Screening Annual and Perennial Ground Covers as In-Row Living Mulch for Central Washington Orchards 2004

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Abstract: Maintaining in-row living mulches in orchard floor management systems offers potential multiple benefits including weed suppression, nutrient cycling, and improved soil quality. The most popular orchard floor management systems in temperate regions maintain permanent vegetative cover (Hogue and Neilsen, 1987). Examples of these systems include mowed grass or legume cover crops in the alleys with an herbicide strip in the tree row, a sod-mulch system with grass alleys and mulch in the tree row, sod in both the alleys and tree row, or living mulches in the tree row in combination with an alley cover.

Suitable in-row living mulches should establish quickly, provide adequate cover to suppress both cool and warm season weeds, be shade tolerant, easy to manage, and provide habitat for increased populations of beneficial insects. Optimal covers would exhibit minimal competition with the trees for moisture and nutrients and would not attract increased vertebrate or arthropod pest activity. 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.

Objectives: Evaluate in-row orchard 'living mulch' species for establishment, vigor and weed competitiveness.

Methods: The purpose of the trial is to screen 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. During the first year, the main objective was to establish the plots and make some initial qualitative assessments. A few quantitative measurements (e.g. seedling count and % cover) were made in 2004 but more will be collected in 2005.

The study was established in 2004 at the Wenatchee Valley College Auvil teaching orchard near East Wenatchee, WA in a Gala/M26 apple block planted in 1995. Treatment plots were laid out in the tree row in a Randomized Complete Block (RCB) experimental design with three replications of 28 treatments (Table 1). Plot size is $0.9m^2$ (76cm x 120cm). Grass alleys (with broadleaf weeds) were maintained between tree rows. Trial species include low growing carpet type perennial ground covers as well as various annual and perennial legumes.

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The research orchard is being managed for organic certification; therefore no herbicide was applied to plots prior to planting. Composted chicken manure was applied 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 prepared by mechanical tillage, raking, and firming with a landscape rake. On 5/22/04, inoculated legume seed and bentgrass seed combinations were broadcast into plots. Seedbeds were then rolled with a packer to shallowly incorporate seed and pack the surface. Treatments are listed in the Appendix Table1. Non-legume perennial plugs were transplanted to plots. Plug sizes ranged from 72s 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. Because of heavy weed pressure in the spring planted plots, we also fall planted (early September) several of the legume species to compare emergence and stand establishment.

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/cm^3), and infiltration rate (.31-1.03 min/cm).

Observations:

Emergence of spring seeded covers was difficult to quantify because weed pressure was extreme (Table1). 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 cm^2 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. Next year's data will help sort this out. **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.

Perennial Non-legume Covers

'Colonial' bentgrass (*Agrostis tenuis)* seedlings emerged and filled in well, quickly establishing a thick mat that provided excellent cover and weed suppression. The grass grew taller than expected (17 cm) but was bent over and did not create a management problem. The bentgrass may be more competitive with the trees than is optimal. However, the root growth was shallow and plants easily pulled out. By lowering seeding rates we might find an optimal rate providing adequate cover and minimal competition to the trees.

Creeping thyme (*Thymus praecox minus),* Irish moss *(Sagina subulata)* and native beach strawberry *(Fragaria chiloensis)* have the potential to develop a carpet like cover and

provide good weed suppression. However, plants are slow growing and required supplemental weed control during the first season. Sweet woodruff (*Galium odoratum)* and sweet alyssum (*Lobularia maritima L.)* show greater potential to fill in and more quickly provide weed suppression in the first season. Both treatments appeared well adapted to conditions in the tree row with stand height of 16-17cm. The sweet alyssum is a tender perennial not expected to overwinter. However, the plants flowered profusely throughout the growing season and we expect that the stand will self–reseed.

Improved stand establishment might be achieved with higher density planting, resulting in an initial cover of >15%, or by seeding (if seed is available). 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 (*Asarum caudatum)* transplants died back and did not establish a stand. 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.

Annual and Perennial Legumes

Clovers. Most clover species performed as expected. The '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 'Dutch' and 'New Zealand' white clovers had the highest seedling counts (> 23/100cm^2 sample area) and resulting biomass production. Counts ranged from 6-13/area for 'O'Connor's' strawberry clover. The white clovers ranked highest for % 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/100cm^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.

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 cm^2 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.

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 cm^2 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^oF.

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.

Birdsfoot trefoil. As expected, Birdsfoot trefoil was slow to establish as a living mulch. **'**Norcen' and 'Kalo' varieties had 10 and 5/100 cm^2 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 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.

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.

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

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 *A. tenuis* Colonial bentgrass	**3**	
Clovers		
T. repens NZ/ *T. fragiferum* Mix	4	23.0
T. repens 'Dutch'	4	26.3
T. repens 'NZ'	4	25.3
T. fragiferum 'O'Connor's'	4	7.3
Medics		
M polymorpha/scutellata Mix****	2	9.3
M. polymorpha 'Santiago'	2	7.7
M. polymorpha 'Serena'		7.3
M. lupulina PI 260980 Afghanistan	2	5.7
M. lupulina PI 251150 Yugoslavia	2	9.0
Birdsfoot trefoil		
L. corniculatus 'Norcen'	1.5	10.7
L. corniculatus 'Kalo'	1	6.3
Subclovers		
T. subterraneum 'Antas'	3	4.3
T. subterraneum Mix 2 **	2	4.7
T. subterraneum Mix 3***	2	4.0
Kura clover		
T. ambiguum 'Rhizo'	1	2.0
T. ambiguum 'Prairie'	1	4.0

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

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 *A. tenuis*	H	86	88	12	17
Carpet type ground covers					
Sweet Alyssum *L. maritima*	G	60*	77	13	16
Sweet Woodruff *G. odoratum*	C	40*	47	23	16.7
Creeping Thyme *T. praecox minus*	D	30*	35	17	4.7
Irish Moss *S. subulata*	F	20*	37	18	3.3
Native Beach Strawberry *F. chiloensis*	B	30*	33	37	8
Native Ginger *A. caudatum*	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 *L. maritima*	12.1	76.7
Sweet Woodruff *G. odoratum*	12	45
Irish Moss *S. subulata*	9.6	36.7
Native Beach Strawberry *F.chiloensis*	12.2	33.3
Creeping Thyme *T. praecox minus*	15.2	31.7
Native Ginger *A. caudatum*	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					
A. tenuis	H	5	88	12	17
Clovers					
T. repens 'Dutch'	O	5	84	17	24.3
T. repens 'NZ'	P	5	84	17	26
T. repens NZ/ *T. fragiferum* Mix	R	4	78	22	25
T. fragiferum 'O'Connor's'	Q	3	55	30	23
T. ambiguum 'Prairie'	M	2	8	60	
T. ambiguum 'Rhizo'	L	1	8	52	
Subclovers					
T. subterraneum 'Antas'	S	3	7	55	12.7
T. subterraneum Mix 3 'Howard', 'Mt. Barker' and 'Tallarook'	V	3	32	43	11.7
T. subterraneum Mix 2 'Clare', 'Nungarin'	U	3	27	47	11
Medics					
M. lupulina PI 260980 Afghanistan	W	4	47	42	13.3
M. polymorpha 'Santiago'	BB	4	8**	47	5.3
M. lupulina PI 251150 Yugoslavia	X	3	43	37	11
M. polymorpha 'Serena'	AA	3	12**	50	7
M polymorpha/scutellata Mix	Z	3	5**	90	
Birdsfoot Trefoil					
L. corniculatus 'Norcen'	J	4	57	30	14
L. corniculatus 'Kalo'	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)
M. polymorpha 'Serena'	40	85	<5	15-18
M. polymorpha 'Santiago'	30	85	<5	15-18
M. lupulina PI260980 Afghanistan	10	40	10	5-10
M. lupulina PI251150 Yugoslavia	15	30	10	5-10
T. ambiguum 'Rhizo' Kura	5	25	15	1-2
T. ambiguum 'Prairie' Kura	15	40	10	2-4
L. corniculatus 'Kalo'	15	45	15	3-4
L. corniculatus 'Norcen'	25	65	10	2-4
L. corniculatus NSV*	30	75	5	7-8
T. subterraneum 'Antas'	62	100	5	12-17
T. subterraneum 'Clare'	40	93	10	10-13
T. subterraneum 'Mt Barker'	32	93	10	5-10
T. subterraneum '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/m^2	Dry wt kg/m^2
A. tenuis	1.87	0.48
T. repens 'NZ'	2.62	0.43
T. fragiferum 'O'Connor's'	1.81	0.39
M. lupulina Afghan	1.3	0.35
T. repens 'Dutch'	1.96	0.34
*T. sub Mix 3****	1.8	0.29
L. corniculatus 'Norcen'	0.98	0.25
***T. subterraneum* 'Antas'**	1.15	0.18
***M. polymorpha* 'Serena'**	0.91	0.14
L. corniculatus 'Kalo'	0.83	0.13
***T. subterraneum* 'Clare'**	0.66	0.13
***M. polymorpha* 'Santiago'**	0.95	0.12
T. ambiguum 'Prairie' Kura	0.2	0.1
***L. corniculatus* NSV**	0.46	0.09
***T. subterraneum* 'Mt Barker'**	0.51	0.083
***T. subterraneum* 'Nungarin'**	0.37	0.077
***L. corniculatus* 'Norcen'**	0.2	0.04
***M. lupulina* PI260980 Afghanistan**	0.17	0.03
***L. corniculatus* 'Kalo'**	0.01	0.03
***M. lupulina* PI251150 Yugoslavia**	0.12	0.01

Species shaded indicate fall planting.

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References

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

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