



Screening Annual and Perennial Ground Covers as In-Row Living Mulch for Central Washington Orchards 2004-2005: Year 2 Report

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Abstract: Establishing in-row living mulches in an orchard understory offers potential multiple benefits including weed suppression, nutrient cycling, and improved soil quality. Suitable living mulches should establish quickly, provide adequate cover to suppress weeds, be shade tolerant and easy to manage, and provide habitat for increased populations of beneficial insects. Optimal covers should exhibit minimal competition with orchard trees and no increase in vertebrate or arthropod pest damage. Legume cover species like white clover establish quickly, suppress weeds and provide nitrogen for the orchard crop but are favored by rodents for their fleshy roots with high moisture content. Screening of multiple types of cover including low growing carpet types, annual and perennial legumes is a step toward developing and recommending specific living mulches. [Add blend with YR 2 observations](#)

Objective: Evaluate a range of species for suitability as in-row living mulches in terms of quick stand establishment, weed suppression, shade tolerance, vigor, growth habit, and rodent activity in the stand.

Methods: Entries were monitored for two seasons. Seedling count, stand cover, weed cover, height, bloom, and select biomass measurements were taken in years 1 and 2. Winter hardiness, reseeding ability of annuals and visual signs of vole activity were also monitored in Year 2. Tree growth parameters were not measured. Plots were mowed for supplemental weed control.

The study was established in May 2004 at the Wenatchee Valley College teaching orchard (East Wenatchee, WA) in a Gala/M26 apple block planted in 1995. Mini-plots of 0.9m² (76cm x 120cm) were laid out in the tree row filling the weed strip. Grass alleys were maintained between tree rows. Spring planted screening entries included low growing carpet type perennial ground covers as well as various annual and perennial legumes (Appendix Table 1). Design was a Randomized Complete Block (RCB) with three replications of 28 entries. Because of heavy spring weed pressure, fall plantings were included for subclover, medic, kura clover and trefoil to compare emergence and stand establishment.

The research orchard is being managed for organic certification; therefore no herbicide was applied to plots prior to planting. Composted chicken manure was applied

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to tree rows at typical rates. Supplemental rock phosphate and BioGrow were applied at recommended rates of P for legume crops and N for the non-legume crops. Seedbeds were tilled, raked and firmed. Inoculated legume seed and bentgrass seed combinations were broadcast into plots on May 22, 2004. Seedbeds were then rolled with a packer to shallowly incorporate seed and pack the surface. Non-legume perennial plugs were transplanted to plots. Plug sizes ranged from 72's to 4"; appropriate numbers were planted equidistantly (20 or 40 cm apart) to provide similar total cover (10-15%) at planting. Plots were irrigated daily for 7-10 days with microjet sprinklers, maintaining a moist seedbed for emergence. Post-emergent irrigation was on the normal orchard schedule.

The orchard soil classification is Pogue fine sandy loam which has an estimated available water holding capacity of 0.11-.014 in/in in the surface 0-30 cm depth. Fine gravel is present in the 0-15 cm and 15-50 cm depths of the Gala blocks. Soil appears fairly uniform and drains well. Soil measurements (0-15 cm depth) from an adjacent block taken in 2001 included soil organic matter (1.4-1.8%), bulk density (1.3-1.4 g/cm³), and infiltration rate (.31-1.03 min/cm).

YR 1 Observations:

Emergence of spring seeded covers was difficult to quantify because weed pressure was extreme (Table 1). Typically, with a few exceptions, seeds did germinate and emerge well with the supplemental irrigation. Emergence (1 and 3 week) was rated on a scale of 0-4 with 0 = none and 4 = excellent. **Seedling counts** were taken in a 100 cm² area at 3 and 5 weeks post planting. All treatments were ranked for **% cover** of mulch and **% weeds** in the stand (Tables 2-5). Plots were hand weeded early in the season to reduce the heavy weed pressure, so these first season rankings were affected by that. Even so, clearly, there are treatment differences in the ability to establish a stand and compete with weeds. **Height** (Tables 2,4,5) and **biomass** (Table 6) measurements were taken for selected treatments to give us additional information on growth habit. For in-row living mulch covers, short or prostrate growth and lower biomass may be advantageous in terms of decreased competition with the crop, and less rodent habitat. Lower biomass of the N-fixing legume covers should help avoid any oversupply of N to the orchard crop that could delay fruit maturity. However, any cover needs adequate vigor and biomass to suppress weed growth.

YR1 Non-legume Covers

YR1 and 2 Year 1 bentgrass seedlings emerged and quickly established a thick mat that provided excellent cover and weed suppression. Excellent season long cover was present in year 2 as well. The bentgrass may be competitive with the trees producing 4500 kg/ha biomass; reducing seeding rates we might optimize cover without the competition to the trees. The grass grew taller than expected (17 cm) indicating some shading effect.

All the non legume perennials were winter hardy. Sweet woodruff and annual sweet alyssum also have potential to establish well and quickly provide weed suppression. Alyssum did not reestablish a stand in Year 2 probably due to shading and/or lack of viable seed. Both treatments appeared well adapted to conditions in the tree row with stand height of 16-17cm. Year 2 woodruff reached 90% cover by April and produced over 2400 kg/ha dry wt biomass. Although creeping thyme (*T. praecox minus*), Irish moss (*S. subulata*) and native beach strawberry (*F. chiloensis*) have the potential to develop a carpet like cover, plants were too low vigor, requiring supplemental weed control during both years.

Improved stand establishment might be achieved with higher density planting or including a nurse crop but does not appear to be economical. Interseeding plots with an annual legume such as burr medic could potentially provide early weed control while the perennial species establishes. Creeping thyme did have some surface die-back perhaps due to the irrigated, shady conditions in the tree row. Many of the areas with early die-back showed healthy new growth later in the season. Wild ginger (*A. caudatum*) transplants died back and did not establish a stand; a few plants were noted in year 2. Summer conditions may have been too hot for this species.

These non-legume covers may be a less attractive food source to rodents than their legume counterparts, especially clovers with their fleshy underground rhizomes. Creeping thyme and Irish moss are prostrate and offer little cover for rodent activity. Sweet woodruff contains coumarin, a compound in which there is interest in its role as a possible rodent repellent. Following establishment, little management should be required for these living mulches. Weed ranking was taken although hand weeding was done in all these plots, limiting the interpretation of the data. Cover rank is the better measure for growth potential, and with better cover should come better weed suppression.

YR1 Annual and Perennial Legumes

Clovers. Most clover species performed as expected. Year 1 ‘Dutch’ and ‘New Zealand’ white and ‘O’Connor’s’ strawberry clover emerged well, and vigorous seedlings established a stand quickly, providing weed suppression in an extremely heavy weed pressure environment. In the shady, irrigated conditions under the trees, clover stand height was ~25 cm. However, no powdery mildew or other disease symptoms were observed. The white clovers had the highest seedling counts ($> 23/100\text{cm}^2$ sample area) and resulting Year 1 biomass production. Counts ranged from 6-13/100 cm^2 for strawberry clover. White clovers ranked highest for Year 1 % cover and weed suppression among the legumes.

Spring planted kura clover (cvs. Rhizo and Prairie) did not emerge well or establish a stand. Kura clovers are typically more difficult to establish because of small, lower vigor seedlings, producing less above ground biomass than typical clover cover crops. Seedling counts were 2 and 4 seedlings/100 cm^2 sample area for ‘Rhizo’ and ‘Prairie’, respectively. Weed pressure was extreme, and disturbance to the plots from hand cultivating probably contributed to the stand failure. Planting kura clover with a nurse crop such as annual ryegrass or oats at low seeding rate would probably be more successful and we may try this in 2005. Potential advantages of the kura clover include longer persistence than the white and strawberry clovers, and lower biomass production and shorter growth habit could mean less competition for water and nutrients with the orchard and reduced cover for rodents. The fall planted kura clover emerged well as weed pressure was low and we were able to observe seedling vigor and growth habit. The ‘Rhizo’ cultivar was more prostrate (1-2 cm tall) and produced less above ground biomass than ‘Prairie’ (2-4 cm tall), a more vigorous seedling. Percent cover at 7 weeks was 25% for Rhizo and 40% for Prairie indicating that even with fall planting stand establishment would benefit from higher seeding rates or a nurse crop.

YR1 Medics. Annual medics performed variably. When planted in spring, the burr medics *M. polymorpha* ‘Santiago’ and ‘Serena’ and the snail medic *M. scutellata* ‘Kelson’ emerged moderately well, flowered and produced seed early in the season. With adequate establishment the potential to suppress early spring weeds should be good. However, mid-

late summer dieback of stand after seeding leaves the ground bare therefore prone to fall weed germination. Some new seedlings did emerge in the fall but did not establish cover. Spring planted burr or snail medic could be used as a component of a medic mix formulated to provide growth and weed control throughout the season. For example, the black medic *M. lupulina* accession from Afghanistan (PI 260980) was less vigorous early in the season but came on strong as the season progressed producing a good cover while *M. polymorpha* died back. While a black medic accession from Yugoslavia (PI 251150) also died back late summer, this appeared to be the result of powdery mildew. The Afghanistan accession remained healthy and vigorous throughout the growing season. Spring 2005 emergence will be observed for all medic plots. Seedling counts ranged from 6-13/100 cm² for the spring planted black, burr and snail medic treatments. Biomass produced by PI 260980 was greater than for PI 251150 because of dieback from powdery mildew. Spring planted biomass from the snail and burr treatments was not measured because of dieback following seed production.

Fall planted burr medics 'Serena' and 'Santiago' performed very well with 85% cover at 7 weeks after planting. The black medics also emerged well but, as in spring, showed less early vigor and growth than burr medics, with 40% and 30% cover at 7 weeks for the Afghanistan and Yugoslavian accessions, respectively. All types were healthy, with no sign of powdery mildew in the Yugoslavian type. Seedlings did not flower prior to frost and will be observed for overwinter hardiness and ability to self-reseed next spring. Weed competition was minimal. Burr and black medic height ranged from 15-18 cm and 5-10 cm, respectively.

YR1 Subclovers. The dense, compact growth of subclovers may offer an advantage over white clovers for orchard floor management if stands can be well established. Spring planted subclover seedling counts ranged from 4-5/ 100 cm² area. Emergence was moderate with the heavy weed pressure and height ranged from 11-13 cm. Stand establishment was less than optimal with 30% or less cover at Day 100. Winter hardiness and the ability of varieties to establish as a self-reseeding cover will be rated in spring 2005. Subclovers will generally tolerate temps to 5°F.

Fall planted subclovers showed excellent emergence, growth and resulting cover of 88-100% at seven weeks post planting. 'Antas' and 'Clare' subclovers have a taller growth habit (10-17 cm) compared to 'Nungarin' and 'Mt. Barker' varieties (5- 10 cm) while vigor appeared to be similar for varieties. The shorter varieties could provide less rodent cover on the orchard floor but still be competitive with weeds. Seedlings did not flower prior to frost. Fall planting dates could be pushed up into August to evaluate potential reseeding.

YR1 Birdsfoot trefoil. As expected, Birdsfoot trefoil was slow to establish as a living mulch. 'Norcen' and 'Kalo' varieties had 10 and 5/100 cm² seedling counts, respectively, with 'Norcen' showing greater vigor, height, % cover and biomass production than 'Kalo'(a dwarf variety). While getting off to a slow start in the heavy weed pressure environment, both varieties performed well in the later half of the summer suppressing weeds and producing biomass. Fall planted trefoil germinated and emerged well with 'Norcen' and a non-specified variety (NSV) reaching 65% and 75% cover 7 weeks after planting and few weeds in stand. 'Kalo' was at 45% cover the same date. The 'Kalo' does not appear to have sufficient vigor to perform well as a living mulch. Trefoil may offer more potential if planted in combination with other crops such as an early season burr medic. This could provide early suppression of cool season weeds during establishment.

Legume/Bentgrass combinations. These plots established well, providing adequate cover and weed suppression. When planted in combination with bentgrass, the black medic PI 260980, kura clover 'Rhizo' and the subclover 'Antas' populations were sparse. A much lower seeding rate of bentgrass and increased rate of the legume would be more conducive to the legume establishment. A potential benefit of the bentgrass/legume mixes might include decreased attractiveness to rodents, improved Year 1 early weed suppression, and lower rates of N fixation. Again, the bentgrass may be overly competitive with the orchard trees and a reduced seeding rate would be recommended.

YR1 Conclusions

Living mulch species performed variably in this initial season. Weed pressure was intense with the spring planting, dominated by annual cool season and warm season grasses. Only a few entries (white clover and bentgrass) performed well without extensive hand weeding. The fall planting had much less weed pressure, as has been experienced in the past. All the species that were fall planted (trefoil, subclover, kura clover, medic) had excellent germination and growth with no weeding, compared to less effective stand establishment in the spring planting, when kura clover failed to establish. Evaluation of winter hardiness, weed suppression, rodent attractiveness, and self-seeding ability in Year 2 will determine which species should be considered for further testing.

Blend with Yr 2

The experience in 2004 confirmed the following previous experiences:

- White clovers and bentgrass establish quickly and can compete with weeds;
- Trefoil is slow to establish
- Alyssum performs well and provides flowers season long
- Fall planting leads to much lower weed competition than spring planting

New observations:

- Strawberry clover established a cover more slowly than the white clovers
- Sweet woodruff has potential to establish and perform well in orchard conditions
- Establishment of native strawberry, creeping thyme and Irish moss is slow; year one cover and establishment should be improved by including a nurse crop
- Subclover and medic species perform variably; species should be grown in combinations to provide adequate cover throughout the season
- The black medic accession from Yugoslavia is susceptible to disease in the orchard environment
- Seeding rates of bentgrass should be explored for optimal cover:competition

Add to report from these year 2 observations **Living mulch (LM) trial**. Weed pressure was severe. Sweet woodruff was the best performing perennial landscape type LM entry and provided early and season-long cover up to 90% by April. Year 2 growth of scotch moss, creeping thyme, and native beach strawberry was again too slow to suppress weeds. Bentgrass also provided complete early cover, out-competing both weeds and legumes planted as a mix; the grass likely competes with tree growth (**Table ?**). **Spring planted** alyssum, subclovers and burr medics did not re-establish stands in Year 2; heavy shade and duff contributed to low germination rate. Black medics had a biennial habit; the Afghanistan selection overwintered well and provided the earliest cover of the spring planted legume entries. White clover had better persistence than strawberry clover. Birdsfoot trefoils also performed well; low vigor kura clover failed to establish well in either year. **Fall planted** subclovers, birdsfoot trefoils, black medic (Afghanistan), and kura clover all over-wintered well. Mt. Barker subclover provided early spring cover of up to 70%. All varieties flowered, produced seed and died back in 2005. Fall planted burr medics and the Yugoslavian black medic did not survive the winter. Evidence of stripped stems indicated vole feeding; it is unknown if vole damage or lack of hardiness was the cause of mortality. **Vole trails** were mapped in March to observe winter damage. Trails were concentrated in Rep 1 white clover and bentgrass plots; the clovers showed heavy feeding activity while bentgrass appeared to provide cover rather than food. There was no evidence of vole damage to tree bark.

An expanded screening in 2005. Overall, entries seeded in 2005 outperformed the 2004 screening, probably a result of improved light and irrigation and/or earlier planting date in the new block. (**Put in citation**). Stand establishment was excellent for most species. Annual and biennial legumes, white clover, alyssum, and Norcen birdsfoot trefoil (BFT) exceeded 70% stand cover by six weeks post planting. The quickly established annuals, particularly medics, had lower % weed cover. The medics and subclovers produced viable seed; fall emergence was present for all varieties. Perennial landscape entries performed variably. Thyme had significantly higher cover (93%) and lower weed cover (7%) at 6 weeks than other entries. Phlox and woodruff also established cover quickly; mint did not survive. Weed pressure was severe at this site. Cover crop and weed competition were detrimental to tree establishment and growth.

Table 1. Emergence rank (0- 4)* and seedling count of spring planted in-row living mulches. 2004.

Living Mulch Treatment	Emergence Rank 0-4 (Day 21)	Seedling Count/100cm ² (Day 36)
Grass <i>A. tenuis</i> Colonial bentgrass	3	
Clovers		
<i>T. repens</i> NZ/ <i>T. fragiferum</i> Mix	4	23.0
<i>T. repens</i> 'Dutch'	4	26.3
<i>T. repens</i> 'NZ'	4	25.3
<i>T. fragiferum</i> 'O'Connor's'	4	7.3
Medics		
<i>M. polymorpha</i> /scutellata Mix	2	9.3
<i>M. polymorpha</i> 'Santiago'	2	7.7
<i>M. polymorpha</i> 'Serena' PI 494565		7.3
<i>M. lupulina</i> PI 260980 Afghanistan	2	5.7
<i>M. lupulina</i> PI 251150 Yugoslavia	2	9.0
Birdsfoot trefoil		
<i>L. corniculatus</i> 'Norcen' PI 592427	1.5	10.7
<i>L. corniculatus</i> 'Kalo' PI 234670	1	6.3
Subclovers		
<i>T. subterraneum</i> 'Antas'	3	4.3
<i>T. subterraneum</i> Mix 2	2	4.7
<i>T. subterraneum</i> Mix 3	2	4.0
Kura clover		
<i>T. ambiguum</i> 'Rhizo' PI 325489	1	2.0
<i>T. ambiguum</i> 'Prairie' PI 427121	1	4.0

* 0 = None, 1 = Sparse, 2 = Moderate, 3 = Good, 4 = Excellent
Seeds were broadcast

Table 2. Year 1 height, ground cover and weed cover of non-legume perennial in-row living mulches. 2004.

Living Mulch	TRT	% Cover (Day 36)	% Cover (Day 100)	% Weeds (Day 100)	Height (cm)
Grass					
Colonial Bentgrass <i>A. tenuis</i>	H	86	88	12	17
Carpet type ground covers					
Sweet Alyssum <i>L. maritima</i>	G	60*	77	13	16
Sweet Woodruff <i>G. odoratum</i>	C	40*	47	23	16.7
Creeping Thyme <i>T. praecox minus</i>	D	30*	35	17	4.7
Irish Moss <i>S. subulata</i>	F	20*	37	18	3.3
Native Beach Strawberry <i>F. chiloensis</i>	B	30*	33	37	8
Native Ginger <i>A. caudatum</i>	E	20*	1	62	0

*Values are estimates.

Plots were weeded throughout season. 2005 data should be more representative as plots will not be hand weeded next year.

Table 3. Year 1 cover of non-legume perennial in-row living mulches planted from plugs. 2004.

Living Mulch	% Cover (0 days)	% Cover (Day 100)
Sweet Alyssum <i>L. maritima</i>	12.1	76.7
Sweet Woodruff <i>G. odoratum</i>	12	45
Irish Moss <i>S. subulata</i>	9.6	36.7
Native Beach Strawberry <i>F. chiloensis</i>	12.2	33.3
Creeping Thyme <i>T. praecox minus</i>	15.2	31.7
Native Ginger <i>A. caudatum</i>	8	1.7

Estimates of % cover were made by visual estimation at 100 days and confirmed by digital image analysis software.

Table 4. Year 1 ground cover, weed cover and height of spring planted legumes.

Living Mulch	TRT	Cover Rank 1-5* (Day 36)	% Cover (Day 100)	% Weeds (Day 100)	Height (cm)
Grass					
<i>A. tenuis</i>	H	5	88	12	17
Clovers					
<i>T. repens</i> 'Dutch'	O	5	84	17	24.3
<i>T. repens</i> 'NZ'	P	5	84	17	26
<i>T. repens</i> NZ/ <i>T. fragiferum</i> Mix	R	4	78	22	25
<i>T. fragiferum</i> 'O'Connor's'	Q	3	55	30	23
<i>T. ambiguum</i> 'Prairie' PI 427121	M	2	8	60	
<i>T. ambiguum</i> 'Rhizo' PI 325489	L	1	8	52	
Subclovers					
<i>T. subterraneum</i> 'Antas'	S	3	7	55	12.7
<i>T. subterraneum</i> Mix 3 'Howard', 'Mt. Barker' and 'Tallarook'	V	3	32	43	11.7
<i>T. subterraneum</i> Mix 2 'Clare', 'Nungarin'	U	3	27	47	11
Medics					
<i>M. lupulina</i> PI 260980 Afghanistan	W	4	47	42	13.3
<i>M. polymorpha</i> 'Santiago'	BB	4	8**	47	5.3
<i>M. lupulina</i> PI 251150 Yugoslavia	X	3	43	37	11
<i>M. polymorpha</i> 'Serena' PI 494565	AA	3	12**	50	7
<i>M. polymorpha/scutellata</i> Mix	Z	3	5**	90	
Birdsfoot Trefoil					
<i>L. corniculatus</i> 'Norcen' PI 592427	J	4	57	30	14
<i>L. corniculatus</i> 'Kalo' PI 234670	I	3	43	32	10

* Relative cover establishment by treatments; 1 = least, 5 = most.

**M. polymorpha stands died back after seeding.

Table 5. Ground cover, weed cover and height of fall planted legumes.

Living Mulch	% Cover (3 weeks)	% Cover (7 weeks)	% Weeds (7 weeks)	Ht, cm (7 weeks)
<i>M. polymorpha</i> 'Serena' PI 494565	40	85	<5	15-18
<i>M. polymorpha</i> 'Santiago'	30	85	<5	15-18
<i>M. lupulina</i> PI 260980 Afghanistan	10	40	10	5-10
<i>M. lupulina</i> PI 251150 Yugoslavia	15	30	10	5-10
<i>T. ambiguum</i> 'Rhizo' Kura PI 325489	5	25	15	1-2
<i>T. ambiguum</i> 'Prairie' Kura PI 427121	15	40	10	2-4
<i>L. corniculatus</i> 'Kalo' PI 234670	15	45	15	3-4
<i>L. corniculatus</i> 'Norcen' PI 592427	25	65	10	2-4
<i>L. corniculatus</i> NSV*	30	75	5	7-8
<i>T. subterraneum</i> 'Antas'	62	100	5	12-17
<i>T. subterraneum</i> 'Clare'	40	93	10	10-13
<i>T. subterraneum</i> 'Mt Barker' PI 279012	32	93	10	5-10
<i>T. subterraneum</i> 'Nungarin'	50	88	5	5-10

*NSV = non specified variety

Table 6. Spring and fall planted biomass production of selected living mulches.

Living Mulch	Fresh wt kg/m²	Dry wt kg/m²
<i>A. tenuis</i>	1.87	0.48
<i>T. repens</i> 'NZ'	2.62	0.43
<i>T. fragiferum</i> 'O'Connor's'	1.81	0.39
<i>M. lupulina</i> PI 260980 Afghanistan	1.3	0.35
<i>T. repens</i> 'Dutch'	1.96	0.34
<i>T. sub</i> Mix 3***	1.8	0.29
<i>L. corniculatus</i> 'Norcen' PI 592427	0.98	0.25
<i>T. subterraneum</i> 'Antas'	1.15	0.18
<i>M. polymorpha</i> 'Serena' PI 494565	0.91	0.14
<i>L. corniculatus</i> 'Kalo' PI 234670	0.83	0.13
<i>T. subterraneum</i> 'Clare'	0.66	0.13
<i>M. polymorpha</i> 'Santiago'	0.95	0.12
<i>T. ambiguum</i> 'Prairie' Kura PI 427121	0.2	0.1
<i>L. corniculatus</i> NSV	0.46	0.09
<i>T. subterraneum</i> 'Mt Barker' PI 279012	0.51	0.083
<i>T. subterraneum</i> 'Nungarin'	0.37	0.077
<i>L. corniculatus</i> 'Norcen' PI 592427	0.2	0.04
<i>M. lupulina</i> PI 260980 Afghanistan	0.17	0.03
<i>L. corniculatus</i> 'Kalo' PI 234670	0.01	0.03
<i>M. lupulina</i> PI 251150 Yugoslavia	0.12	0.01

Species shaded indicate fall planting.

Any Yr 2 data to add?

Table 2. Percent cover potential in second year, LM trial (planted 2004).*

2004 Entry	Scientific name	YR 2 % Cover LM -- 3/31/05	YR 2 % Cover LM -- 6/15/05
Perennial Landscape* LM			
Sweet woodruff	<i>Galium odoratum</i>	95	90
Scotch/Irish moss	<i>Sagina subulata</i>	35	55
Creeping thyme	<i>Thymus praecox minus</i>	35	45
Native beach strawberry	<i>Fragaria chiloensis</i>	35	40
Spring Seeded** LM			
Bentgrass, Colonial	<i>Agrostis tenuis</i>	93	78
White clover, Dutch	<i>Trifolium repens</i>	53	73
Black medic, Afghanistan	<i>Medicago lupulina</i>	50	73
White clover, New Zealand	<i>Trifolium repens</i>	47	90
Birdsfoot trefoil, Norcen	<i>Lotus corniculatus</i>	38	72
Strawberry clover	<i>Trifolium fragiferum</i>	35	75
Birdsfoot trefoil, Kalo	<i>Lotus corniculatus</i>	27	70
Black medic, Yugoslavia	<i>Medicago lupulina</i>	10	33
Kura clover, Prairie	<i>Trifolium ambiguum</i>	5	17
Kura clover, Rhizo	<i>Trifolium ambiguum</i>	2	12
Fall Seeded** LM			
Subclover, Mt. Barker	<i>Trifolium subterraneum</i>	72	5
Subclover, Antas	<i>Trifolium subterraneum</i>	40	5
Subclover, Clare	<i>Trifolium subterraneum</i>	30	5
Subclover, Nungarin	<i>Trifolium subterraneum</i>	50	5
Birdsfoot trefoil, all	<i>Lotus corniculatus</i>	50	20
Black medic, Afghanistan	<i>Medicago lupulina</i>	15	15

* Best results

** Average of three reps

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Appendix Table 1. Spring planted in-row living mulch treatment list. 2004

TRT Code Treatment

A	Control – Bare ground
B	<i>Fragaria chiloensis</i> Native beach strawberry, plugs
C	<i>Galium odoratum</i> sweet woodruff, plugs
D	<i>Thymus praecox minus</i> Creeping thyme, plugs
E	<i>Asarum caudatum</i> Native ginger, plugs
F	<i>Sagina subulata</i> Irish moss, plugs
G	<i>Lobularia maritima</i> sweet alyssum, plugs
H	<i>Agrostis tenuis</i> 'Colonial' bentgrass
I	<i>Lotus corniculatus</i> PI 234670 'Kalo' Birdsfoot trefoil
J	<i>Lotus corniculatus</i> PI 592427 'Norcen' Birdsfoot trefoil
K	<i>L. corniculatus</i> PI 234670 'Kalo' bentgrass Mix
L	<i>Trifolium ambiguum</i> PI 325489 'Rhizo' kura clover
M	<i>Trifolium ambiguum</i> PI 427121 'Prairie' kura clover
N	<i>T. ambiguum</i> PI 325489 'Rhizo' bentgrass Mix
O	<i>T. repens</i> 'Dutch' white clover
P	<i>T. repens</i> 'NZ' white clover
Q	<i>T. fragiferum</i> 'O'Conner's' strawberry clover
R	<i>T. repens</i> / <i>T. fragiferum</i> Mix
S	<i>T. subterraneum</i> 'Antas' subclover
T	<i>T. subterraneum</i> Mix 1 (Antas subclover, bentgrass)
U	<i>T. subterraneum</i> Mix 2 ('Clare' and 'Nungarin' subclover)
V	<i>T. subterraneum</i> Mix 3 ('Howard' PI 277436, 'Mt. Barker' PI 279012 and 'Tallarook' PI 277439)
W	<i>Medicago lupulina</i> PI 260980 Afghanistan black medic
X	<i>Medicago lupulina</i> PI 251150 Yugoslavia black medic
Y	<i>M. lupulina</i> PI 260980 Afg black medic/ bentgrass Mix
Z	<i>Medicago polymorpha/scutellata</i> Mix ('Serena', 'Santiago' burr medic and 'Kelson' snail medic)
AA	<i>M. polymorpha</i> PI 494565 'Serena' burr medic
BB	<i>M. polymorpha</i> 'Santiago' burr medic

Medic did come out in bentgrass/Afgh mix in YR 2 plot 67 had 65% medic and 30 bent

OBJECTIVES:

Evaluate 'living mulch' species for establishment, vigor and weed competitiveness.

PROCEDURES:

The initial 2004 Living Mulch (LM) screening trial was monitored for a second season; stand cover, competition with weeds, height, bloom dates, and visual signs of rodent attractiveness were monitored and select biomass samples were taken in both YR 1 and 2. Winter hardiness and reseeding ability of annuals were also monitored in YR 2. Tree

growth parameters were not measured. Plots were mowed for supplemental weed control. Refer to on-line report for Year 1 procedures and progress:

<http://organic.tfrec.wsu.edu/OrganicIFP/OrchardFloorManagement/LM%20Report04.pdf>

In 2005 a second screening trial was established in a new Pinata/M7 apple block in transition to organic certification. Trees are more sensitive to competition and potential vole damage, and increased sunlight is available to the cover species during establishment. Selected species were planted as “Living Mulch” filling the understory weed strip (LM), or as a 45cm “Sandwich” under the trees with adjacent tillage in the remaining weed strip. Entries were grouped by species, species randomized within each group, groups randomized within each of 3 replications. Entries included both perennial landscape species and various legume and non-legumes. Sandwich entries included transplanted perennial *Thymus serpyllum*, *Galium odoratum* (sweet woodruff), *Mentha requienii* (Corsican mint), *Phlox subulata*, *Ajuga reptans*, *Potentilla neumaniana*, and *Veronica repens* and seeded Dutch white clover, black medic, an annual subclovers mix and fall planted chickweed (*Stellaria media*). The LM perennial entries included native kinnikinnick plugs, and seeded *T. serpyllum*, Colonial bentgrass, kura clover, and 3 birdsfoot trefoil varieties. Seeded annual LM entries included alyssum, Five Spot (*Nemophila maculate*), and several varieties of medic and subclover. Plots received preplant fertilizer (pelleted chicken manure) at a rate of 93#N/ac (assumed 50% available) according to typical orchard needs. Supplemental fertilizer was not applied for the mulch crops. Because of major competition for nutrients from both LMs and weeds, trees received supplemental foliar nutrient applications and a midseason liquid fertilizer injection of 32# total N(assumed available). Seedling emergence, stand establishment, % cover (LM and weeds), peak stand biomass and height were measured. Flowering dates and seed production were observed. Plots were mowed for supplemental weed control.

PROGRESS TOWARDS OBJECTIVES:

2. Living Mulch Initial Screening. For Year 1 Living Mulch Progress, refer to online report: [Screening Annual and Perennial Ground Covers as In-Row Living Mulch for Central Washington Orchards - 2004](#)

Year 2 progress. All perennial landscape entries were winter hardy. *Galium odoratum* is a promising landscape type entry providing potential early and season-long cover of 90% by April, limiting cheatgrass and cool season broadleaf competition. Colonial bentgrass also provided complete early cover out-competing weeds and legumes planted as a mix; the grass may compete with tree growth. Year 2 growth of *S. subulata*, *T. praecox* and *F. chiloensis* was again too slow to establish complete cover or suppress weeds. Year 2 cover potential for these species was estimated at 40-55%, up from 30-35% in YR1. The carpet type growth of the thyme and Scotch moss did show potential weed suppression. Alyssum did not successfully self-reseed and establish a stand in Year 2; heavy shade and duff may have contributed to low germination rate or seed may have had a low % viability. **Could use PICT1283 April 05 *Galium***

Spring planted annual subclovers and burr medics did not re-establish stands in YR 2. Black medics appeared to have a biennial habit and were winter hardy, the Afghanistan

selection again outperformed the Yugoslavian. Typically, the perennial legumes maintained stands and flowered in YR 2. White clover appeared to have better persistence than strawberry clover; kura clover failed to establish well in either YR 1 or 2. Birdsfoot trefoil varieties provided early cover; both had an estimated 70% cover midseason.

Fall planted subclovers, black medic (Afghanistan), birdsfoot trefoil and kura clover all overwintered well. Subclover provided early spring cover ranging from 30% (Clare) to 70% (Mt. Barker). All varieties flowered, produced seed and died back in 2005. There was limited new seedling emergence. Fall planted burr medics and the Yugoslavian black medic did not survive the winter. Evidence of stripped stems indicated vole feeding ie it is not known whether vole damage or lack of hardiness was the cause of mortality. Fall planted black medic from Afghanistan also had apparent vole damage but did establish a peak stand of 50% ? cover.

Fall planted birdsfoot trefoil 50% early cover and kura clover low vigor - 25% cover
Clovers

Vole trails were mapped in March to observe winter damage; only one replication showed much activity. Trails were concentrated in the spring planted clover (*T.repens*) and bentgrass plots. Both Dutch and New Zealand white clovers had heavy feeding activity. Bentgrass appeared to provide cover rather than food. Stems were stripped in the fall planted medics. There was no vole damage to tree bark.

Potential YR 2 cover of Year 2 Living Mulch entries*

Spring transplanted perennial Living Mulch	% Mulch Cover 3/31/05	% Mulch Cover 5/27/05	% Mulch Cover 6/15/05
<i>Fragaria chiloensis</i>	35	35	40
<i>Galium odoratum</i>	95	98	90
<i>Thymus praecox minus</i>	35	35	45
<i>Sagina subulata</i>	35	35	55
<i>Lobularia maritima</i> L.	0	0	0

*Landscape entry table shows best results of three reps

Spring Seeded Living Mulch	% Mulch Cover 3/31/05	% Mulch Cover 6/15/05
<i>A. tenuis</i>	93	78
<i>T. repens</i> NZ/ <i>T. fragiferum</i> Mix	60	95
<i>T. repens</i> 'Dutch'	53	73
<i>T. repens</i> 'NZ'	47	90
<i>T. fragiferum</i>	35	75
<i>M. lupulina</i> Afghan	50	73
<i>M. lupulina</i> Yugo	10	33
<i>L. corniculatus</i> 'Norcen'	38	72
<i>L. corniculatus</i> 'Kalo'	27	70
<i>T. ambiguum</i> 'Prairie' Kura	5	17
<i>T. ambiguum</i> 'Rhizo' Kura	2	12

* Average of three reps

