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Managing Seedling Emergence of *Cuphea* in Iowa

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Cuphea, a western hemisphere genus of some 260 species, has been proposed as a domestic source of medium-chain fatty acids. These fatty acids are used primarily in soap and detergent manufacture and are presently extracted from imported tropical oils or from petroleum. Considerable difficulty in obtaining consistent plant stands with direct seeding has been experienced at two Iowa locations. Trials were initiated in 1987 and continued through 1994 to test various treatments upon seedling emergence of *C. laminuligera* Koehne, *C. lanceolata* Ait., and hybrid *C. viscosissima* Jacq. × *C. lanceolata.* These treatments included planting depths from 1.3 to 6.4 cm, seeding rates of 1.5 to 10 kg ha^{-1}, and soil packing or not. Emerged seedlings from pure live seed planted remained less than 60% with all treatments. Increased seeding depth decreased seedling emergence from 29% to 0. Increased seeding-rate increased the number of emerged seedlings, but significant increases were dependent upon the year. Soil packing significantly increased the number of emerged seedlings in 1994 by 14%. Heavy rainfall immediately after planting caused severe stand-losses in 1989, 1991, and 1993. Additional research on seedling emergence under differing conditions would be necessary prior to commercial planting of *Cuphea* in Iowa.

INDEX DESCRIPTORS: *Cuphea,* new crops, alternative crops, oilseeds, agronomic practices.

Certain *Cuphea* species have been proposed as a domestic source of medium-chain fatty acids (MCFA). These fatty acids are currently extracted from imported tropical seed oils or from petroleum products and are used in the manufacture of soaps and detergents and in the preparation of certain special foods (Graham 1989; Thompson 1984). Knapp (1993) proposed that selections from the interspecific hybrid *C. viscosissima* × *C. lanceolata* were the most promising germplasm for domesticating *Cuphea* as an oilseed crop.

We have been collecting, maintaining, distributing, and enhancing *Cuphea* germplasm at the USDA-Agricultural Research Service North Central Regional Plant Introduction Station (NCRPIS) in Ames, Iowa since 1986. During this period, we have encountered considerable difficulty obtaining consistent stand-establishment when planting *Cuphea* seed in the field. Establishing consistent stands of *Cuphea* has not been a problem under irrigated conditions in the Willamette Valley in Oregon (Knapp pers. comm. 1993).

Failure to consistently establish adequate stands is a severe constraint to developing improved cultivars and to commercialization of *Cuphea* in Iowa. This is complicated by post-harvest dormancy of some *Cuphea* species and the requirement of light for germination (Grabe pers. comm. 1986). The trials reported in this paper were designed to create a stand-establishment management system for *Cuphea* at Ames, Iowa.

METHODS

Experiment 1

Seed of *Cuphea laminuligera* Koehne (accession number LA11, a mixture of accessions PI 534691 and PI 561482, obtained from Dr. S. A. Knapp, Oregon State Univ.) was planted in a seeding-rate, seeding-depth trial at Ames (Webster clay loam, fine-loamy, mixed, mesictypic haplaquolls) in 1987 and 1988. Seed amounts were adjusted to plant 1.5, 2.5, 3.5, and 4.5 kg ha^{-1} pure-live seed in plots 1.4 × 3 m. Planting depths were 1.9, 3.8, and 6.4 cm in 1987 and 1.3, 1.9, 2.5, 3.2, and 3.8 cm in 1988. A factorial randomized complete block design with 4 replications was used. The 1987 trial was planted with three double-disk openers 46 cm apart. These openers are commonly used for planting small grains. The 1988 and subsequent trials were planted with Acra-Plant V-Disk shoe type openers. Balan at 8.4 l ha^{-1} was applied preplant for weed control.

The number of emerged seedlings was counted for each plot of the 1987 and 1988 trials at the two- to four-leaf stage of growth. Plants were hand harvested after a killing frost on 2 October, 1987. Plants were placed into mesh nylon bags and air dried at ca. 32°C. Plants were then threshed, and seed yield ha^{-1} was determined. Analysis of variance was calculated by using MSTAT software (Nissen 1983). Plots from the 1988 trial were not harvested because of very poor stands.

Experiment 2

Trials from 1990 through 1992 were designed to test various soil-packing treatments on seedling emergence of *C. lanceolata* accession LN86 (obtained from Dr. S.A. Knapp, Oregon State Univ.). Plot size was 1 × 6 m with three rows 46 cm apart for the drill-planted treatments. Seeding rates on a pure live seed basis of 4.5 kg ha^{-1} were used. The complete field was packed once ca. 2 weeks prior to seeding. Plots were then treated with no additional packing, one additional preplant packing, or one additional postplant packing. A Brillion seeder, 3 m wide, was used for packing. Seeding was accomplished by planter as described for experiment 1 or by broadcasting with a hand-propelled lawn seeder. Balan was also applied for weed control in these trials as described in experiment 1. A factorial, randomized complete block design with 4 replications was used.

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Table 1. Experiment 1. Number of emerged seedlings of *Cuphea laminuligera* accession LA11. Ames, IA 1987–1988.

TREATMENT SEEDING RATE kg ha^{-1}		SEEDLINGS m^{-2}		% EMERGED SEEDLINGS[a]	
1987	1988	1987	1988	1987	1988
1.5	1.5	12	5	16	2.1
2.5	2.5	18	7	14	1.7
3.5	3.5	26	11	16	2.0
4.5	4.5	28	10	13	1.4
	lsd p=.05	8	3		
Seedling depth cm					
1987	1988				
1.9	1.3	42	19	29	4.1
3.9	1.9	12	15	8	3.4
6.4	2.5	9	6	6	1.2
	3.2		1		.1
	3.8		>1		>.1
	lsd p=.05	7	3		

[a]Percent emerged seedlings in relation to number of live seed planted

Table 2. Experiment 1. Seed yield of *Cuphea laminuligera* accession LA11. Ames, IA 1987.

TREATMENT SEEDING RATE kg ha^{-1}	SEED YIELD g m^{-2}
1.5	3.4
2.5	5.0
3.5	6.1
4.5	6.4
lsd p=.05	1.3
Seeding depth cm	
1.9	6.8
3.8	5.5
6.4	3.3
lsd p=.05	1.1

Table 3. Experiment 2. Seedling emergence *Cuphea lanceolata* accession LA86. Ames, IA.

	EMERGED SEEDLINGS m^{-2}			% EMERGED SEEDLINGS[a]		
TREATMENT	1990	1991	1992	1990	1991	1992
Drilled	66	30	84	41	18	51
Broadcast	78	21	67	46	12	41
lsd p=.05	NS	NS	5			
Packing						
+0pp[b]	87	25	81	54	15	49
+1pp[b]	61	29	77	37	17	48
1pp[b]+1 post[c]	64	22	64	39	13	42
lsd p=.05	NS	NS	NS			

[a]Percent emerged seedlings in relation to number of live seed planted
[b]pp = preplant packing
[c]post = postplant packing

The number of emerged seedlings was determined from 5 random 30-cm sections of the 3 rows in the drill-seeded plots. In the broadcast-seeded plots, emerged seedlings in 5 random 30 cm^2 sections of each plot were counted. The mean number of emerged seedlings were determined. Plots were windrowed onto large, nylon screens at harvest. Harvest was conducted the third or fourth week of September or immediately after frost for 1990 and 1992 trials. The 1991 trial was not harvested because the stands were very poor. Plant material was air dried and subsequently threshed. Seed yields and analysis of variance were determined as in experiment 1.

Experiment 3

Experiment 3 was conducted in 1993 and 1994 to determine the effect of packing and seeding rates on varieties selected for improved emergence. The interspecific hybrid *C. viscosissima* × *C. lanceolata* accession IH50 as well as LN86 (obtained from Dr. S.A. Knapp, Oregon State Univ.) were used for these trials. IH50 had been observed to have good seedling emergence in selection trials at Ames in 1992. Each accession was planted at 1, 5, and 10 kg pure-live seed ha^{-1} in packed and unpacked plots. Packing was accomplished just prior to seeding, but after the herbicide was applied. All other materials and methods for Experiment 3 were the same as for Experiment 2.

RESULTS AND DISCUSSION

When seedling emergence trials began in 1987, we were learning accession characteristics and were restricted by availability of seed. We had not yet determined which species of *Cuphea* had the best chance for successful domestication.

Experiment 1

Increasing seeding depths decreased the number of emerged seedlings and greater seeding-rates increased the number of emerged seedlings for both years (Table 1). The percentage of pure-live seed planted that emerged was low, particularly in 1988. Seed yield from 1987 plots increased with improved stands (Table 2). Trials were abandoned in 1988 after the low number of emerged seedlings was determined. The reason for very poor seedling emergence in 1988 was not determined.

Experiment 2

Data from experiment 1 indicated the necessity for shallow planting depths. Heavy rains immediately after planting in 1989 contributed to poor emergence. Replanting after the rain had compacted the soil resulted in adequate seedling emergence. This observation along with increased seedling emergence in tractor wheel tracks led to the decision to test packing on seedling emergence in 1990. The complete field was packed ca. 2 weeks before planting to simulate compaction observed following heavy rain the previous year. Also, we wanted to test very shallow seeding made possible by broadcast seeding.

There were no significant differences in the number of emerged seedlings from drilled or broadcast plots in 1990 and 1991 (Table 3). Statistically, more emerged seedlings were counted in drilled plots than in broadcast plots in 1992. In 1990 trials, slightly greater numbers and percentages of seedlings emerged in broadcast plots, but in the other two years (1991 and 1992) the drilled plots had slightly higher numbers and percent emerged seedlings. Additional

Table 4. Experiment 2. Seed yield *Cuphea lanceolata* accession LA86. Ames, IA.

TREATMENT	SEED YIELD $g\ m^{-2}$ 1990	1992
Drilled	10.4	29.3
Broadcast	12.8	31.0
lsd p=.05	NS	NS
+0pp[a]	10.3	30.8
+1pp[a]	13.1	29.2
+1pp[a]+1post[b]	11.4	30.6
lsd p=.05	NS	NS

[a]preplant packing
[b]postplant packing

Table 5. Experiment 3. Seedling emergence of *Cuphea lanceolata* accessions LN86 and IH50. Ames, IA.

TREATMENT	SEEDLINGS m^{-2} 1993	1994	% EMERGENCE 1993	1994
LN86	18	45	9.7	31.4
IH50	21	44	11.1	30.3
packed[b]	16	55*	8.9	38.3
unpacked[b]	22	35*	12.1	23.9
Seeding rate kg ha^{-1}				
1	5	11	2.9	12.6
5	21	38	11.5	26.4
10	31	85	16.9	29.4
lsd p = .05	10	18		

*Means significantly different at p=.05
Percent emerged seedlings in relation to number of live seed planted
[b]Means of LN86 and IH50 together

soil packing had no significant effect on numbers of emerged seedlings. Heavy rains immediately after planting in 1991 caused severe soil erosion and loss of stand.

Planting method or additional soil packing did not significantly affect seed yields from harvested plots in 1990 or 1992 (Table 4).

Experiment 3

Knapp (1993) proposed developing the interspecific hybrid *C. viscosissima* × *C. lanceolata* for commercial production of *Cuphea.* We had observed IH50 (a selection of this hybrid developed by Knapp) in selection trials in 1992. This accession had significantly better seedling emergence than other hybrid selections grown (Roath unpubl. data 1992). We included this accession, along with LN86, in 1993 and 1994 trials.

LN86 and IH50 had nearly equal numbers and percentage of emerged seedlings in 1993 and 1994 trials (Table 5).

Soil packing provided mixed results in these trials (Table 5). In 1993, there was no significant differences between the number of emerged seedlings in packed and unpacked plots. However, unpacked plots had greater actual numbers and percent of emerged seedlings than did plots with soil packing. Here again, heavy rains immediately after planting caused severe washing and stand loss. The number of emerging seedlings could have been affected more by rain-caused soil erosion than by packing or the lack of it. There were significantly more seedlings that emerged in packed than in unpacked plots in 1994.

Table 6. Experiment 3. Seed yield of *Cuphea lanceolata* accession LN86 and IH50. Ames, IA.

TREATMENT	SEED YIELD $g\ m^{-2}$ 1993	1994
LN86	20	66
IH50	22	75
packed	25*	74
unpacked	17*	67
Seed rate kg ha^{-1}		
1	17	51
5	23	81
10	23	80
lsd p=.05	NS	14

*Means significantly different at p=.05

Increasing seeding rates increased the number and percent of emerged seedling in these trials (Table 5).

There were no significant differences in yield of the two cultivars grown in the 1993 and 1994 trials (Table 6). Packed plots had greater yield than unpacked plots in 1993, whereas the number of emerged seedlings was greater in unpacked plots (Table 5). In 1994, increasing seed rates to 5 kg ha^{-1} resulted in increased yields, but additional increases in seeding rates had no effect on seed yield. Both of these accessions have the wild type mature-seed presentation (Graham 1988), and are, therefore, susceptible to seed shatter. It is possible that a high percentage of seed had shattered and was nor recovered during harvest. This could at least partially explain the inconsistent relationships between stand and seed yield, as well as the relatively low yields. These two accession have vigorous growth habits and are able to grow and flower continuously throughout the season. This character could explain some of the plants' ability to compensate for insufficient stand by producing larger plants to occupy spaces between plants.

Consistent stand establishment continues to be a barrier to growing *Cuphea* successfully at Ames, Iowa. Small seed size and light required for germination dictates shallow planting, which exacerbates the problem. Variations in seedbed condirions inherent to rainfed conditions contributes to the problem. Although data were not conclusive, it appeared thar soil packing can help increase the number of emerged seedlings. The only variable that consistently increased the number of emerged seedlings was an increased number of planted seed. We were not successful in obtaining seedling emergence of more than 54% of pure-live seed planted at the highest seeding rates, and more often only 30% to 40% of pure-live seed emerged.

Untimely rainfall contributed to emergence problems. Heavy rain prior to seedling emergence can cause severe washing and loss of stand. This is a difficult problem to overcome, as rain amounts are often unpredictable, and shallow planting into packed seedbeds are particularly susceptible to erosion.

Additional research on seedling emergence under a wider range of environmental conditions would be necessary prior to commercial planting of *Cuphea* in Iowa.

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