PEPPERMINT INTERCROP SCREENING TRIALS

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Abstract

This report summarizes a project that investigated relay intercropping of peppermint to reduce nitrate leaching. The project was funded by the Oregon Department of Environmental Quality, in order to evaluate different crops for their potential as intercrops, both for their fall and spring nitrogen (N) uptake. Three experiments are described as the screening trial, cereal trial, and the sudan trial. 'Monida' oats and 'Humis' rape both extracted fair rates of fall N, and did not create removal problems. Only Monida oats, with no winter survival, produced an acceptable peppermint oil yield. Sprinkler irrigation appears to be more desirable than furrow irrigation for the germination of intercrops. Other recommendations are given.

Introduction

Relay intercropping is defined as growing two or more crops simultaneously during part of the life cycle of each (Andrews and Kassam, 1976). Peppermint relay intercropping was studied for the first time by the author using rye ***(Secale cereale)*** in 1993 (Mitchell, 1994). The study showed that less than full-cover rye could be planted into an existing peppermint crop, and have no adverse effects on subsequent mint yield the following summer. Spring mulching with rye had been practiced previously in the Midwest, where single rows spaced 6 to 10 ft. apart have been used to prevent wind erosion in the spring. Rye rows are either chopped out later, or left to mature and decay during the summer.

Cover cropping, in contrast, is the practice of planting off-season crops after harvest. Elsewhere in the Pacific Northwest, cover crops have been planted between vegetable and potato crops in the fall, then plowed under in the spring (Edwards, 1986; Peache and William, 1994). Because peppermint is grown perennially, usually in five-year rotations, cover crops, as defined, can only be beneficial before and after the rotation. Here we test intercropping of peppermint, which will leave the perennial crop in place. The use of intercrops to remove excess soil N is an innovation. As suggested by the earlier study (Mitchell, 1994), other benefits may result, including allelopathy (weed suppression) (Al-Khatib and Boydston 1994), the production of plant exudates toxic to nematodes, and habitat for beneficial insects.

In July and August 1994, five trials were initiated with different crops following peppermint harvest, but these were later reduced to three trials because of poor sudan germination. The trials consisted of three experiments: 1) a general *screening trial* with 9 different plant species and 2 planting dates, 2) a *cereal trial* with 10 different cereals and 2 seeding rates, and 3) a *sudan trial* with 2 planting dates. The experiments measured soil N at planting and in the fall, plant N uptake, peppermint regrowth characteristics, and subsequent peppermint yield in August 1995. Chosen crops are listed in Table 1. The trials will be described in further detail below.

Table 1. Crops selected for screening and cereal trial, Madras, Oregon, 1994.

	Beneficial Characteristics	*Winterhardy*
Screening trial		
sudan	halophyte, rapid growth, C4 plant, possible nematode toxins	no
'Wheeler' rye	nematode toxin, symphylan toxin as good as Dyfonate.	very
marigold		no
crimson clover	removes and fixes N, usually meant for plowdown	yes
annual ryegrass	good competition against weeds	yes
hairy vetch	removes and fixes N, usually meant for plowdown	yes
'Gwen' barley	feed barley, early to mid maturity, small head, rough-awned	very
'Humis' rape	Used in potato trial at Hermiston for weed suppression	low
quinoa	halophyte, grown as high-protein grain in Andes	no
Cereal Trial		
'Wheeler' rye	nematode toxin, symphylan toxin as good as Dyfonate	very
common rye,	allelopathy, easy to obtain	yes
K-2 rye	allelopathy, stands very erect, used in 1993 study	yes
'Micah' barley	weed suppression, used in earlier cover crop trials	yes
'Gwen' barley	feed barley, early to mid maturity, small head, rough-awned	very
'Belford' barley	feed barley, performed well in central Oregon trials	low
'Adams' wheat	soft white spring wheat	yes
'Gene' wheat,	soft white winter wheat, awnless, early maturity, short	low
'Monida' oats	rapid fall growth, used for feed	no
annual ryegrass	good competition against weeds	yes

Methods

Screening Trial

The *screening trial* consisted of forage, cereal, brassica (rape), and sorghum (sudan) crops planted into established peppermint that was furrow irrigated. The objective of this trial was to screen crops for intercrop potential.

The screening trial consisted of three replicates of 25 by 7.5-ft. plots. Two planting dates were applied as strip treatments within the randomized block design. The first planting was hand broadcast into a peppermint 'Black Mitcham' field on July 22, prior to harvest. This planting did not have good germination before harvest, but several plants emerged later.

The second planting was broadcast planted by hand on August 17 following an August 13 harvest. On August 18, the field was rotary corrugated to cover the seeds with 0.5 inches of soil. After the August 20-21 flood irrigation, the soil beds between the furrows were inadequately soaked, and sprinkler irrigation was used on August 30, and in September. By September 6, most plots of the second planting had germinated.

The first 32˚ F frost occurred October 12, the first 28˚ F frost on October 13, and the first 24˚ F frost on November 3, 1994.

Plant sampling occurred from October 31 to November 8. Samples (1 ft^2) were taken from each plot and plants were separated into cover plant, cover root, mint old biomass (originating before harvest), new mint growth, and mint rhizomes. Three soil cores were taken from the bed and composited for two depths: 0 to 12 inches, and 12 inches to hardpan.

On April 1, 1995, cover plants and mint rhizomes were again sampled from each plot, and plant total Kjeldahl nitrogen (TKN) was determined on all samples.

Peppermint was harvested on August 9, 1995 with at forage plot harvester from a 3.33 by 25 foot area. Peppermint oil was distilled from samples at a research distillery at COARC.

Cereal Trial

The cereal trial was planted into a stand of peppermint 'Murray Mitcham'. Treatments were two seeding rates of 10 different cereals, as listed in Table 1. On September 13, 1994, the field was rototilled to 3 inches, because soil compaction prevented direct seeding. On September 14, plots (5-ft wide with six 1-ft rows) were planted with a experimental grain planter. Plot size was 20 ft. by 5 ft. The 'full' seeding rate was 100 lb/a, a recommended rate for winter grain, and the 'half' rate was 50 lb/a. There were two replicates of each seeding rate for all 10 cereals. Borders were planted with Micah barley. One treatment, the K-2 rye was planted by hand a week later on September 20 (the delay resulting from seed availability). Germination was good for all crops with the exception of the Micah barley.

On November 10, soil and plant samples were taken from 1-ft^2 quadrates. The samples were 3 inches deep, and were washed and separated into two categories: rhizomes and mint plants, and cereal plants. Dry weights and plant TKN were determined for each plot. Soil samples were taken in increments of 0 to 12 inches and 12 to 18 inches.

In early spring 1995, the plants and soils were sampled in a like manner. The March 15, 1995 sampling included rhizomes and plants together, since the plants had not yet emerged. The Monida oats were all winter killed, and there were weak stands of Belford and Micah barley. On April 21, 1995, all cereal plots were mowed with a Jan mower, such that one row was left standing to test for the effects of wind protection. Complete removal of the cereal occurred on June 4, 1995. Harvest occurred on August 9, 1995 as outlined above for an 3.33 by 20 foot area.

Sudan Trial

The *sudan trial* was designed to compare different planting dates of sudan and different tillage treatments. Sudan was planted at two times. The first was hand broadcasted on July 14, 1994 into peppermint 'Murray Mitcham' prior to harvest. Unfortunately, the first planting did not germinate. A second planting occurred on August 18, following an August 13 harvest, and was hand broadcast, then covered with soil from a rotary corrugator.

Planting rate was 20 lb/a. Plot size was 20 ft by 10 ft. On August 31, soil sampleS were taken at three depth increments: 0 to 6 inches, 6 to 12 inches, and 12 to 24 inches. Four cores were taken in each plot.

The seeding rate was not adequate for a full stand, hence, the tillage and removal treatments were not imposed. On October 24, 1994, plants and soils were sampled in replicates 1 and 2. The first planting date treatment was used as a non-planted control to compare the sudan-planted and non-sudan peppermint. Plants were divided into rhizomes, dry peppermint stems, plant growth since harvest, and old leaves plus duff. Sudan upper growth and roots were also measured in the sudan plants from three quadrates. No subsequent yield data was taken.

Results

Screening Trial

The first planting (July 22) did not result in germination either before or after harvest, and consequently plant and soil measurements were not taken. However some plots germinated later. For the second planting (August 17), only the sudan and quinoa had less than good germination, attributed to inadequate seeding rates. The sudan seed source had poor germination rate, and did not perform well in the furrow-irrigated screening trial. The sprinkler-irrigated sudan trial had better germination. The quinoa was planted at a low rate due to limited supply. These rates were reflected in the poor fall dry matter yield as indicated in Table 2. The low marigold yield was not due to poor germination, but rather to the poor growth in the fall, and the October frosts killed the small plants and made plant sampling impossible.

The fall yield and nitrogen uptake are given in Table 2. Due to high variability of plant population, there was no significant difference in yield, nevertheless, yield and N uptake are given for each crop. Rape had the highest N uptake at 64 lb/a, and, the majority took up 28 to 44 lb/a, with the exception of sudan, marigold, and quinoa, which all had poor germination. The control treatment had 38 lb N/a, consisting of dandelion ***(Taraxacum ojficindle)*** that invaded many of the plots. Results from the cereal and sudan trials, which follow, will show that there is more potential for N uptake than indicated here.

Regrowth of peppermint was measured as 1) residual dry matter from harvest, 2) new stems and leaves, and 3) rhizomes. None of the components were statistically different among treatments, and the means are given in Table 2.

In comparison, the rape 'Humis' performed well for removing N from the soil. The seeding rate of 5 lb/a may need to be increased in order for the rape to extract N at its full potential. Sprinkle irrigating may also improve fall growth of rape. There was moderate winter survival, 1,300 lb/a, in the mild winter of 1995, but we do not anticipate a cover crop removal problem. Rape could probably be removed by flail chopping or grazing in the spring. The high TKN content of rape (3.5 percent) results in a low carbon-nitrogen ratio, and means rape should quickly decompose within the following growing season, and N should be available for mint uptake.

Table 2. Screening Trial Fall Yield and N Data, Madras, Oregon 1994-1995.

Crop	Seed	Fall DM	TKN	N uptake	Root	TKN	Root N Uptake	Total N Uptake
	(lb/a)	(lb/a)		(lb/a)	(lb/a)	%	(lb/a)	(lb/a)
Sudan Grass	20	264	3.4	6	505	1.2	6	12
Wheeler Rye	100	1174	2.4	30	1020	1.4	14	44
Marigold	5	0			0	--	0	
Crimson Clover	20	1071	2.5	30	527	2.7	14	44
Annual Ryegrass	15	1135	2.4	21	445	1.6	7	28
Hairy Vetch	30	1030	2.8	16	504	2.6	13	29
Barley 'Gwen'	100	1254	2.3	29	803	1.1	9	36
Rape 'Humis'	5	1135	3.5	52	341	3.5	12	64
Quinoa	2	959	3.6	38				38

Peppermint components (averaged)

	Dry Matter	TKN	N uptake	
	(lb/a)		(lb/a)	
Old residual stems + leaves		1328	0.89	11.8
New mint stems + leaves	2453	1.32	32.4	
Mint rhizomes	2165	1.01	21.9	

Plants varied in their winterhardiness as indicated by the spring dry matter and soil N data (Table 3). The cereal (rye, barley) and legume crops (clover, vetch) increased in dry matter over the winter, while rape lost dry matter, and sudan, marigold, and quinoa were not winterhardy.

Soil nitrogen sampled on September 9, 1994 averaged 6 lb N/a across all plots, which is a relatively small amount in the soil after harvest. In November, the soil N level increased to 20 lb N/a, indicating mineralization of N from soil organic matter occurred in the interim. A calculation of mineralized N for Wheeler Rye showed an increase of 14 lb N/a in the soil, 32 lb/a in the new mint, and 44 lb N/a in the intercrop and its roots. The grand total was 90 lb N/a mineralized in September and October. Other crops extracted more and less nitrogen (Table 2), but this had no statistically significant effect on the measured soil N in the field.

Oil and dry matter yield were not significantly different among treatments. The mean oil yield was 32 lb/a, indicative of the poor yield of the field.

Cereal Trial

Seeding rates of 50 and 100 lb/a did not influence either fall dry matter or plant N uptake, hence the data herein will reflect the averages over both seeding rates. The herbicide terbicil (Sinbar) had a manifest effect on parts of the plots where plants germinated, then died. This effect ran in strips through the trial where there was a possible overlap of Sinbar that had been applied in the spring of 1993. The presence of the strips was manifest in a significant block effect on dry matter.

Dry matter yield and N uptake in the fall differed by treatment at the 0.10 significance level, as listed in Table 4, but mean comparisons were not made. March dry matter and plant N were significantly different among treatments (Table 4). Micah barley had significantly less dry matter than the other cereals in Fall and March because of poor germination, unlike other trials where it performed well (Murray and McGrath, 1992). K-2 rye fall dry matter was low due to a later planting than the others. Monida oats, and Belford and Gwen barley were best at extracting fall N. Monida oats and Belford barley had poor winter survival, which may be beneficial for extracting fall N, while avoiding potential removal problems the following spring.

K-2, Wheeler, and Cereal rye had excellent winter survival and regrowth, as did Gwen barley. These would likely result in removal problems if one was counting on a peppermint crop. If cover cropping were done at the end of a mint rotation, these would work well, and could be plowed down prior to planting in the spring, or taken as a hay or grain crop in the summer. However, if these cereals were used as a relay intercrop, they would need to be sprayed out in the spring, or else planted as windbreaks in wider strips.

Mint rhizomes were statistically unaffected by the cereal species in the fall, with an average of 820 lb/a (Table 5). Rhizome N uptake was also identical among treatments, averaging 19 lb N/a (Table 5). But in the spring, there was a significant cereal effect on mint rhizomes with 'Adams' wheat and cereal rye lower than the others (Table 5). The overall poor yields,

Table 3. Screening trial spring intercrop dry matter and N data, sampled April 1, and August peppermint dry matter and oil yield, 1995, Madras, Oregon.

Crop	Spring Dry Matter	TKN	N plant	August Peppermint Dry Matter	August Peppermint Oil Yield
(lb/a)	(lb/a)	%	(lb/a)	(lb/a)	
Sudan Grass	0		0	2593	36
Wheeler Rye	5325	2.4	75	1587	34
Marigold	0		0	2518	32
Crimson Clover	2504	2.5	72	2596	34
Annual Ryegrass	2383	2.4	31	2462	29
Hairy Vetch	1996	2.8	79	1243	11
Barley 'Gwen'	3620	2.3	90	3788	35
Rape 'Humis'	1308	3.5	41	2450	37
Quinoa	0		0	3106	34
Control (no cover crop)	1093*	3.6	30	3059	35
Mint stems and rhizomes	2033	1.47	29		

Table 4. Cereal trial dry matter and N uptake, sampled in November 1994 and March 1995, Madras, Oregon. Column values followed by the same letter are not significantly different for Duncan's test at 0.05.

Crop	Fall Dry Matter	Fall TKN	Fall N Uptake	March Dry Matter	March Plant N
	(lb/a)	%	(lb/a)	(lb/a)	(lb/a)
Oats 'Monida'	2842	4.2	119	70 e	0 c
Barley 'Belford'	2447	4.1	101	756 de	24 bc
Barley 'Gwen'	2437	5.0	121	4258 ab	128 a
Rye 'Wheeler'	2300	3.8	88	3656 abcde	72 abc
Wheat 'Adams'	1914	4.4	85	1137 bcde	33 abc
Wheat 'Gene'	1797	4.5	80	3687 abed	97 abc
Rye, Cereal	1739	4.9	85	2838 abcde	59 abc
Annual Ryegrass	1689	4.0	68	2394 abcde	50 abc
Rye, K-2	1562	5.1	79	4754 a	131 a
Barley 'Micah'	1367	4.5	61	801 cde	26 bc
Mint rhizomes	820	2.29	19	95	

Table 5. Rhizome dry matter and later peppermint dry matter and oil yields, Cereal Trial, Madras, Oregon, 1994-1995. Peppermint data is for the half-rate seeding treatments. Column values followed by the same letter are not significantly different for Duncan's test 0.10.

Crop	Rhizome Dry Matter		Aug. 95 Peppermint	
	Nov. 94	Mar. 95	Dry Matter	Oil Yield
	(lb/a)	(lb/a)	(lb/a)	(lb/a)
Annual Ryegrass	789	158 a	0 b	0 b
Rye, K-2	866	137 ab	660 b	3 b
Wheat 'Gene'	883	125 ab	1307 ab	11 b
Barley 'Micah'	854	108 ab	744 ab	12 b
Oats 'Monida'	775	89 ab	**2891 a**	**51 a**
Barley 'Gwen'	852	79 ab	0 b	0 b
Rye 'Wheeler'	746	74 ab	493 b	3 b
Barley 'Belford'	708	70 ab	1417ab	21 b
Wheat 'Adams'	729	55 b	849ab	13 b
Rye, Cereal	1000	55 b	440 b	4 b
mean	820	95		
significance	NS	0.10	0.01	0.01

with the exception of Monida oats, suggests competition or allelopathy was excessive.

The low rhizome mass of the cereal trial resulted from rototilling, which cut the rhizomes into smaller pieces that evidently did not survive well over winter. Overall, there were large decreases in rhizomes over winter--the average decreased from 820 to 95 lb/a (Table 5). This was not enough to produce a good yield of peppermint when other competition existed. This is in contrast to the screening-trial rhizome mass of 2,165 and 2,030 lb/a in Fall and Spring (Tables 2 and 3), respectively.

November soil nitrate sampling was low (5 lb N/a) in all treatments. There were no differences among the cereal treatments or plant densities.

In general, the planting density was too high and the cereals were more competitive than the peppermint in the spring. The only exception was Monida oats, which did not survive the winter to compete in the spring. Peppermint oil yield was only acceptable for the Monida oats that had 51 lb/a (Table 5).

Sudan Trial

The sudan trial was plagued with poor germination, although the late planting date may have also reduced growth. Results showed the sudan trial produced significantly less new peppermint growth. Comparison with a non-planted control shows that sudan extracted only 15 lb/a of N. Interestingly, the sudan treatment produced 1,728 lb/a of new plants with 25 lb N/a while the control had 3,116 lb/a of new plants with 41 lb N/a. In other words, sudan caused a significant reduction in peppermint N uptake of 16 lb N/a. Lower growth is attributed to the effects of the rotary corrugator that was used in planting to cover the seeds. The fall new growth was reduced, but rhizomes mass was greater under this treatment. This increase in rhizome mass was expected from the corrugator, which buried the plants.

The soil N data did not differ by treatment, with the initial amount at 21 lb/a available in the top foot and the field soil N at 8 lb N/a (data not shown). This was a reduction of 13 lb N/a, and 41 lb N/a were extracted by the sudan and no-sudan control. The difference of 28 lb N/a can be attributed to soil mineralization.

In order for sudan to be a viable fall intercrop for peppermint, the seedling rate would need to be increased to several times the 20 lb/a rate used here. Because the sudan is susceptible to cooler weather, one option would be to plant earlier. However, earlier plantings depend on an earlier harvest that may not be practical. Sudan does not compare well with Monida oats (119 lb/a of N removed), which also winter kills.

Conclusions and Recommendations

1. Sprinkler irrigation appears to be more desirable than furrow irrigation for the germination of intercrops. While this conclusion may be limited to our soil and crop conditions at the Madras site, it is important to consider.

2. Rape extracted the most N in the screening trial. We recommend a seeding rate slightly higher than the 5 lb/a used here. Rape may be advantageous because its removal may be less problematic than for winterhardy cereals.

3. Monida oats and Belford barley were effective at removing N in the fall and were not winterhardy. Belford barley had limited survival, and Monida oats none at all. These crops appear to be good options for avoiding spring crop removal while extracting N. The fall and spring rhizome mass was unaffected by these treatments. Only the Monida Oats had acceptable peppermint oil yield.

4. Cereals planted at 50 lb/a into a tilled peppermint field grew as well as higher density plantings.

5. If rye or other winterhardy cereals are to be used, they should probably be planted at rates lower than 50 lb/a and with wider spacings than the 12-inch rows used here.

6. Sudan may have no advantage over Monida oats as a crop that will winter kill. Sudan may be allelopathic to peppermint when grown simultaneously as an intercrop.

7. Preharvest planting of crops was detrimental to germination and growth. The best practices were to plant and irrigate as soon as possible after harvest.

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