A Comparison of Seeding Rate, Spacing, and Weed Control Methods in the Virginia Tech Transplanted Meadow

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Summary. Combinations of seeding rate, spacing, and weed control treatments were evaluated for their effect on the performance of the Virginia Tech transplanted meadow technique. The treatments consisted of seeding at 112 or 56 g/90 m²; within-row transplant spacing of 30, 45, or 60 cm; and mulching, oryzalin application, or no weed control measures. Plant competition alone was insufficient, whereas oryzalin was the most effective for weed control but also reduced the plant stand and floral display. Mulch provided effective weed control with maximum floral display. Close transplant spacing within rows resulted in quick site coverage initially, but this advantage disappeared after 8 weeks compared to wider spacing. Seeding rate did not affect site coverage until the meadow reached maturity at 12 weeks. The lower seed rate allowed more lodging, resulting in a more open appearance and greater canopy light transmission. Chemical name

used: 4-(dipropylamino)-3,5-dinitrobenzenesulfonamide (oryzalin).

The wildflower meadow concept has generated considerable interest as a low-maintenance landscape alternative, relying on a core combination of herbaceous species, which provide an abundance of color. Actually, this concept artificially replicates a true meadow in many geographic locations and is seldom low maintenance due to invasive weed competition (Martin, 1986). True meadows, on the other hand, generally contain a high percentage of grasses and a large diversity of other herbaceous species capable of excluding most invasive weeds through competition (Bartels, 1992). Initial site preparation is frequently the key to successful wildflower meadow weed control (Bartels, 1992; Martin, 1986; Wilson, 1992). Herbicide use, soil fumigation, and/or repeated cultivation are the main practices used to reduce the occurrence of weeds due to dormant residual seeds (Bartels, 1992; Martin, 1986). Pre-emergent herbicides have been examined for extended weed control; however, many herbaceous perennials have shown phytotoxicity symptoms (Derr, 1993). Hand-weeding or mulching are viable alternatives, especially when the seeds are planted in rows or blocks or the site is limited in size (Wilson, 1992). Mulches and natural plant competition work well together to control annual weeds but do little for perennial weed species (Derr and Appleton, 1992). Wilson (1992) suggests learning to live with a few grasses and weeds in your meadow especially if they are relatively inconspicuous.

The most common options for meadow installation have been the use of direct-seeding, carpets (sods), and transplants. Direct-seeding may be considered the easiest and least expensive of all options, requiring no special equipment and only the cost of seeds; carpets are the most expensive but also the most reliable for weed control; transplants have the advantage of bypassing the germination-establishment problems associated with direct-seeding but still require attention to weed control. The Virginia Tech transplanted meadow (VTTM) technique uses annuals started in cell packs that then are transplanted to the prepared meadow site. It is designed to provide

a temporary meadow-like landscape with some species diversity and an abundance of color. Early site preparation, mulch, and plant competition are the main weed control measures relied on. Transplanting the meadow results in rapid stand establishment that provides an early start over weeds. End of season mowing and tilling greatly reduce the establishment of perennial weeds. Unlike most direct-seeded perennial meadows, VTTM provides constant color within a month of transplanting through to the first frost; however, it does require yearly replanting. Due to the labor involved in transplanting and mulching, VTTM may be limited to relatively small sites in high traffic areas, but they need not be.

Our objective was to determine the effect of seeding rate, spacing, and weed control on the wildflower meadow appearance using the VTTM technique.

Materials and methods

The selected site was a neglected field on the Virginia Tech campus. For at least 10 years before this experiment, the field supported the growth of a diverse mix of native and exotic species that were mowed regularly throughout the growing season. Glyphosate was applied as a broadcast spray to the site as a 2% active-ingredient solution in early spring and was followed by tilling (20 cm) 7 d later. After another 10 d to allow for weed seed germination, glyphosate was applied a second time at the same rate. On the day of transplanting, the site was tilled again to facilitate installation of plants.

The eight annuals used in the VTTM seed mix were selected for their economical cost, ability to grow and flower rapidly from seed, and ability to survive drought and poor soil fertility conditions. The species used were *Celosia argentea plumosa* L. 'Pampas Plumes', *Centaurea cyanus* L., *Coreopsis tinctoria* Nutt., *Cosmos sulphureus* Cav., *Gypsophila elegans* Bieb., *Papaver rhoeas* L., *Tagetes erecta* L. 'Crackerjack', and *Zinnia elegans* Jacq. 'Gold Medal Mixture'. Seven or 14 g of each species were combined for total seeding at 56 or 112 g/90 m².

Cell packs [10 × 10 × 5 cm (0.5 L)] were filled with a commercial soil-less medium containing peatmoss, perlite, and vermiculite (Sunshine Mix 1, Fisons, Vancouver, Canada). The seed

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mixture was combined with a large quantity (≈ 4 L) of clean sand to provide even distribution of the seed when sowing. The sand-seed mixture was hand-broadcasted in at least two perpendicular passes over the top of the media-filled cell packs. The cell packs then were watered thoroughly and as needed thereafter.

One month after sowing, the seedlings had produced a dense root system allowing for intact removal from the cell pack and subsequent transplanting into the field plots. The spacing treatments were 30 cm between rows and 30, 45, or 60 cm within rows. Two 22.5-m² plots were planted for each treatment combination of spacing and seeding rate. The main plots were divided into three subplots based on weed control method: mulch, oryzalin (100 ml·100 m⁻²), or no treatment (control). After transplanting, the plots were watered thoroughly. For the first month, plots were watered as needed. After 1 month, rainfall was the only source of water.

Between 13:00 and 15:00 HR, three quantum light measurements (quantum light meter model LI-185B; Li-Cor, Lincoln, Neb.) were recorded from between and within the rows of each subplot every 2 weeks beginning 2 weeks after transplanting. Light readings were taken at ground level to measure the amount of light transmission through the canopy as an indication of canopy density. Weed control treatments were nested within the main factorial treatments of seeding rate and spacing. The data were analyzed as a nested design using the analysis of variance procedure of the SAS statistical package.

Results

None of the interactions between weed control treatment, spacing, and

seeding rate were statistically significant; the results discussed reflect main effects differences. There were no differences in light transmission through the between-row canopy for any of the spacing treatments. During the first 4 weeks, within-row light transmission was significantly less when plants were spaced at 30 cm than when spaced at 45 or 60 cm. After 6 weeks there were no differences at 30- and 45-cm spacings, but there was significantly more light transmission at 60-cm spacing. No significant differences between or within rows were observed among spacing treatments after 8 weeks (Table 1). Seeding rates of 56 and 112 g·90 m⁻² had no significant effect on light transmission either within or between rows during most of the experiment (Table 2). The only significant differences in light transmission were within the rows at week 4 and between the rows at week 12, at which times the lower seeding rate allowed greater light penetration of the canopy compared to the effect of the higher seeding rate. At week 12 there was also a visual difference between the seed rates (data not shown).

There was a decrease in light transmission within and between rows after 4 weeks in the nontreated control plots (Table 3). Plants in the mulched plots grew more quickly than in the oryzalin-treated plots as indicated by decreased light readings between the rows after 4 weeks and within the rows after 8 weeks. At 8 weeks all weed control treatments significantly differed for within-row light measurements. These differences were due to invasive weeds in the control, denser plant stand in the mulched plots, and a thinner plant stand in the oryzalin treated plots. The control plots had the lowest measured light transmission, followed by the

mulched plots and the oryzalin-treated plots. There were no differences between the control and mulched plots at 10 weeks. At 12 weeks, the control plots had the least light penetration within rows. The mulched and oryzalin-treated plots were significantly different within rows at 8 and 10 weeks but not at 12 weeks. The control and mulched plots were not significantly different between rows throughout the experiment. The oryzalin-treated plots allowed more light transmission within and between rows at all times during the experiment except at weeks 2 and 12.

Discussion

Seeding rates as low as 56 g·90 m⁻² can be used effectively in the VTMM with little impact on the meadow's appearance, effectively reducing the cost of the VTMM technique. After 12 weeks, some plants leaned or lodged excessively but they never reduced the meadow's visual attractiveness.

Spacing of the plugs in the transplanted meadow did not have a lasting affect on meadow appearance. Initially, close spacing provided quick coverage of the site. After only 8 weeks, however, no difference in canopy coverage was observed even at spacings as great as 60 cm within the rows.

Plant competition can't be relied on for a satisfactory weed control in the transplanted meadow. The lowest light transmissions through the canopy occurred in control plots that relied entirely on the annual flower species to out-compete the weeds. This reduction in light transmission occurred as early as 4 weeks into the study and was attributed, in large part, to the weeds present rather than to vigorous growth of desired species. Between-row light transmission levels for the mulched plots were comparable to those of the

control plots. In the mulched plots, the reduced light levels came not from weeds between the rows but from larger, more vigorous, transplanted plants. In general, the mulched plants appeared to grow larger and more quickly, reducing the between-row light

Table 1. The effects of transplant spacing on light transmission between and within rows through the canopy of the transplanted meadow.

Date (1993)	Week	Light transmission ($\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$)					
		Within			Between		
		Spacing (cm)			Spacing (cm)		
		30 × 30	30 × 45	30 × 60	30 × 30	30 × 45	30 × 60
26 June	2	5321 b	5533 a	5663 a	5358 a	5208 a	5304 a
9 July	4	1532 b	3736 a	3418 a	1270 a	1425 a	1566 a
23 July	6	266 b	358 b	1178 a	221 a	189 a	448 a
9 Aug.	8	270 a	173 a	329 a	248 a	132 a	212 a
20 Aug.	10	266 a	276 a	266 a	205 a	128 a	158 a
3 Sept.	12	260 a	255 a	319 a	167 a	115 a	117 a

^aMean separation within rows (date), Student-Newman-Keuls test, $P=0.05$.

Table 2. The effects of seeding rate on light transmission through the canopy within and between the rows of the transplanted meadow.

Date (1993)	Week	Light transmission ($\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$)			
		Within		Between	
		Seeding rate ($1\text{ g}\cdot 90\text{m}^{-2}$)		Seeding rate ($\text{g}\cdot\text{m}^{-2}$)	
		56	112	56	112
25 June	2	5489 a	5522 a	5250 a	5331 a
9 July	4	3483 a	2345 b	1828 a	1013 a
23 July	6	748 a	450 a	279 a	292 a
9 Aug.	8	253 a	262 a	202 a	193 a
20 Aug.	10	275 a	264 a	167 a	160 a
3 Sept.	12	346 a	211 a	169 a	96 b

^aMean separation within rows (date), Student-Newman-Keuls test, $P = 0.05$.

Table 3. The effects of weed control method on light transmission through the canopy within and between the rows of the transplanted meadow.

Date (1993)	Week	Light transmission ($\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$)					
		Within			Between		
		Control	Mulch	Oryzalin	Control	Mulch	Oryzalin
25 June	2	5517 a ²	5450 a	5550 a	5354 a	5279 a	5238 a
9 July	4	2044 b	3117 a	3581 a	863 b	1007 b	2392 a
23 July	6	348 b	719 a	729 a	153 b	143 b	561 a
9 Aug.	8	199 c	256 b	318 a	161 b	182 b	250 a
20 Aug.	10	220 b	233 b	355 a	130 b	131 b	231 a
3 Sept.	12	176 b	298 a	361 a	124 a	126 a	148 a

^aMean separation within rows (date), Student-Newman-Keuls test, $P = 0.05$.

transmission levels to that in the control plots. This is likely a result of less weed competition and greater moisture availability provided by the mulch cover. Oryzalin-treated plots allowed the highest light transmission levels through week 12 compared to the mulch and control plots. These plots appeared to have fewer plants, likely resulting from a phytotoxic response to the herbicide or due to the prevention of further seed germination immediately following transplanting. In the mature meadow, the mulched and control plots appeared to have more *Celosia*, *Tagetes*, and *Zinnia* than the oryzalin-treated plots. *Coreopsis tinctoria* appeared to be the predominant species in the oryzalin-treated plots.

Stand density was manipulated by planting fewer seeds and transplanting the plugs further apart. Both of these methods are viable options for using less seed and reducing the overall cost of the technique. The one negative effect was the lack of interplant support in the mature meadow. The pre-emergent herbicide, oryzalin, provided excellent weed control at the expense

of some species diversity and speed of establishment. Mulch, while labor intensive to apply, provided excellent weed control with the added benefit of enhancing plant growth.

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Photoperiod of Poinsettia Stock Plants Influences Rooting of Cuttings

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SUMMARY. Rooting of cuttings from three cultivars of *Euphorbia pulcherrima* Willd. was evaluated after regulating the photoperiod during the stock plant stage. One group of stock plants was exposed to a night break (4 hours) and another group was exposed to natural daylength during September. Cuttings harvested in late September from 'Freedom Red' and 'Monet' stock plants grown under the 4-hour night break rooted more rapidly and had greater root mass than 'Freedom Red' and 'Monet' grown under natural daylength, whereas rooting of cuttings from 'V-17 Angelika Marble' was not influenced by the photoperiods tested. Using a night break to prevent flower initiation of stock plants produced a higher-quality cutting when propagation took place after the critical daylength for flowering had passed.

Vegatively propagated cuttings from stock plants produce flowering plants true to cultivar (Ecke et al., 1990). The speed of adventitious rooting from vegetatively propagated cuttings is important because rapid rooting minimizes exposure to diseases, which is a major

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