Abstract  A series of field demonstrations and experiments implemented from 1995 to 1998 in northern New South Wales confirmed that late post-emergence applications of flamprop-M-methyl (112.5 to 225.0 g a.i. ha\(^{-1}\)) to wild oat (\textit{Avena} spp.) infested wheat crops greatly reduced wild oat seed production without unnecessary crop damage. The main benefits of this technique include the prevention or management of group A herbicide resistant wild oat populations and the ability to dramatically deplete wild oat seedbanks, and consequently reduce next seasons’ infestations. To fully understand the persistence of this weed, a change in attitude from that of treating the weed as an annual phenomenon to that of treating a longer-term infestation is required.

INTRODUCTION

Medd \textit{et al.} (1992) introduced the concept of ‘selective spray-topping’ (SST) to describe the technique of late post-emergence application of selective herbicides in a crop to reduce weed seed production. The objective of the SST technique differs from the traditional use of pre- or early post-emergence herbicides where the aim is to reduce competition from weeds, conserving crop yield.

Because of its short-lived seedbank, wild oats was the initial weed targeted for testing of SST, and a modified use pattern for flamprop-M-methyl was registered in April 1999 to embrace the technique. Further testing of SST using other herbicides on broadleaf weeds is showing promising results, particularly on Brassicaceaeous weeds (Madafiglio \textit{et al.} 1995, 1999).

Recruitment of wild oat seedlings occurs over a protracted period from autumn to spring, with the main cohorts occurring generally early in the life of a winter crop. Control traditionally targets these early cohorts to reduce competition. However seed production from escapes, survivors or new recruits which emerge after in-crop control treatments are undertaken, are the likely main cause of wild oats persistence. Medd \textit{et al.} (1995) showed, as predicted, that if seed production is reduced from the residual plants, wild oat populations are depleted dramatically. The depletion of populations through this or other means such as winter fallowing and summer cropping provides significant economic benefits (Jones and Medd 1997).

Ideally, SST should be delayed until recruitment is complete to ensure that all plants with a potential to reproduce are targeted. However, Cook (1998) determined from pot and field studies that there is an apparent optimum wild oat growth stage of 20\% tillers elongating (approximately Zadoks DC 31 to 32) when SST should be undertaken. To achieve maximum impact from SST, therefore, the arrival of the optimum growth stage needs to coincide with cessation of recruitment. Consequently, deciding on the time for application of SST herbicides will often be a compromise between going early to minimize seed production of the earlier cohorts and waiting for recruitment to cease so as to maximize abortion of late recruits.

Notwithstanding the apparent optimum growth stage for SST, a practical ‘timing window’ was purported by Cook (1998), starting when wild oats commence jointing (Zadoks DC 31) and finishing at mid-booting (Zadoks DC 45). Cook (1998) also found the development of wheat and wild oats was closely correlated (\(y = 1.19x, r^2 = 0.77\)) and the SST ‘timing window’ lasts for 20 to 30 days.

However, Cook (1998) also found that flamprop-M-methyl applied at half of the recommended dose rate (RDR) specified for plant control, when applied at the commencement of the ‘timing window’, resulted in significantly less wild oat seed production than full RDRs applied at the end of the ‘timing window’. Therefore, substantial cost savings would result if SST applications were made early in the ‘timing window’ near or just prior to the apparent optimum wild oat growth stage, when half RDRs would suffice.

To test the robustness of these timing and dose rate findings, a number of demonstration trials were undertaken throughout northern New South Wales during 1995 to 1998 to promote SST.
MATERIALS AND METHODS

All treatments were conducted in commercial wheat crops infested naturally with wild oats with densities below 50 plants m$^{-2}$. Eight wheat cultivars (Kamillaroi, Wollaroi, Janz, Sunelg, Sunlin, Hartog, Sunstate and Suneca) were involved in the trials.

Flamprop-M-methyl was the only herbicide used in both the replicated experiments (years 1995, 1997-8) and unreplicated demonstrations (year 1996). The rates of flamprop-M-methyl used were either half, three quarters and full RDRs, with the full RDR being 225 g a.i. ha$^{-1}$. An adjuvant, Uptake®, was added to the half and three quarters RDR treatments of flamprop-M-methyl on most occasions at a rate of 5mL L$^{-1}$. Experiments conducted in 1997 also involved the addition of another adjuvant, Hasten® at a rate identical to that of Uptake®, to the three quarter RDR treatment. These adjuvants were required with the lower herbicide rates to possibly improve herbicide efficacy.

Replicated experiments consisted of a randomised complete block design with three (1995: Bellata) or four (1997-8: Somerton, Boggabri and Merriwa) replications per treatment. Treatment plot dimensions were 4 m by 10 m, the middle three metres of the 4 m width was sprayed with a small hand-hell boom. The CO$_2$ pressurised boom was fitted with 800L Teejet® flat fan nozzles, applying a spray volume between 122 or 125 L ha$^{-1}$.

In 1996, the unreplicated demonstrations were treated with an 8 m wide commercial boom fitted with Hardi® 110-12 nozzles mounted onto a four wheel drive traytop vehicle. Spray volume was 60 L ha$^{-1}$. Size of treatment plots were generally 8 m x at least 100 m. Sixteen sites were sprayed for the demonstrations, covering a region south to Merriwa, east to Tamworth, north to Moree and west to Coonamble in northern NSW. The Coonamble site was not assessed.

Wild oats were sprayed just prior to, after and mostly within the SST ‘timing window’. A general description of wheat growth stages were recorded at the time of spraying using the methods described by Zadoks et al. (1974), a technique that places emphasis on the main tiller. More detailed assessments of the wild oat growth stages were achieved using the same technique as wheat but the method was used on all wild oat tillers. The tiller growth stages were categorised into either vegetative or elongating stages. The elongating category also included tillers that were in the booting or inflorescence stage. Therefore the vegetative tillers were defined as those that were equal to or less than Zadoks DC 20 and elongating tillers were more advanced than Zadoks DC 20.

Wheat yields were taken at nine sites (three replicated experiments and six demonstrations sites) by hand harvesting four 0.25 m$^2$ quadrats per plot, except in 1997 when a small plot harvester took 14.8 m$^2$ per plot. Harvested samples were used to determine 1,000 wheat kernel weights.

Wild oats were assessed by either counting panicles per 10 m$^2$ (1995), harvesting four 0.25 m$^2$ quadrats per plot (1996-8) or by collecting 10 or 20 random wild oat plants (1996). Harvested wild oat plants were processed to determine either the reduction in seed production (seed m$^{-2}$) or fecundity (seeds plant$^{-1}$) of wild oats, relative to the untreated control plants.

RESULTS

Reducing seed production of wild oats As depicted in Figure 1, high levels of herbicide efficacy (> 70% reduction in reproductive capability of wild oats) were evident across most wild oat growth stages. This occurred for 22 out of 23 treatments, with the only exception, a 51% reduction in wild oat fecundity at full RDR. This is possibly a chance result since the half RDR at the same site resulted in an 84% reduction. The figure also shows that there was little difference between flamprop-M-methyl at full RDRs compared with half RDRs plus Uptake® adjuvant. Herbicide efficacy remained constant across the range of wild oat growth stages. It was noted that the best results occurred in crops with an excellent competitive nature, regardless of the wild oat growth stage. Furthermore, moisture stress or disease was not considered to be a limiting factor.

Wild oat contamination in harvested wheat was reduced greatly by using the technique of SST (Table 1). Contamination, relative to the untreated control was reduced by 62 to 92% and 83 to 97% for the Somerton and Boggabri sites, respectively. Crop competitiveness at the Boggabri site was considered greater than the Somerton site and therefore herbicide efficacy tended to be better at the Boggabri site. Addition of Uptake® significantly reduced wild oat contamination of wheat treated with flamprop-M-methyl at the three quarter RDR (168.8 g ha$^{-1}$) compared with no addition of adjuvant (P<0.05).
Table 1. Effects of various flamprop-M-methyl treatments on wild oat seed numbers (natural log. transformed for Somerton experiment only) contaminating harvested wheat grain (taken from 14.8 m²). Back transformed data in parentheses.

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U  Uptake® added at 5 mL L⁻¹.
H Hasten® added at 5 mL L⁻¹.

Wheat phytotoxicity The results presented in Figures 2 and 3 show the consistent tolerance of various wheat cultivars to SST treatments over a wide range of growth stages. However, in 1995 the durum wheat cultivar, Kamillaro, was sprayed at Zadoks DC 41 to 47 and unacceptable phytotoxicity resulted.

The wheat cultivars represented in Figure 2 were Wollaro, Janz, Sunstate and Sunlin. Most data were above the 100% level (nil effect level) and the average of all data was 111%; = 11% average increase in yield relative to the untreated control. The scatter plot (Figure 3) of wheat kernel weights show an even distribution above and below the 100% level (nil effect level); average = 105%, indicating a slight trend to greater kernel weight.

Figure 1. Relationship between wild oat growth stage at herbicide application and reduction in wild oat reproductive capability for both half (+ Uptake® adjuvant) and full RDRs (no adjuvant) of flamprop-M-methyl

Figure 2. Relationship between wild oat growth stage at herbicide application and the relative yield of wheat (relative to untreated control) for both half, three quarters and full RDRs of flamprop-M-methyl
**DISCUSSION**

The application of flamprop-M-methyl as a SST treatment to minimise seed production of wild oats was consistently effective in numerous field trials conducted over a range of sites and seasons. We conclude, therefore, that SST is a robust technique which can provide high levels of reduction in wild oat seed production over variable environmental conditions. It is also concluded that SST results in minimal crop damage in bread wheat cultivars and is effective over a range of early reproductive crop/weed growth stages and dose rates of flamprop-M-methyl. Durum wheat cultivars, particularly Kamillaroit, have displayed a sensitivity to flamprop-M-methyl with unacceptable crop phytotoxicity and are therefore not suitable for SST.

A decline in efficacy for later applications than the apparent optimal stage of development reported by Cook (1998) was not evident in these trials. However, until further evidence is available the recommendation remains that flamprop-M-methyl be applied in the SST ‘timing window’ of from the commencement of wild oat jointing (DC 31) to mid-booting (DC 45).

The benefits of adjuvants were also reinforced by these trials. Uptake® (paraffinic oil 647 g L⁻¹ + non-ionic surfactant 228 g L⁻¹) improved the efficacy of half and three quarter RDRs of flamprop-M-methyl by reducing wild oat seed contamination in wheat and enhancing reductions in wild oat seed production.

These results justify the registration of SST for applications of flamprop-M-methyl by showing that the technique is effective and reliable.

A main benefit of the technique is to provide growers with an option for sustainable reductions of wild oat seed banks. Because flamprop-M-methyl is a group K herbicide, the technique will be of value also for rotation with other in-crop herbicides, especially the group A fops and dims, to combat herbicide resistance.

**ACKNOWLEDGMENTS**

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**REFERENCES**


