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Seed Yield Response to Fungicide Application in Paclobutrazol Treated Perennial Ryegrass¹

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ABSTRACT

Fungicide application (triadimefon plus carbendazim plus captafol) at monthly intervals from tillering (February) until harvest (July) to perennial ryegrass cv. S24 treated with the growth retardant paclobutrazol (PP333) at spikelet initiation (March), increased seed yield in 1981 and 1982 by increasing the number of seeds per spikelet. Seed yield responses to fungicide application in these non-lodged crops were not as great as those previously reported for lodged crops.

The incidence of leaf pathogens in both years was low. Fungicide application increased leaf area duration by delaying the senescence of photosynthetic tissue. The importance of source size and duration in the perennial ryegrass seed crop is discussed.

Additional index words: *Lolium perenne* L., seed production, seeds per spikelet, leaf senescence, leaf area duration.

INTRODUCTION

Seed yields in the perennial ryegrass (*Lolium perenne* L.) seed crop are usually around one-tenth of the theoretical

potential because of poor seed site utilization (Hampton and Hebblethwaite, 1983). Recent experiments with chemical manipulation of the crop have shown that both growth retardant and fungicide application can significantly increase seed yield (Hebblethwaite et al., 1982; Hampton and Hebblethwaite 1984; 1985a).

Poor seed site utilization resulting from seed abortion has been associated with lodging of the crop (Hebblethwaite et al., 1980). Hampton and Hebblethwaite (1985a) suggested that seed abortion occurred because of assimilate shortage, due to competition from the elongating stem (Clemence and Hebblethwaite, 1984) and from vegetative tillers (Hampton, 1983), as well as from a loss of photosynthetic tissue in a lodged canopy.

Fungicide application to lodged crops increased seed yield by increasing the number of seeds per spikelet. Hampton and Hebblethwaite (1984) showed that these increases were associated with an increased leaf area duration brought about by delays in senescence of photosynthetic tissue. Seed yield increases in response to growth retardant application have also been associated with increased numbers of seeds per spikelet (Hebblethwaite et al., 1980; 1982), although recent experiments with paclobutrazol (PP333) have demonstrated that increased fertile tiller production also contributed to seed yield increases (Hampton and Hebblethwaite, 1985a).

Paclobutrazol has fungicidal properties (Froggatt et al., 1982), and Hampton and Hebblethwaite (1985a) showed that one effect of its application was to increase leaf area duration. However, the effects of the fungicidal properties of the chemical and the delay in leaf tissue death because of the absence of lodging could not be differentiated. Trials in 1981 and 1982 examined whether the substantial seed yield increases obtained from paclobutrazol application could be further increased by fungicide application.

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MATERIALS AND METHODS

Experiments were carried out at the University of Nottingham Experimental Farm, Sutton Bonington, Loughborough, Leics., U.K. Certified basic seed of perennial ryegrass cv. S24 was sown in the autumn of 1980 and 1981 at 12 kg ha⁻¹ with a row width of 15 cm in plots 1.5 x 12 m. In 1981, all plots received 160 kg N ha⁻¹ on 19 March, and in 1982, 120 kg N ha⁻¹ on 25 March. Paclobutrazol was applied at 2.0 kg a.i. ha⁻¹ in 250 l water ha⁻¹ to all plots at spikelet initiation (24 March 1981; 30 March 1982). Other experimental details have been previously described (Hampton and Hebblethwaite, 1985a).

Fungicide (Bayer UK087 = triadimefon 6.25%, carben-dazim 10%, captafol 40%) was applied as 2 kg product ha⁻¹ in 250 l water ha⁻¹ (Hampton and Hebblethwaite 1984). In both years, treatments were either nil or full (six applications between 18 February 1981 and 10 July 1981; five applications between 4 March 1982 and 28 June 1982, at 3-4 week intervals). Treatments were replicated four times in a randomized block design.

Foliar damage was assessed by selecting 10 tillers at random from each plot and scoring for diseased tissue and senesced tissue using percentage keys (Anon., 1976). Leaf area index (LAI) was determined using an electronic planimeter, and leaf area duration (LAD) was determined by graphing LAI over time (77 days in 1981, 79 days in 1982), and determining the area under the curve. Methods for growth analysis, determining yield potential and yield components have been previously described (Hampton and Hebblethwaite, 1985a). Seed was harvested at 40% seed moisture content by cutting an area of 5.5 m² from each plot with a reciprocating knife mower, and cool air drying the cut material to 12-15% straw moisture content before the seed was threshed and cleaned. Yield results are expressed as 0% moisture content.

RESULTS

Lesions, Leaf Area and Senescence

Before ear emergence in both years, treatment differences

in the percentage of leaf tissue with fungal lesions, and the percentage of senesced tissue were not significant. However, when compared with data for untreated plots (Hampton, 1983), both paclobutrazol and fungicide application reduced the level of infection by leaf pathogens, and slowed down the rate of leaf tissue senescence (e.g. Table 1). As previously reported (Hampton and Hebblethwaite, 1984), the incidence of leaf pathogens in both years was low, and from ear emergence until harvest, no significant treatment differences were recorded.

Prior to peak anthesis (8 June 1981; 6 June 1982), differences in total photosynthetic area index and in reproductive leaf area index were not significant (Table 2). From anthesis on, reproductive LAI was increased by fungicide application, and leaf area duration was also increased (Table 2).

Table 2. The effect of fungicide application to paclobutrazol treated perennial ryegrass on reproductive leaf area index (LAI) and leaf area duration (LAD days).

| Treatment | LAI | | LAD | |
|---------------------------|------------------------|------|-------|------|
| Date of Assessment | | | | |
| 1981 | 18 May 3 June 22 July | | | |
| —fungicide | 2.7 | 4.1 | 1.5 | 39.3 |
| +fungicide | 2.8 | 5.4 | 3.1 | 49.0 |
| S.E.D. (7 d.f.) | 0.9 | 0.4* | 0.5* | 4.1* |
| LSD .05 | NS | 1.0 | 1.2 | 9.7 |
| Date of Assessment | | | | |
| 1982 | 10 May 11 June 29 July | | | |
| —fungicide | 0.4 | 2.6 | 0.4 | 47.9 |
| +fungicide | 0.1 | 3.0 | 1.1 | 52.6 |
| S.E.D. (7 d.f.) | 0.2 | 0.5 | 0.1** | 3.6 |
| LSD .05 | NS | NS | 0.2 | NS |

*Significant at P=.05

**Significant at P=.01

Table 1. The effect of paclobutrazol and fungicide application to perennial ryegrass on the percentage of leaf tissue with i) fungal lesions; ii) senesced tissue 25 April 1981.

| Treatment | Flag leaf | | Penultimate leaf (leaf two) | | Subpenultimate leaf (leaf three) | |
|----------------------------|----------------------|------------|--------------------------------|------------|-------------------------------------|------------|
| | lesions ² | senescence | lesions | senescence | lesions | senescence |
| Nil ¹ | 11.8 | 15.6 | 11.9 | 40.3 | 7.0 | 68.7 |
| Paclobutrazol | 1.7 | 9.5 | 2.7 | 19.9 | 2.6 | 40.2 |
| Fungicide (2 applications) | 1.4 | 6.4 | 1.9 | 18.4 | 2.2 | 36.6 |
| S.E.D. (11 d.f.) | 1.3** | 1.9** | 0.9** | 2.3** | 1.1** | 2.7** |
| LSD .05 | 2.9 | 4.2 | 2.0 | 5.1 | 2.4 | 5.9 |

¹data from Hampton (1983)

²mainly *Drechslera* spp.

**Significant at P=.01

Crop Growth

In 1981, fungicide application reduced the number of autumn induced fertile tillers killed by eyespot (*Pseudocercospora herpotrichoides* (Fron.) Deighton) (Hampton and Hebblethwaite, 1984), so that at anthesis, fertile tiller numbers differed significantly (Table 3). However, by final harvest, the number of fertile tillers was similar for both treatments. In 1982, fertile tiller numbers did not differ significantly.

Fungicide application did not significantly increase total dry matter (DM) accumulation, although from anthesis on, reproductive leaf DM was increased in both years (data not presented).

Yield Potential

At anthesis in both years, the number of florets per spikelet and spikelets per tiller did not differ between treatments (Table 3).

Table 3. The effect of fungicide application to paclobutrazol treated perennial ryegrass on seed yield potential measured at anthesis, 1981 and 1982.

| Treatment | Mean floret number per spikelet | Mean spikelet number per tiller | Fertile tillers (m ⁻²) |
|-----------------|---------------------------------|---------------------------------|------------------------------------|
| 1981 | | | |
| —fungicide | 8.51 | 23.4 | 4477 |
| +fungicide | 8.76 | 22.6 | 5313 |
| S.E.D. (7 d.f.) | 0.37 | 0.56 | 326.4* |
| LSD .05 | NS | NS | 773.6 |
| 1982 | | | |
| —fungicide | 7.55 | 21.9 | 3415 |
| +fungicide | 8.13 | 22.4 | 4131 |
| S.E.D. (7 d.f.) | 0.32 | 0.38 | 315.7 |
| LSD .05 | NS | NS | NS |

*Significant at P=.05

Seed Yield and Yield Components

Fungicide application increased seed yield by 16 g m⁻² in 1981 and 28 g m⁻² in 1982, but only the latter increase was significant (Table 4). The increased number of seeds per unit area were explained by an increase in the number of seeds per spikelet, as other seed yield components did not differ significantly (Table 4).

DISCUSSION

The response obtained from fungicide application to an erect crop was similar to that obtained by Hampton and Hebblethwaite (1984) in a lodged crop--an increase in LAD and a reduction in seed abortion. Developing seeds may abort because seed growth is inhibited hormonally (Evans et al., 1975), or because assimilate supply is limited (Mohamed and Marshall, 1979). In the perennial ryegrass seed crop, it appears highly likely that assimilate shortage is the most important factor influencing the number of seeds per spikelet (Hebblethwaite et al., 1980; Hampton and Hebblethwaite, 1985b).

Lodging has been shown to restrict light interception and reduce the efficiency of photosynthesis (de Wit, 1965). Woledge (1972) showed that shading of photosynthetic tissue reduced the longevity of grass leaves and increased the rate of decline of net photosynthesis in relation to age. Prevention of lodging by paclobutrazol application has been shown to increase leaf area duration (Hampton and Hebblethwaite, 1985a), and to increase assimilate flow to the ear from the leaves (Hampton 1983). Jaggard et al., (1982) also suggested that paclobutrazol treated plants may have a greater photosynthetic capability because of an increased net photosynthesis rate.

Hampton (1983) demonstrated that the ears of paclobutrazol treated plants were better able to compete with other sinks, (particularly the elongating stem and vegetative tillers), for assimilate supply. However, net movement of

Table 4. The effect of fungicide application to paclobutrazol treated perennial ryegrass on seed yield and yield components, 1981 and 1982.

| Treatment | Seed yield (gm ⁻²) | Fertile tillers (m ⁻²) | Spikelets per tiller | Seeds per spikelet (calc) | T.S.W. (g) | Seed number m ⁻² x 10 ⁴ (calc) |
|-----------------|--------------------------------|------------------------------------|----------------------|---------------------------|------------|--|
| 1981 | | | | | | |
| —fungicide | 172.2 | 3567 | 20.3 | 1.23 | 1.93 | 8.93 |
| +fungicide | 187.9 | 3646 | 20.2 | 1.32 | 1.93 | 9.73 |
| S.E.D. (7 d.f.) | 12.8 | 281.6 | 0.56 | 0.09 | 0.04 | 0.65 |
| LSD .05 | NS | NS | NS | NS | NS | NS |
| 1982 | | | | | | |
| —fungicide | 256.8 | 3415 | 20.9 | 2.02 | 1.77 | 14.47 |
| +fungicide | 284.5 | 3472 | 20.1 | 2.17 | 1.87 | 15.18 |
| S.E.D. (7 d.f.) | 9.1* | 293.7 | 0.45 | 0.04* | 0.11 | 0.49 |
| LSD .05 | 21.6 | NS | NS | 0.09 | NS | NS |

*Significant P=.05

assimilate was still down the plant to the vegetative tillers. Results from this trial suggest that even in non-lodged paclobutrazol treated plants, the area of actively photosynthesising tissue was insufficient to meet all the demands from the various sinks. Delaying leaf tissue senescence through fungicide application may have provided a greater photosynthetic source and allowed more seeds per spikelet to be retained through until harvest.

The use of fungicides in the perennial ryegrass seed crop requires further investigation. Trials in both lodged and upright crops have demonstrated that sequential fungicide applications delayed leaf tissue senescence in the absence of leaf pathogens, and possible reasons for this have been previously discussed (Hampton and Hebblethwaite, 1984). However, there is still little information available as to the effects of pathogens on seed production (Labruyere, 1980), and the effects of single critically timed fungicide applications on seed yield, as sequential applications are not financially viable. Recent work (Hampton, 1983; Hampton and Hebblethwaite, 1985a) has suggested that the photosynthetic capacity of the plant between ear emergence and anthesis strongly influences the number of seeds retained per spikelet. The effects of fungicide application at this time need to be evaluated.

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