Effect of carboxin seed dressing on emergence, coleoptile length and primary leaf growth of wheat and barley

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Summary

The effects of treating seed with carboxin (0, 0.25, 0.5, 0.75, 1, 1.5, 2, 3 and 5 g kg^{-1} seed) on emergence, coleoptile length and primary leaf growth of barley (*cvv.* Grimmett and Prior) and wheat (*cv.* Banks) were measured at 15, 20, 25 and 30°C.

Carboxin increased the coleoptile length of Grimmett at 15°C and of Prior at 15 and 20°C, but shortened Prior coleoptiles and reduced Prior emergence at 25 and 30°C. The improvement in coleoptile length of barley at 15 and 20°C was not significantly increased above 1 g kg^{-1} seed. The highest rate of carboxin (5 g kg^{-1}) shortened coleoptiles of Banks at all four temperatures.

Carboxin also reduced primary leaf length in 11 of the 12 cultivar × temperature treatments.

Introduction

In Queensland, deep sowing (80 to 100 mm) of winter cereals is often necessary in order to place seed into moist soil. However, recent cultivars of wheat and malting barley have shorter coleoptiles than their predecessors (Whan 1976*a*, Radford 1987*a*). Short coleoptiles in association with deep sowing have reduced the establishment of wheat and barley (Whan 1976*b*, Radford 1987*a*) and reduced the vigour of barley seedlings (Kaufmann 1968). Wheat cultivars sown deeper than their maximum coleoptile length suffer major reductions in emergence (Whan 1976*b*). A means of increasing coleoptile length would therefore be useful.

The systemic fungicide carboxin, when used as a seed dressing, has increased the coleoptile length of barley by 10 to 17 mm and also increased field establishment (Radford and Wildermuth 1987). Apparently, this fungicide can act as a growth regulator. Such action may be stimulatory or inhibitory depending on the concentration of the chemical (Tukey 1969).

Carboxin is used at a rate of 0.25 g kg^{-1} seed to control covered smut (*Ustilago hordei* [Pers.] Lagerh.) in barley and at a higher rate of 0.94 g kg^{-1} seed to control loose smut (*Ustilago nuda* [Jens.] Rostr.) in wheat and barley.

This paper reports the effects of different rates of carboxin seed treatment on the emergence, coleoptile length and primary leaf growth of barley and wheat at four temperatures. Since high temperatures severely shorten the coleoptiles of wheat (Burleigh *et al.* 1964, Radford 1987*b*) and barley (Radford 1987 *a*), technology for increasing coleoptile length at high temperatures would help overcome establishment problems in winter cereals.

Materials and methods

Seed of barley (*cvv.* Grimmett and Prior) and wheat (*cv.* Banks) treated with different rates of carboxin were germinated at 15, 20, 25 and 30°C. Seeds were placed 10 mm deep in 60 mm of a mix containing equal portions of sand and peat moss at approximately 29% gravimetric water content. Plantings were made in boxes sealed to exclude light and to minimize water loss. Time was allowed for the primary leaves of the seedlings to emerge from their coleoptiles (12 days at 15°C, 8 days at 20°C, 7 days at 25°C and 6 days at 30°C).

Treatments

The 10 seed treatments are listed in Table 1. There were two control treatments: untreated seed and seed with a coating of talc (equal to the highest rate of carboxin). Inert seed coatings, such as talc, can affect the germination and field establishment of some pasture grass species (Scott 1975, Dowling 1978). Where only small quantities of carboxin were applied, the chemical was mixed with talc to ensure even distribution (Table 1). Seed dressings were applied as dry powder and tumbled with the seed for 30 min to ensure thorough mixing. The untreated seed was also tumbled.

Table 1 Rates of carboxin and talc in treatments

Carboxin (g kg^{-1} seed)	Vitavax 75®* (g kg^{-1} seed)	Talc (g kg^{-1} seed)
0	0	0
0	0	6.67
0.25	0.33	1.00
0.50	0.67	0.67
0.75	1.00	0.33
1.00	1.33	0
1.50	2.00	0
2.00	2.67	0
3.00	4.00	0
5.00	6.67	0

* Vitavax 75®, which contains 75% carboxin, was used as the source of carboxin.

Design

Each treatment consisted of 20 seeds sown in a single row 300 mm long. Different treatments were sown in rows 40 mm apart in the same box. Boxes were used as replicates. Design was a randomized block with four replications.

Measurements

Seedling emergence was determined by counting the number of seedlings equal to or longer than 10 mm (seedling depth). Seedlings were removed and their coleoptiles and primary leaves measured from seed to tip.

Statistical analysis

All experiments were analysed by factorial analysis of variance.

Results

Emergence

Carboxin did not affect the emergence of Grimmett ($P > 0.05$) at any temperature or Prior at 15 and 20°C (Figure 1). However, at 25 and 30°C, rates of carboxin between 1 and 5 g kg^{-1} significantly ($P < 0.05$) reduced the emergence of Prior.

Carboxin had no significant ($P > 0.05$) effect on the emergence of Banks at 15, 20 or 30°C, but at 25°C some significant ($P < 0.05$) differences occurred (Figure 1).

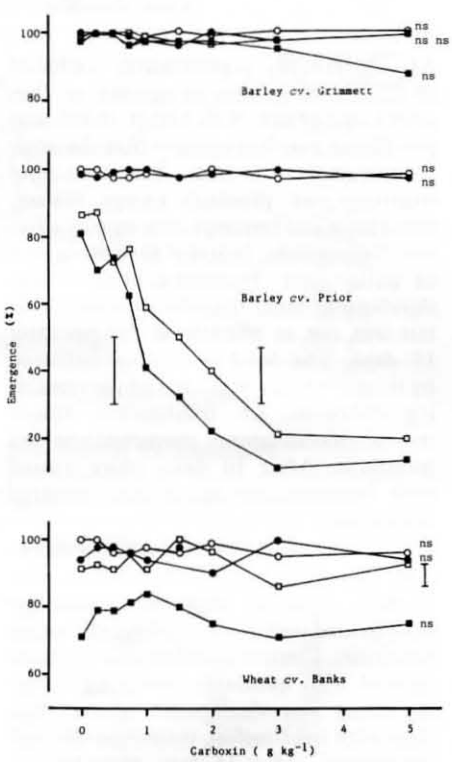

Figure 1 Effect of rate of carboxin seed treatment on emergence of barley (*cvv.* Prior and Grimmett) and wheat (*cv.* Banks) at 15°C (○), 20°C (●), 25°C (□) and 30°C (■). (Vertical bars indicate l.s.d. (P = 0.05); ns, not significant.)

Wheat emergence was consistently lower at 30°C than at 15, 20 or 25°C.

Talc had no effect on the germination of any cultivar at any temperature.

Coleoptile length

Carboxin had a significant effect on the final coleoptile length of Grimmett only at 15°C (Figure 2). At this temperature, seed treated at 0.5 to 5 g kg^{-1} had significantly longer coleoptiles ($P<0.05$) than untreated seed.

Carboxin affected the coleoptile elongation of Prior at all four temperatures (Figure 2). At 15 and 20°C, carboxin caused increases ($P<0.05$) in coleoptile length, and at 25 and 30°C reductions ($P<0.05$). Quantities of 1 to 5 g kg^{-1} generally increased coleoptile length at 15 and 20°C.

There were no significant ($P>0.05$) increases in the coleoptile length of Banks with carboxin treatment, but 5 g kg^{-1} shortened Banks coleoptiles at all temperatures, and 3 g kg^{-1} shortened them at 15, 20 and 25°C ($P<0.05$) (Figure 2).

In general, talc did not affect coleoptile length.

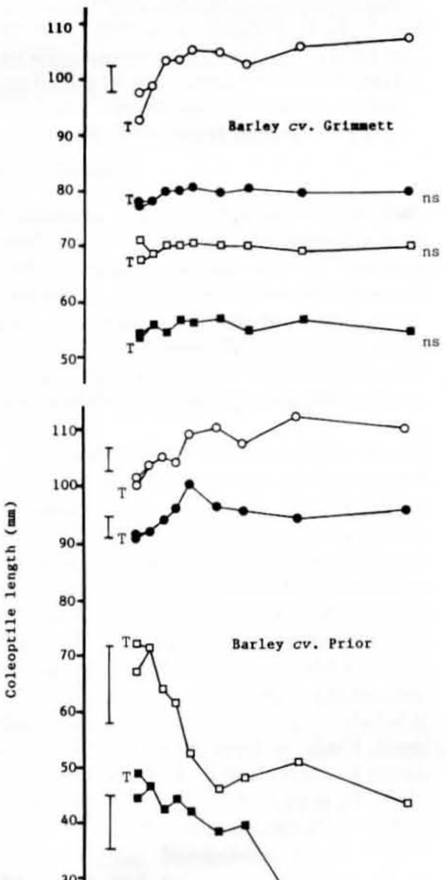

Figure 2 Effect of rate of carboxin seed treatment and talc (T), on coleoptile length of barley (cvv. Prior and Grimmett) and wheat (cv. Banks) at 15°C (○), 20°C (●), 25°C (□) and 30°C (■). (Vertical bar indicates l.s.d. (P = 0.05); ns, not significant.)

Primary leaf length

High rates of carboxin reduced ($P<0.05$) primary leaf length in 11 of the 12 cultivar × temperature treatment combinations (Figure 3). There was a similar, but non-significant, trend for Prior at 30°C.

Talc had no effect.

Discussion

Carboxin seed-dressing increased the final coleoptile length of both barley cultivars at 15°C and of Prior at 20°C. Rates above 1 g kg^{-1} caused no further increase. Temperatures between 15 and 20°C commonly occur in seedbeds in Queensland between May and August when winter cereals are sown. For example, Purss (1971) showed that the maximum soil temperature during this period at a depth of 76 mm at Millmerran was 20°C.

When carboxin increased coleoptile length, however, it also reduced primary leaf length, particularly at the high rates. This indicates that rate of seedling growth and hence seedling vigour could be adversely affected by carboxin application. Furthermore, Lovett and Jessop (1982) have shown that substances which stimulate the elongation of wheat coleoptiles often inhibit root growth. Such inhibition in a dry seedbed could adversely affect seedling emergence. Nevertheless, Radford and Wildermuth (1987) found that carboxin treatment of barley seed increased field establishment after deep sowing without reducing the rate of field emergence.

At 25 and 30°C, carboxin application at rates as low as 1 g kg^{-1} seed reduced the emergence and coleoptile length of Prior as well as the length of the primary leaf. These combined reductions would be a severe disadvantage with respect to field establishment at these temperatures. High rates of carboxin application may also cause establishment problems with wheat. Hohenhaus and Heslehurst (personal communication) found that carboxin reduced the germination and coleoptile length of five wheat cultivars (Bass, Flinders, Kite, Sunstar and Vasco).

Carboxin consistently reduced the primary leaf length of wheat and barley seedlings and either increased or reduced coleoptile length. Its systemic action as a growth regulator may therefore have altered the relative growth rates of coleoptile and primary leaf. This apparently allowed more time for coleoptile elongation prior to emergence of the primary leaf in barley at low temperatures (15 to 20°C). The interaction with temperature is probably a result of different optimal temperatures for growth of the coleoptile and the primary leaf (Allan *et al.* 1962).

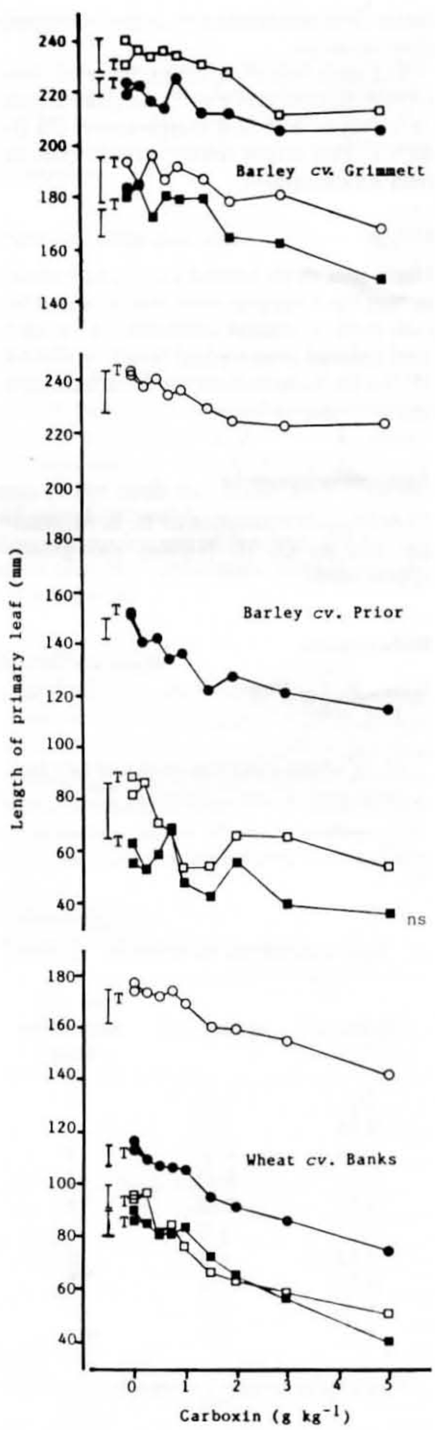

Figure 3 Effect of rate of carboxin seed treatment and talc (T), on the length of the primary leaf of barley (cvv. Prior and Grimmett) and wheat (cv. Banks) at 15°C (○), 20°C (●), 25°C (□) and 30°C (■). (Vertical bar indicates l.s.d (P = 0.05); ns, not significant.)

Conclusions

Barley

Carboxin seed dressing at 1 g kg^{-1} seed (the rate used to control loose smut) can increase the length of barley coleoptiles at the temperatures found in seedbeds at conventional sowing times in Queensland (May to August). Such increases should result in better field establishment, especially from deep sowings.

The same rate of carboxin, however, can reduce the emergence and coleoptile length of barley at high soil temperatures (25 to 30°C). This could result in reductions in field establishment.

Wheat

High rates of carboxin (3 to 5 g kg^{-1} seed) reduce the coleoptile length of wheat. The rate used to control loose smut (1 g kg^{-1} seed reduced primary leaf length at 20 and 25°C. Such reduction could affect field establishment adversely.

Acknowledgments

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