Influence of Seed Size, Planting Depth, and Companion Crop on Emergence and Vigor of Seedlings in Sweetclover

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ABSTRACT

Seed size has been shown to have an important influence on the emergence and early growth of seedlings of several forage legumes, but only fragmentary information on seed size effects in sweetclover (*Melilotus* spp.) has been published. Therefore, a 2-year study was conducted in which spring and fall seedings of small, medium, and large seeds of 'Madrid' and 'N13' sweetclover (*Melilotus officinalis* (L.) Lam.) were made at depths of 19, 38, and 57 mm. The spring seeding also included a comparison of a companion crop (oats) with no companion crop. Data on emergence score and plant height were collected for the spring seeding only; stand count and dry matter yield of tops and roots were measured for both spring and fall seedings.

The companion crop had little effect on emergence score, but it reduced stand count and plant height, and was highly detrimental to dry matter yield. The performance of Madrid was poorer in all respects than that of N13, an experimental cultivar with relatively large seeds. As planting depth was increased, stand counts decreased, but the performance of plants that emerged from the greater depths was relatively good. The most striking results of increased seed size appeared to be improved emergence score and increased dry matter production.

Additional index words: Melilotus officinalis (L.) Lam., Top/root ratio.

STUDIES of the relationship between seed size and and plant performance date back many years. For example, in 1908 one of the papers published in Volume 1 of the *Proceedings of the American Society of Agronomy* reported the results of a study of seed size and yield in 12 farm crops (14). An even earlier report (7) presented the results of a preliminary survey of 35 legumes (including sweetclover, *Melilotus* spp.), in which seedlings from a small number of large and small seeds of each entry were compared. These early studies revealed that plants from large seeds were generally more vigorous than plants from small seeds of the same variety. Similarly, in his excellent 1959 review on seed size in forage legumes, Black (2) concluded that the accumulation of dry matter during early seedling growth is directly related to seed size, and that seed size limits the depth from which seedlings can emerge.

Seed size is of continuing interest to agronomists, as shown by recent reports on such diverse crops as wheat (*Triticum aestivum* L.) (9), soybeans (*Glycine max* (L.) Merr.) (3), and rapeseed (*Brassica campestris* L.) (1). Recent papers involving seed size of forage legumes include reports on alfalfa (*Medicago sativa* L.) (4), birdsfoot trefoil (*Lotus corniculatus* L.) (4, 13), milkvetch (*Astragalus* spp.) (12), sainfoin (*Onobrychis viciifolia* Scop.) (4), white clover (*Trifolium repens* L.) (8), and red clover (*Trifolium pratense* L.) (5). All of these reports agree generally with the earlier observations in indicating that the performance of plants from large seeds was superior to that of plants from small seeds. A recent paper (10) indicates that sunflower (*Helianthus annuus* L.) departs from this general rule. In this instance, size of achenes planted had no significant effect on yield of achenes produced.

Except for the very early work already cited (7), no data on seed size and seedling vigor in sweetclover have been found in the literature. Because of this apparent paucity of published information on sweetclover, and because of the increased importance this crop could assume in the event of a continuing shortage of N fertilizer, we decided to complete the analysis of some data gathered at the Nebraska Agricultural Experiment Station in the early 1960's, concerning the influence of seed size, planting depth, and companion crop on seedling vigor in sweetclover. The results of this analysis form the basis of this paper.

MATERIALS AND METHODS

Cultivars. 'Madrid' and 'N13', both of which are cultivars of yellow-flowered biennial sweetclover (*Melilotus officinalis* (L.) Lam.), were used in this 2-year study. Madrid is a commercial cultivar originally introduced from Spain (11). N13 is an experimental cultivar selected from a large-seeded introduction (P.I. 178,985) from Turkey (6).

Seed Sizes. Hand screens were used to separate seeds of each cultivar into three size classes. Seed weights were then determined for each size class (Table 1). Seeds from the first screening were used for spring planting in both 1960 and 1961 and for fall planting in 1960. Newer seed lots of both cultivars were screened for the fall planting in 1961.

Planting Procedure. Germination percentage was determined for each seed-size class for both cultivars, and these percentages

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Table 1. Mean weights of three size classes of Madrid and N13 sweet clover seeds.

Variety	Size class	Seed weight*	
		First screening†	Second screening‡
		mg/100 seeds	
Madrid	Small	150	150
	Medium	211	180
	Large	259	221
N13	Small	256	233
	Medium	396	392
	Large	530	514

* Each figure represents the mean of four determinations. † Used for planting in the spring and fall of 1960 and the spring of 1961. ‡ Used for planting in the fall of 1961.

Table 2. Dates of planting and data collection.

Planting or observation	Date in	
	1960	1961*
Spring seeding		
Oats planted	25 Apr.	18 Apr.
Sweetclover planted	10 May	24 Apr.
Emergence scored	17 May	8 May
Stands counted	28 May	22 May
Height measured	28 June	29 May
Plants harvested	14 June, 28 June, 12 July	29 May, 12 June, 26 June
Fall seeding		
Sweetclover planted	10 Aug.	14 Aug.
Stands counted	26 Aug.	9 Sept.
Plants harvested	6 Sept., 20 Sept., 4 Oct.	21 Sept., 5 Oct., 19 Oct.

* Data were not complete for 26 June 61 harvest. Therefore, the combined analysis for spring seeding is based on only the first two harvests in both years.

Table 3. Two-year means for emergence score, stand count, plant height, and dry-matter yield for various comparisons.

Time of seeding	Comparison	Emergence score*†	Stand count	Plant ht†	DM yield‡	
					Tops	Roots
			plants/plot	cm	mg/plant	
Spring	Companion crop					
	None	1.97	179	18.7	475	72
	Oats	1.94	160	12.9	22	3
	L.S.D. 0.01	ns	10	1.2	72	13
	Variety					
	Madrid	2.47	105	13.5	221	29
	N13	1.44	234	18.0	276	47
	L.S.D. 0.01	0.11	8	0.8	43	9
	Seed size					
	Small	2.34	153	13.9	202	30
	Medium	1.83	185	16.2	249	38
	Large	1.69	170	17.1	294	45
	L.S.D. 0.01	0.13	6	0.6	26	5
	Planting depth, mm					
	19	1.80	238	16.1	229	34
	38	1.88	165	16.3	261	40
	57	2.19	104	14.9	255	39
	L.S.D. 0.05	0.10	6	0.5	23	5
	L.S.D. 0.01	0.13	8	0.6	31	7
Fall	Variety					
	Madrid		100		344	160
	N13		144		402	313
	L.S.D. 0.01		10		58	57
	Seed size					
	Small		87		312	186
	Medium		141		372	236
	Large		139		435	286
	L.S.D. 0.05		9		52	31
	L.S.D. 0.01		12		69	41
	Planting depth, mm					
	19		188		345	216
	38		127		394	244
	57		53		380	249
	L.S.D. 0.01		17		ns	ns

* Scoring system for emergence: 1 = fastest to emerge, to 3 = slowest to emerge.
† Emergence and plant height were not measured for the fall plantings.
‡ Mean of two harvests for spring seeding and three harvests for fall seeding.

(ranging from about 70 to 90%) were used in adjustment of seeding rates, to provide comparable numbers of viable seeds. In 1960, a seeding rate of 60 viable seeds/m was used. In 1961, 80 viable seeds/m were planted for all entries except the small class of Madrid planted at the greatest depth (57 mm), for which 240 seeds/m were planted in an attempt to obtain sufficient plants.

A V-belt hand seeder was used for planting at depths of 19, 38, and 57 mm. Each row was raked level after seeding, to assure uniform planting depth. One-row plots were used, with a spacing of 0.91 m between plots (rows). Row lengths were 5.5 m in 1960 and 6.7 m in 1961.

In both years, spring plantings were made with and without a companion crop. The companion crop, 'Nemaha' oats (*Avena sativa* L.), was seeded at a rate of 36 kg/ha with a grain drill, at right angles to the direction of the sweetclover rows. In 1960, oats was planted 6 days before the sweetclover; in 1961, the interval was 15 days before the sweetclover.

All plantings were made on a Sharpsburg silty clay loam soil at the Agronomy Farm, Lincoln, Neb.

Collection of Data. For the spring seeding in each year, the entries were scored on a 3-point scale for speed of emergence 1 or 2 weeks after planting. Entries that emerged most rapidly were assigned a score of 1, and those that emerged most slowly were given a score of 3. Subsequently, seedlings were counted, and plant height (one apparently representative plant per plot) and dry matter production were measured. Only stand counts and dry matter production were measured for the fall seedings. To measure dry matter production, three harvests were made at intervals of 2 weeks. In 1960, each harvest consisted of 10 plants/row. The point at which harvesting was to start in each row was selected at random, and from that point, the next 10 plants were dug in order. Roots of the harvested plants were washed, and tops and roots were separated, dried, and weighed. In 1961, each harvest consisted of 50 plants/row, except that in rows with poor stands, approximately one-third of the plants in the row were dug at each harvest. Actual dates of planting and data collection are summarized in Table 2.

Experimental Design. For the spring seedings, a split-split-split-split plot design was used, with four replications. The comparisons assigned to the four splits were as follows: first — oats vs. no companion crop; second — Madrid vs. N13; third — three seed sizes; and fourth — three planting depths. The design for the fall seedings was similar to that for the spring except that the comparison of oats vs no companion crop was not included.

Conventional analysis-of-variance techniques were used in analyzing and interpreting the data.

RESULTS AND DISCUSSION

The 1960 growing season was more favorable for sweetclover than the 1961 season. However, the trends observed in both years were very smiliar. Accordingly, only the results of the combined analysis of both years' data are presented here. Overall means and L.S.D. values are presented in Table 3.

In the comparison of oats vs. no oats, the companion crop had no appreciable effect on emergence score, but it reduced stand count and plant height, and was highly detrimental to vigor, as reflected in dry matter yield/plant. Yields of both tops and roots in plantings with oats were less than 5% as great as yields in the absence of a companion crop.

In the cultivar comparison, N13 was superior to Madrid in all attributes measured for both spring and fall seedings. As shown in Table 1, seeds of N13 were appreciably larger than those of Madrid. Although this size difference was confounded with other possible differences between the two cultivars, at least some of the superiority of N13 very likely was due to larger seed size.

A definite relationship was observed between seed size and seedling vigor as shown by emergence score, seedling height, and yields of tops and roots in the spring seeding. Seed size and yields also were closely related in the fall seeding. In both spring and fall seedings, stand counts from small seeds were significantly less than stand counts from medium or large seeds. For unknown reasons, stand counts from large seeds were either no different from (fall seeding) or significantly lower than (spring seeding) stand counts from the medium seed class.

The most pronounced effect of planting depth was on stand count. Effects on emergence score, plant height, and yields of tops and roots, although statistically significant in the spring seeding, were not large. Depth of planting had much more influence on the ability of seedlings to emerge from the soil than on their performance after emergence.

Among the numerous interactions, the one of greatest practical importance is the two-factor interaction involving the influence of planting depth and seed size on stand count. The combined analyses indicated highly significant values for this interaction in both spring and fall seedings. Examination of the stand count means for the various seed sizes within each planting depth revealed that stand counts from medium and large seeds were greater than counts from small seeds, especially at the 38 and 57-mm planting depths. This ability of seedlings from larger seeds to emerge from greater depths could be extremely important to stand establishment when the moisture supply is limited.

A number of other statistically significant interactions of two or more factors were indicated by the combined analysis of variance. However, graphing of the means involved in many of the two-factor interactions indicated that changes in the magnitude of the differences between means, rather than in the direction of these differences, were involved. Therefore, main effects rather than interactions have been given primary emphasis in this discussion.

This study demonstrated a striking difference between spring and fall seedings with respect to the ratio of dry weight of tops to dry weight of roots. For the overall means shown in Table 3 this ratio varied from 5.9 to 7.6 for spring-seeded plants and from 1.3 to 2.2 for fall-seeded plants. It is true that the values for spring seeding were based on only two harvests whereas those for fall seeding represent three harvests each year, and there was a strong tendency for the top:root ratio to decrease with increasing seedling age. However, when only the first two harvests were considered, top:root ratios for the fall seeding still were considerably less than the values for the spring seeding. Fall seeding thus appears to have been relatively much more favorable for root growth than spring seeding.

The results clearly indicate that large seed size in sweetclover is advantageous for improved stand establishment. The feasibility of breeding for larger seed size would depend on the heritability of this trait. Heritability was not investigated in these experiments. However, large-seeded lines have been established by selection within P.I.178,985 and another introduction, P.I.227,594 (11). Thus, seed size in sweetclover probably is influenced to a considerable degree by genotype, and good progress in breeding for large seed size could be expected.

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