the accumulation of reactive oxygen species, damage plant tissues and cells' structure and function and inhibit the growth and development of plants, etc.

Now, studying the salt tolerance mechanism and the physiological and biochemical changes of wheat under the salt stress would be of great significance to explore the salt stress mechanism and improve plant salt resistance (Kefu and Fazeng, 1999). At present, many scholars have studied the response changes of wheat to adversity under salt stress, such as metabolism, respiration, photosynthesis, enzyme activity and so on. The fresh weight, dry weight, relative fresh weight and dry weight of barley presented a declining trend with the increase of salt concentration, (Zhiping and Shoujun, 2014); Some studies showed that SOD and POD activity turned out to be an firstly increasing and then decreasing trend with increasing NaCl concentration (Tailiang and Zhaosheng, 2015; Nan and Yuwei, 2014; Jing *et al*., 2015). There are some certain effects of the salt stress on the growth of tomato seedlings (Chunyan *et al*., 2015).

Throughout the growth cycle of wheat, the bud stage and seedling stage is very sensitive to salt and the salt tolerance is gradually increasing with the growth and development process of wheat. At present, there are very few related studies about the effects of the salt stress on the growth and physiological characteristics of dryland wheat seedlings. Thus, this pot experiment studied the effects of the different salt stress on the morphological characteristics (leaf length, plant height, aboveground and underground fresh weight) and physiological features (POD and SOD activity) in dryland wheat seedlings with the variety wheat Jimai22. This study selects an appropriate soil salinity to promote the growth of wheat seedlings and provides a new technical way to improve the yield of dryland wheat.

Corresponding Author: Yan Shi, Dryland-Technology Key Laboratory of Shandong Province, Qingdao Agricultural University, Qingdao, 266109, Shandong Province, China

Table 1: Design of treatments (g/pot)

Treatment	CK	T1	T2	T3	T4
NaCl (%)	0	0.1	0.2	0.3	0.4

MATERIALS AND METHODS

Experimental design: This experiment was carried out from December, 2014 to January, 2015 by pots in the artificial climate chamber of Qingdao Agricultural University with the variety wheat Jimai22. The soil was sandy loam soil with soil organic matter content 1.1%, total N 1.2%, available nitrogen 89 mg/kg, available phosphorus 36 mg/kg, available potassium 105 mg/kg. This experiment using a randomized block design, designed 5 treatments with 4 replicates/treatment, which were detailed in Table 1. (1.3 kg) soil was applied into the pot with length of 20 cm, width of 13.5 cm and a height of 8 cm. After accelerating germination of wheat seeds, the test pots with 6 seeds were cultured into artificial climate chamber. According to the growth period of wheat seedlings, we irrigated these treatments with different salt stress. When wheat seedlings grew to the four-leaf stage, we began to sample. The indicators of physiological characteristics in dryland wheat seedlings were measured on Dec 18th, 23th and 28th, 2014 and Jan 2nd, 2015, respectively.

Items: The aboveground and underground fresh weight was weighed by analytical balance; the root ratio is the provider of the root dry weight divided by the shoot dry weight. Determine Superoxide Dismutase (SOD) activity and Peroxidase (POD) activity in accordance with the methods of Aiguo *et al*. (1983) and Hecheng (2000).

RESULTS

Effects of different salt stress on leaf length of dryland wheat seedlings: We can find out from Fig. 1 that leaves length of different treatments were gradually increasing with the growth of dryland wheat seedlings; Accompanied by an increase of salt stress, leaves length of all treatments presented a firstly increasing and then declining trend with the specific performance of T2>T1>T3>CK>T4 in the mass, T2 was the highest and T4 was the lowest. On Dec. 23rd, 2014, it's easy to learn that leaf length of CK was 23.1 cm and leaves length of T1, T2, T3 and T4 were respectively 1.06, 1.13, 1.03 and 0.93 times that of CK, with T2 being the highest. It can be inferred that T2 was the most reasonable salt stress to ensure wheat longer leaves.

Effects of different salt stress on plant height of dryland wheat seedlings: As can be seen from Fig. 2, plant height in all treatments showed an slowly increasing trend in general and plant height of each growth period showed T2>T1>T3>CK>T4. Compared with the control group CK, the plant height of T1, T2 and T3 were respectively higher by 2.83, 10.05 and 2.09%, in addition to T4 decreased by 3.04% on Jan. 2nd, 2015. It was visible that the plant height of T2 was the highest and T4 was the lowest.

Effects of different salt stress on aboveground fresh weight of dryland wheat seedlings: We can see from Fig. 3, aboveground fresh weight was gradually increasing with the growth of dryland wheat seedlings. At the same time, aboveground fresh weight of T1, T2 and T3 were higher than that of CK, but T4 was lower than CK. The aboveground fresh weight of all treatments showed T2>T1>T3>CK>T4 in each measurement period. On Dec. 28th, the aboveground fresh weight of T1, T2 and T3 were respectively higher than that of CK 42.80, 52.33 and7.50%, except for T4 showing a reduction of 22.11%. The aboveground fresh weight of T2 reached the highest.

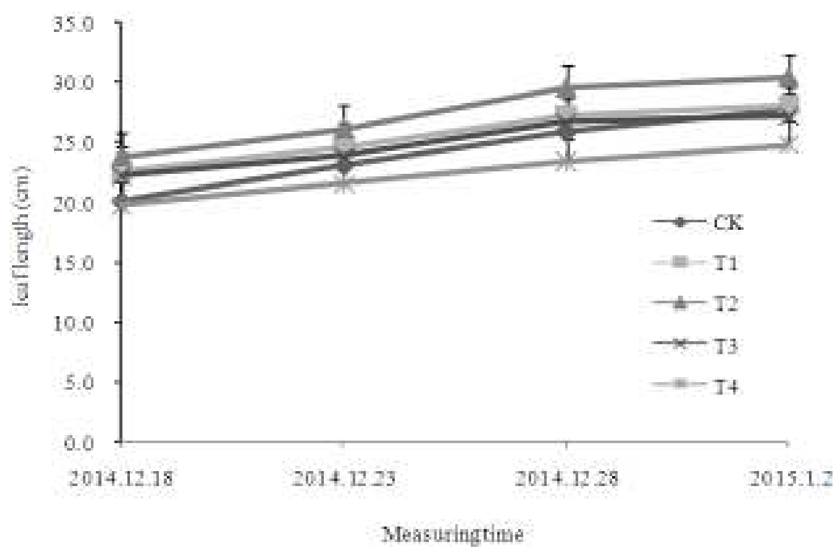

Fig. 1: Effect of different salt stress on leaf length of dryland wheat seedlingss

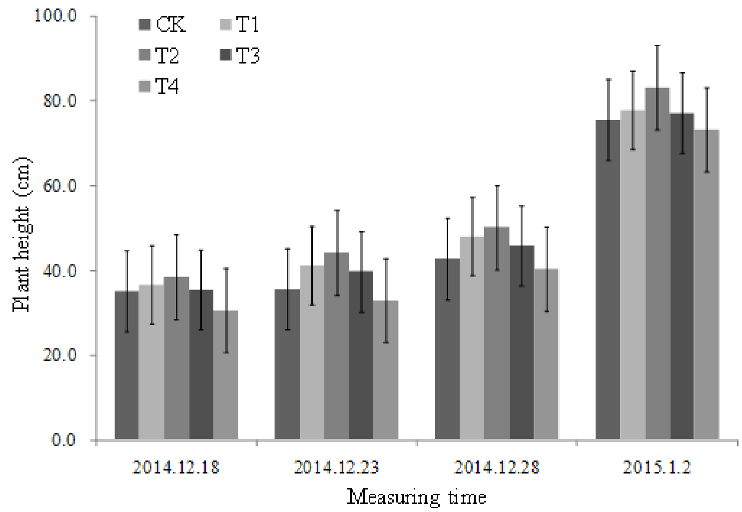

Fig. 2: Effect of different salt stress on plant height of dryland wheat seedlings

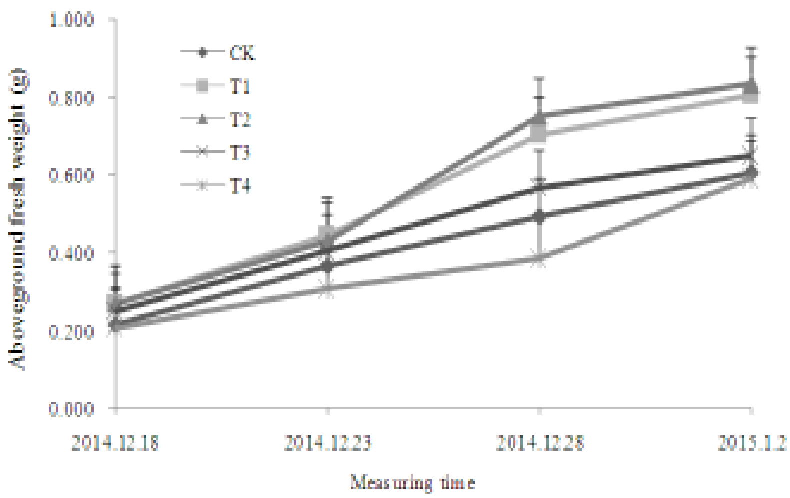

Fig. 3: Effect of different salt stress on aboveground fresh weight of dryland wheat seedlings

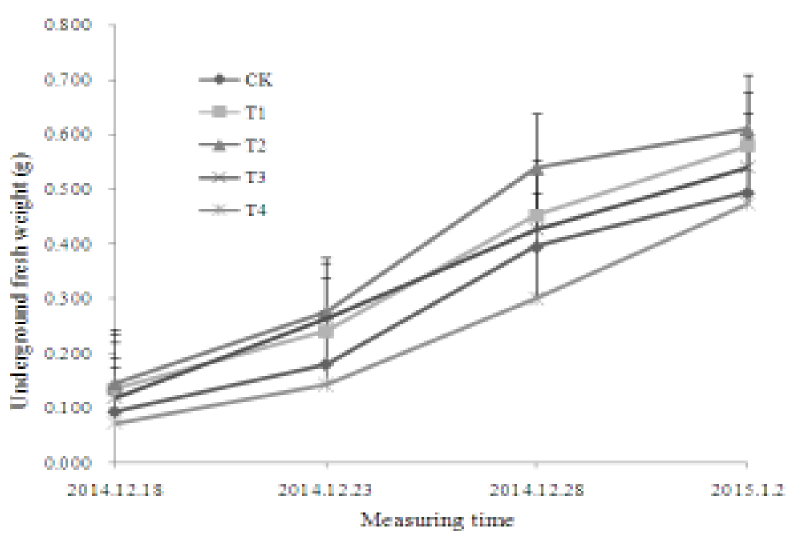

Fig. 4: Effect of different salt stress on underground fresh weight of dryland wheat seedlings

Effects of different salt stress on underground fresh weight of dryland wheat seedlings: With the growth of dryland wheat seedlings, underground fresh weight in all treatments showed an increasing trend in general and the underground fresh weight showed T2>T1>T3>CK>T4 on Dec. 18th, Dec. 28th, 2014 and Jan. 2nd, 2015, respectively (Fig. 4). On Jan. 2nd, it's easy to learn that the underground fresh weight of CK was 0.493 g and underground fresh weight of T1, T2, T3 and T4 were respectively 1.17, 1.24, 1.09 and 0.96 times that of CK, with T2 being the highest and T4 being the lowest. Visibly, only suitable salt stress in a certain range can be conducive to the increase of underground fresh weight of dryland wheat seedlings.

Effects of different salt stress on POD activity of dryland wheat seedlings: Seen from Fig. 5, POD activity of all treatments performed a decline trend with the growth of dryland wheat seedlings. In each measuring period, POD activity of all treatments presented an overall performance of T2>T1>T3>CK>T4. Compared with CK, the POD activity of T1, T2 and T3 turned out to be higher than CK and T4 was lower than CK. When the POD activity of CK showed 132.51 U/g • min, T1, T2 and T3 were respectively higher by 10.28, 16.83 and 2.64% as compared with CK, while T4 was lower than CK by 2.15%. T2 had the highest POD activity, whereas T4 was the lowest.

Effects of different salt stress on SOD activity of dryland wheat seedlings: As was shown in Fig. 6, SOD activity showed a gradually decreasing trend in the overall from Dec. 18th, 2014 to Jan. 2nd, 2015. SOD activity of each measuring period showed T2>T1>

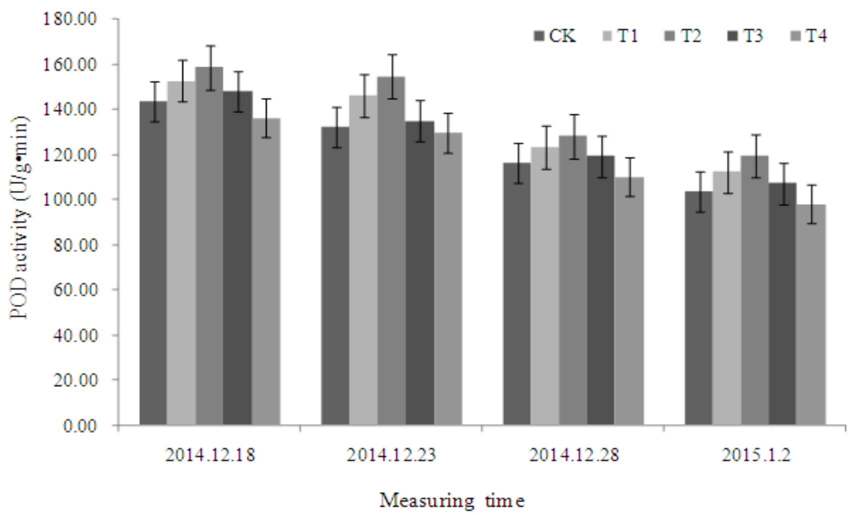

Fig. 5: Effect of different salt stress on POD activity weight of dryland wheat seedlings

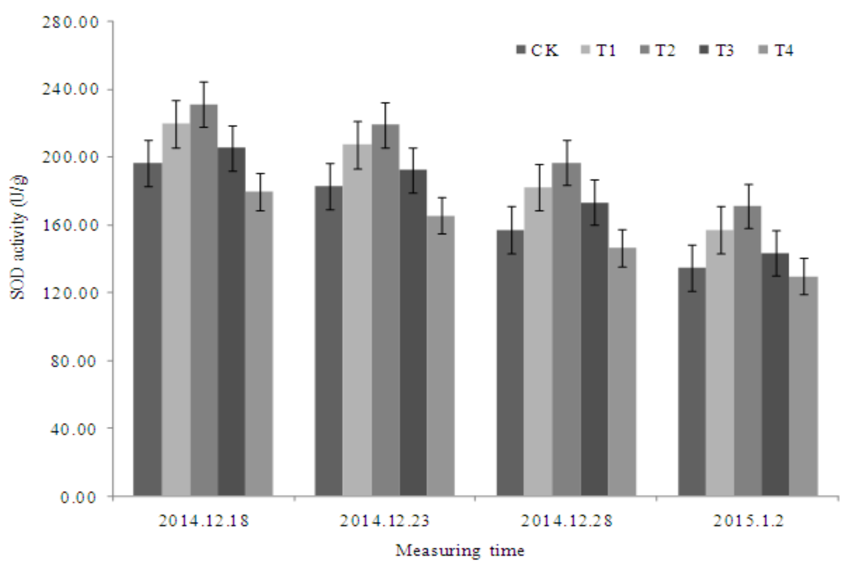

Fig. 6: Effect of different salt stress on SOD activity weight of dryland wheat seedlings

T3>CK>T4, we can find that T2 was the highest and T4 was the lowest. On Jan. 2nd, the SOD activity of the control CK was 135.08 U/g and SOD activity of T1, T2, T3 and T4 were respectively 1.16, 1.27, 1.06 and 0.96 times that of CK, so the SOD activity of T2 showed the highest when T4 was the lowest.

DISCUSSION AND CONCLUSION

In agricultural production, some morphological characteristics such as leaf, plant height and dry matter accumulation may reflect the growth status of wheat and is essential to measure wheat yields. Superoxide Dismutase (SOD) and Peroxidase (POD) are physiological characteristic indicators of measuring whether wheat leaves would be decline and fall or not, which is essential to delay the decline of wheat plant (Dandan and Yan, 2013). Free radicals could cause plant membrane lipid peroxidation and reactive oxygen damage, promote cell senescence, but SOD would remove excess free radicals in organic to keep the plant owning a permanent health status (Zhiguang *et al*., 2002; Yongsheng and Jishuang, 2005). POD presents in the cell peroxide and could eliminate hydrogen peroxide, phenols and amines and other harmful substances and it is one of the critical enzymes of active oxygen scavenging system (Jianwei and Hong, 2014). Excessive salt stress can cause cell parenchymal damage and reduce POD vitality. Some studies have shown that salt stress has a certain inhibition on the growth of wheat seedlings (Yanfei, 2010); The effect of different NaCl concentrations on growth and endogenous hormone of wheat varies with NaCl concentrations' changes (Haiying and Changhai, 2011); Seedling emergence rate and plant height of wheat decreased with the increase of soil salinity (Jianhua and Yuejin, 2007); Some study has pointed out that SOD and POD activity of seedlings increased with the increase of salt stress concentration and SOD activity decreased and POD increased with the extension of salt stress time (Min and Runguo, 2010); The low salt stress could increase the peroxide hydrogen enzyme activity, chlorophyll content and proline content, but high salt stress significantly would reduce them (Enliang, 2009).

The experimental results indicated that different salt stress had different effects on the growth and physiological characteristics of dryland wheat. Leaf length, plant height, aboveground and underground fresh weight in different treatments turned out to be increasing firstly and then decreasing with the increase of salt stress, with specific performance of T2>T1>T3> CK>T4; Within a certain range of salt stress, salt stress could increase leaf length, plant height and promote the accumulation of dry matter in wheat seedlings, but if the salt stress range was exceeded, excessive salt stress would inhibit the growth of wheat seedlings; The leaf length, plant height, aboveground and underground fresh weight of the treatment T2 showed the maximum under 0.2% salt stress. The results are almost consistent with the previous research (Yanfei, 2010; Jianhua and Yuejin, 2007). Thus, a reasonable salt stress could promote the growth of dryland wheat seedlings, but excessive salt stress was unfavorable to wheat growth.

The experimental results also showed that the SOD and POD activity of all treatments presented an overall performance of T2>T1>T3>CK>T4, with T2 being the highest and T4 showing the lowest. Among these treatments, 0.2% salt stress of T2 was the most conducive to increase SOD and POD activity in dryland wheat seedlings. This result is slightly different from Min and Runguo (2010). It may be inferred that appropriate salt stress would be better to scavenge reactive oxygen species, maintain a healthy growth environment for wheat and promote better growth of dryland wheat seedlings.

ACKNOWLEDGMENT

Supported by the program of "The research on the efficient use technology and demonstration of nitrogen fertilizer in main crops (201203079)"; "Integrated research and demonstration of the balanced increase in winter wheat and summer maize in Shandong Province (2012BAD04B05)"; Funded by Shandong Modern Agricultural Technology and Industry System-cultivation and soil fertilizer (SDAIT-04-022-08) and the Innovation team of high water use efficiency in Dryland Crop of Shandong Province and The wheat and maize Collaborative Innovation Center in Shandong Province.

REFERENCES

Aiguo, W., L. Guanghua and S. Congben, 1983. Study on superoxide dismutase in soybean seeds. J. Plant Physiol., 9(1): 77-83.

Chunyan, L., Z. Guangyong and W. Weixing, 2015. Effects of NaCl stress on germination and growth of tomato seedling. Agric. Res. Appl., 1(1): 19-22.

Dandan, L. and S. Yan, 2013. Effects of controlled release fertilizer on the flag leaves senescence in dry-land wheat. Adv. J. Food Sci. Technol., 5(05): 557-560.

Enliang, L., 2009. Effects of three kinds of salt stress on physiological functions of wheat in trefoil period. Xinjiang Agric. Univ., 32(6): 21-25.

Haiying, L. and C. Changhai, 2011. Effects of salt stress growth and endogenous hormone in wheat seedlings with the application of organic manure. J. Ecol., 31(15): 4215-4224.

Hecheng, L., 2000. The Principle and Technology of Plant Physiology and Biochemistry Experiment. Higher Education Press, Beijing.

Jianhua, G. and L. Yuejin, 2007. Effects of three kinds of salt stress on growth of wheat seedlings. North China Agric. Univ., 22(3): 148-150.

Jianwei, L. and Z. Hong, 2014. Determination of germination and physiological indices of wheat seeds under salt stress. Nat. Sci. J. Harbin Normal Univ., 30(3): 133-136.

Jinfang, Z. and L. Jingtao, 2015. Effects of salt stress on physiological characteristics of China's Liu seedlings. J. Ecol., 35(15): 1-9.

Jing, Z., X. Qiang and Z. Ting, 2015. Effects of NaCl stress on physiological and biochemical characteristics of different varieties of pepper seedlings. Northwest Agric. Forestry Univ., 2(2): 120-125.

Kefu, Z. and L. Fazeng, 1999. Chinese Halophytes. Science Press, Beijing.

Min, Z. and C. Runguo, 2010. Effects of salt stress on antioxidant enzymes system in wheat seedling germination period. Hebei Normal Univ., 24(3): 15-18.

Nan, H. and S. Yuwei, 2014. Effects of salt stress on photosynthetic fluorescence and antioxidant enzyme activity in maize seedlings leaves. Mod. Agric. Sci. Technol., 24: 36-40.

Tailiang, W. and H. Zhaosheng, 2015. Effects of NaCl stress on physiological and biochemical characteristics of Bermuda grass. Grassland Turf., 35(1): 63-67.

Yanfei, Y., 2010. Effects of salt stress on morphological and physiological characteristics of wheat. Nanjing Agric. Univ., (6): 18-19.

Yongsheng, G. and C. Jishuang, 2005. Effects of lanthanum on antioxidant system activity in wheat seedling leaves under salt stress. Chinese Rare Earth Soc., 23(4): 490-495.

Zhanli, H. and S. Yan, 2014. Effects of super absorbent resin on soil characteristics in dry-land wheat. Adv. J. Food Sci. Technol., 6(4): 480-483.

Zhiguang, Q., H. Zhanjing and S. Yinzhu, 2002. Effects of salt stress on superoxide dismutase activity in salt tolerance mutant wheat seedlings. Hebei Normal Univ., 26(4): 406-409.

Zhiping, L. and X. Shoujun, 2014. Effects of NaCl stress on growth and photosynthetic characteristics of barley seedlings. Barl. Cereal Sci., 4: 1-7.