RESEARCH PROJECT TITLE: Developing optimal agronomic management systems for direct seeding *Brassica* oilseed and mustard crops in the Pacific Northwest.

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FINAL REPORT:

PROJECT OBJECTIVES:

1. Determine more optimal agronomic practices for direct seeding winter canola by examining the effects of straw management, row spacing, seeder opener type, and starter fertilizer rate.

2. Determine more optimal agronomic practices for direct seeding spring canola, oriental mustard and yellow mustard by examining the effects of straw management and seeding rate.

KEY WORDS: canola, mustard, seeding rate, straw management

ZONE OF INTEREST: Annual cropping; low, intermediate and high rainfall; non-irrigated.

ABSTRACT OF RESEARCH FINDINGS: Straw management is critical for successful crop establishment and high yield in both winter and spring canola. Winter canola offers a greater challenge in obtaining suitable crop stands compared to either spring canola or oriental or yellow mustard. Better winter canola stands were obtained from early planting into burned straw or after light harrowing. Lowest plant stands and seed yields of winter canola were obtained with chopped straw and no-treatment control. The Great Plains double disc opener drill was inferior compared to the Flexi-Coil 'stealth' shank opener. Early planting is a major component of maximum yields. Even in situations with good soil moisture, seed yield of winter canola direct seeded into wheat stubble was significantly lower than when seeded into pea stubble or chemical fallow. Spring Brassica crops are less sensitive to straw management compared to winter canola, and good plant stands were obtained in all straw treatments and seeding rates. Higher seeding rates produced significantly and consistently higher yield over treatments and cultivars. Highest seed yield in spring crops was after light harrowing or the no-treatment control compared to straw mowing or burning. It should be noted that the 2003 and 2005 seasons were particularly hot and dry and the greater straw retained more moisture and cooler soil conditions in spring. These conditions in fall planting would be detrimental to plant growth, hence burning and harrowing in fall crops showed an advantage. Highest spring yields were obtained from Pacific Gold Oriental mustard, followed by IdaGold yellow mustard and lowest yield were obtained by Sunrise spring canola. Canola yield were highest with cool wet summers, while yellow mustard was particularly suited to hotter and drier environments.

RESULTS AND INTERPRETATION:

Winter canola trials:

2002-2003 season: In the 2002-2003 season winter canola studies were carried out using the winter canola cultivar 'Athena', which was specifically developed for late planting in Oregon and Idaho. Two field trials were planted at Moscow in the fall of 2002. The previous crop on the first trial site was winter wheat with 105 bu/acre yield, and the second trial was planted on chemical fallow following spring barley. A randomized strip-strip-plot design was used at each planting date. These experiments were planted on September 26 with duplicate plantings on October 4. Main-strips in the trials were assigned to straw management (burn, harrow, chop/mow, and no-treatment). Strip-plots were planted perpendicular to the straw management and were assigned to seeder opener type (Great Plains double disc opener and Flexi-Coil shank opener). Sub-strip-plots were row spacing (18-inch spacing and 9-inch spacing) and starter fertilizer rates (10lb – low and 20lb – high N, in 16:20:0 dry fertilizer mix). Each treatment combination was replicated four times at each site. Unit plot size was 10 feet x 25 feet.

Plant emergence and crop stand from the early planting on chemical fallow was very poor (Table 1), while no measurable seeding emergence was recorded on the recrop site or from the later planted trials. Averaged over all treatments in the early trial, only 1.2 plants yd^{-2} emerged. Despite the low seedling emergence, the Flexi-Coil planter resulted in significantly higher plant stands compared to the Great Plains drill. Significantly greater plant stands were obtained from the burn and harrow treatments compared to the straw chopping and no-treatment control. Despite a fairly mild winter, without snow cover, none of the treatment combinations survived to obtain yield data.

To supplement the above mentioned trials, a similar trial was planted in tilled summer fallow. This was a split-plot design which, of course, did not include the straw management factors. Seeder opener type (Great Plains double disc opener and Flexi-Coil) was assigned to main plots. Split-plots were row spacing (18-inch spacing and 9-inch spacing) and starter fertilizer rates (10lb – low and 20lb – high N, in 16:20:0 dry fertilizer mix). Each treatment combination was randomized four times and planted in on September 27 with duplicate plantings on October 4. Unit plot size was 5 feet x 20 feet.

Seedling emergence stand counts were markedly higher than the trials planted as recrop (Table 2), and on average 22 plants yd^{-2} emerged from the early planting and only 2.6 plants yd^{-2} planted a week later. Starter fertilizer had little effect on plant stands. As in the other trials, the Flexi-Coil planter resulted in significantly higher plants stands than the Great Plains drill. Similar results were obtained for seed yield (Table 2) where earlier planting produced almost threefold the yield of later planting, and the Flexi-Coil drill resulted in a highly significant increase in seed yield over the Great Plains drill. In a number of situations the higher starter fertilizer had a negative effect on seed yield. There was little difference in seed yield of the narrow and wide row spacing when the Flexi-Coil was used for planting. However, significant yield increase at 18-inch row spacing was obtained using the Great Plains drill.

2003-2004 season: As a result of poor performance in the 2002-2003 growing season, it was decided not to include the Great Plains drill in the 2003/2004 trials. In fall of 2003 winter canola trials were planted at two seeding dates in Moscow, Idaho, and once at Pendleton, Oregon. A randomized strip-strip-plot design was used at each location and planting date. Moscow planting dates were September 16 and September 26, while the Pendleton trial was planted on

October 7. Main-strips in the trials were assigned to straw management (Burn, harrow, mow, and no-treatment). Strip-plots, planted at right angles to the straw management, were winter canola cultivars 'Ericka' and 'Athena', which have both shown late-planting potential. Sub-strip-plots were row spacing (18-inch spacing and 9-inch spacing) and starter fertilizer rates (10lb – low and 20lb – high N, in 16:20:0 dry fertilizer mix). Each treatment combination was replicated four times at each site. Unit plot size was 10 feet x 25 feet at Pendleton and 5 feet by 25 ft at Moscow.

Markedly better seedling establishment was achieved in fall 2003 compared to the previous year. An average of 22.5 plants m^{-2} emerged from the Moscow earlier planting date and 15 plants m^{-2} from the later planting. Plant stand counts from the earlier planting were significantly higher in the straw burn and harrow treatments compared to the mowed straw and no-treatment control. There was no significant difference in fall plant stands over treatments in the later planting (Table 5).

Despite good seedling and emergence in all 2003 planted evaluation trials, 95 to 100% winter-kill occurred in the last week of October and first week of November. On October 22nd day-time temperature was 80^{o} F while night-time temperature dropped to 8^{o} F, one week later. This temperature differential was sufficient to cause crop failure throughout the trials. It was noted that 100% of our breeding plots at Genesee were winter-killed during the same period while 30 to 45% winter kill was observed on breeding lines at Moscow. One should also note that the breeding plots lost to temperature change were well established plants seeded into good summer fallow ground in mid-August.

2004-2005 season: Fall planting conditions were ideal for re-crop winter canola in 2004 compared to the previous two dry years. Similar straw management trials were planted in Moscow on September 15 into good moisture. Seedling emergence in all straw treatments was good, although seedling emergence where seeded into standing wheat stubble was delayed by two days compared to seeding into chemical fallow. Warm conditions after a wet period in September resulted in good seedling growth and all plants were at the rosette stage going into the winter.

Given the results obtained from the previous two years of study, it was decided to examine the effect of a previous wheat crop compared to a previous pea crop or chemical fallow. In spring of 2004, two strips were planted of spring wheat, pea and two strips of chemical fallow. The crop in 2003 had been winter wheat. In fall 2004, a trial was planted at right angles to the spring crop strips including the treatments of three cultivars (Athena and Ericka, *Brassica napus* types, and Salut a *B. rapa* canola), with two started nitrogen rates (25 and 50 units of N) and two seeding rates (5 and 10 lb/acre). The whole trial was therefore a strip-split plot design with previous crops as main strips and with started nitrogen as split-plot and cultivars and seeding rates as split-split plots. Each plot size was 20 x 20 feet with four replicates.

Started nitrogen had no effect on seedling stand establishment or seed yield. Stand establishment was, however, significantly different for cultivars, previous crops and for the interaction between cultivars and previous crops (Table 6). Highest plant stands were obtained from Athena and lowest stands from Ericka. Stand counts of Athena and Salut were almost halved when planted into pea or wheat stubble compared to planting into chemical fallow. Ericka stand counts were similar in chemical fallow and planted onto pea, but significantly lower when planted into wheat stubble. Over all cultivars and other treatments, stand counts were

significantly higher for planting into chemical fallow and significantly reduced when planted into wheat stubble.

Seed yield was somewhat related to fall plant stand counts whereby there were significant yield differences between previous crops, cultivars and the interaction between previous crops and cultivars (Table 7). Over all treatments and previous crops, Athena produced significantly higher seed yield than either Ericka or Salut, which produced yields that were 68% and 66% lower, respectively. Significantly higher Athena yield was obtained from planting into chemical fallow and significantly lower yield from planting into wheat stubble. Yield of Ericka was not significantly different when planted into chemical fallow or pea stubble, but was significantly reduced when planted into wheat stubble. Salut yield was not significantly affected by the previous crop.

Results from this study suggest that planting into wheat stubble results in lower plant stands and seed yield compared to planting into chemical fallow or pea stubble. The increased yield from chemical fallow could be related to soil moisture although fall 2004 was notably wet and heavy rains had proceeded planting. Soil tests were conducted from each plot combination in the spring of 2005 and nitrogen top-dressed to give an equivalent 120 lb N/acre. Greater yield after pea could have related to differential nitrogen availability in the fall (although there was no affect of starter fertilizer on any character), or that the pea crop land had greater moisture availability for canola growth. Irrespective of the ultimate cause observed from this study there is a suggestion that direct seeding winter canola into standing wheat straw has serious impacts on yield.

Conclusions: Successfully direct seeding winter canola into standing wheat straw is considerably more difficult than seeding into wheat straw with a spring *Brassica* crop. Greatest difficulties in fall establishment relate to the amount of straw that is not decomposed and attaining fall seedlings that have sufficient growth to survive winter condition. The slow fall seedling growth could be caused by low soil temperatures due to straw cover and limited thermal units available in the late fall. However, even when the straw is burned, winter-kill is highly probable. In the 2004-2005 season, there was sufficient soil moisture followed by a mild winter and yet seeding into wheat straw resulted in significant yield losses compared to seeding into chemical fallow or pea stubble. Greater research combined with better adaptation for fall direct seeding is most likely to result in the availability of a reliable direct seeded winter canola crop for this region.

Spring canola and mustard trials: All spring canola and mustard trials were planted in a randomized strip-split-plot design using a Flexi-Coil shank drill. Main-strips were randomly assigned to straw management treatments (burn, harrow, mow/chip, and no-treatment). The crop species/cultivars ('Sunrise' spring canola – *Brassica napus*, 'IdaGold' yellow mustard – *Sinapis alba*, and 'Pacific Gold' Oriental mustard – *B. juncea*) were planted as strip-plots at right angles to the straw management treatments. All three cultivars were developed by the University of Idaho to be adapted to growing conditions in the Pacific Northwest region. Sub-strip plots were assigned to low and high seeding rate (4 and 8lb/acre for canola, 5 and 10lb/acre for yellow mustard, and 2.5 and 5lb/acre for oriental mustard, to accommodate for seed size differences). All fertilizer was granular and banded below and to the side of the seed at a rate of 210 lb/acre of 16:0:0:6. Each treatment combination was replicated four times at each site and the unit plot size was 15 feet x 25 feet.

2003 trials: The 2003 spring field trials were affected by late planting which resulted from cold, wet weather that was followed by a hot, dry summer, causing lower than average seed yields. Field trials were planned for threelocations in 2003, Moscow, Genesee and Grangeville. However the Grangeville and Moscow sites were lost due to excessively wet conditions and data was only collected from the Genesee site.

Significant differences in plant stands were found between the different straw management treatments (Table 8). Highest plant stand counts were obtained from the straw burning and chopping treatments and significantly lower plant stands were obtained in the no-treatment control compared to the others. Although different weights of seed were planted from each species to allow for differences in seed size, Sunrise (*B. napus*) had significantly lower plant stands under all straw treatments compared to the two mustard species. As expected, higher seeding rates resulted in significantly higher plant stand counts (Table 9) over all treatments and species. Straw treatment had no significant effect on plant height (Table 10).

Seeding rate did have significant effect on seed yield under different straw management or different crop species. Although the burn treatment had highest plant stand counts, this treatment resulted in significantly lower seed yield compared to the chopped straw and no-treatment control (Table 11). Highest seed yield was obtained from the oriental mustard cultivar Pacific Gold, while IdaGold and Sunrise yields were not significantly different. Straw management had no effect on dockage (chaff) or seed oil content (Table 12 and Table 13, respectively).

2004 trials: In 2004, field trials were planted at four locations (Moscow, Genesee, and Craigmont in Idaho and Pendleton in Oregon) in an attempt to counter loosing two locations in 2003. Good direct seeding conditions were found at all four test sites, and sites were planted in a timely manner. Planting dates were on March 23 at Pendleton, on April 9 at Genesee, on April 13 at Craigmont, and on April 27 at Moscow.

Significantly ($P<0.05$) higher plant stand counts were found when wheat straw was mowed compared to direct seeding into standing straw (Table 14). Sunrise had poorest stand counts while Pacific Gold had highest counts across all straw treatments. Stand counts of the two mustard cultivars was relatively constant over treatments. However, Sunrise showed marked reduction in stand count in the burn and standing straw treatments (Table 15).

As expected, higher plant stands were obtained by increasing seeding rates (Table 16). However, there was no seeding rate x cultivar interaction. Tallest plants were obtained after seeding into burned straw (Table 17), while shortest plants were obtained by direct seeding into standing straw. On average, plants direct seeded into standing straw flowered 54.2 days after planting, which was significantly later than plants seeded into straw that had been harrowed or mowed.

Averaged over the three cultivars, seed yield of the direct seeded, burned and mowed treatments were not significantly different. However, significantly higher seed yield was obtained by harrowing the straw prior to planting (Table 18). Highest yield was obtained from Pacific Gold, followed by IdaGold, with Sunrise being significantly lower than either of the mustard cultivars. Yield of Pacific Gold was very similar irrespective of straw treatment and ranged from 3,249 lb/acre in burned straw to 3,172 lb/acre when direct seeded into standing straw, a range of 77 lb/acre from highest to lowest. Sunrise, in contrast was most affected over

treatments, ranging from a high of 2,292 lb/acre seeded into harrowed ground, and lowest at 1,907 when seeded into burned straw, a difference of 385 lb/acre. IdaGold was intermediate in response with a difference of 178 lb/acre between highest and lowest yield over treatments.

Over all cultivars, significantly higher seed yield was obtained from the higher seeding rates (Table 19). Sunrise was most responsive to increased seeding rate and showed 20% increase in seed yield with a higher seeding rate. Both mustards were more tolerant to lower seeding rates higher seeding only increased seed yield by 4% in each cultivar. The difference in seed yield with low and high seeding rate of Sunrise was related to the yield potential of each site. For example, at the two lowest yielding sites (Moscow and Craigmont, Idaho) higher seeding rates of Sunrise were 23% and 55% higher yielding, respectively (Table 20). At the two higher yielding locations, Genesee and Pendleton, Sunrise yield increase due to higher seeding rates were 15% and 3%, respectively. It is reasonable to suggest that the lower yielding sites were the result of less optimal growing conditions, suggesting that higher seeding rates of Sunrise would be justified under poor growth conditions. Seed yield of the mustard cultivars did not follow this trend.

As expected, the cultivars produced significantly different oil content (Table 21). Significantly higher oil content was obtained from the mow treatment compared to burn or no straw treatment. Lowest oil content was obtained when direct seeding cultivars into standing straw.

2005 trials: The 2005 trials were to be planted at Moscow, Genesee and Pendleton, however, the Moscow trial was not planted due to wet soil conditions such that planting would have been delayed until early June. The Pendleton site was planted on April 20 and the Genesee site was planted on May 5. These planting dates were both later than desired.

Good plant stands were obtained from both locations (Table 22). Although Pacific Gold stand counts were significantly higher compared to Sunrise, all three species has sufficient seedlings emerge. Despite the high seeding rate being twice that of the lower seeding rate, the number of seedlings that emerged was similar, albeit that the difference between the rates was formally significant, the higher seeding rate emergence was only 10% greater than the lower rate (Table 23).

Pacific Gold plants were significantly taller than either Sunrise or IdaGold (Table 24) and plants seeded directly into standing wheat straw were significantly taller than when planted into the other three straw treatments. Seed yield from direct seeded treatments was significantly higher than from seeding into mow, harrow, or burn treatments (Table 25). The 2005 growing season began with late spring rains that delayed planting followed by a hot, dry summer and fall. The taller plants and higher seed yield from direct seeding into standing straw could have resulted from better moisture retention, cooler summer soil temperatures, or lower wheat straw residues in this year. The mustard cultivars produced significantly higher seed yield than Sunrise canola. This could also be related to the hot, dry summer. There was a significant interaction for yield between cultivars and location in 2005 (Table 26). At Genesee all cultivars produced yields higher than 1300 lb/acre. However, Sunrise canola yield decreased almost 90% at Pendleton compared to Moscow, while Oriental and yellow mustard yield were reduced at Pendleton by 46% and 36%, respectively. This shows the better adaptation of yellow mustard and Oriental mustard to high temperatures and moisture stress.

Conclusions: The greatest variable factor over the three years was site location. Highest average seed yield was from the Pendleton site in 2004 with 3834 lb/acre, while lowest seed yield was from the Pendleton site in 2005 (632 lb/acre).

Results from 2004 trials were similar to those from 2003 in that direct seeding into standing straw produced lower plant stands, a shorter crop, lower seed yield and oil content. In the 2003 trials, highest seed yield was obtained when straw was harrowed prior to planting. However, in the 2005 season, the highest yield was obtained from seeding into standing wheat straw. The mustard cultivars were less responsive to different seeding rates and Sunrise canola required higher seed rates, particularly at the low yield potential sites. The 2005 trials were in agreement with the other years in that yellow and Oriental mustard are less responsive to varying environmental, straw management treatments and seeding rates than canola.

Over all environments and treatments, highest seed yield was from Pacific Gold Oriental mustard at 2435 lb/acre, followed by IdaGold yellow mustard at 2247 lb/acre and lowest yield was obtained from Sunrise canola at 1865 lb/acre (Table 27). Over all locations, seeding spring Brassica crops into standing wheat straw or harrowed straw produced significantly higher seed yield (2228 and 2235 lb/acre, respectively) than seeding into mowed wheat straw (2139 lb/acre) or burned straw (2138 lb/acre). On average, higher seeding rates produced significantly higher seed yield (2265 lb/acre) than lower seed rates (2103 lb/acre). However, growers would need to consider whether this increase in yield was justified with an increase in seed cost.

Overall, all three cultivars examined showed potential when direct seeded in the Pacific Northwest. Pacific Gold had overall better adaptation and higher yield throughout the study, yellow mustard has greatest potential in dry and hot years compared to the other two, and canola only had high seed yield potential in cooler summers with less moisture stress.

PUBLICATIONS AND PRESENTATIONS:

Davis, J.B. and J. Brown. 2005. Potential of Oilseed Production in the Pacific Northwest. In: Sustainable Transportation Conference – Biodiesel Fuel Production. Moscow, ID, September 22, 2005.

Wittman, N. 2005. Straw management and agronomic practices for optimal productivity of winter and spring canola (*Brassica napus* L.), Oriental mustard (*Brassica juncea* L.) and yellow mustard (*Sinapis alba* L.) in the dryland regions of the Pacific Northwest. A thesis presented for MS degree at the University of Idaho, July 2005.

Wittman, N, J. Brown and J.B. Davis. 2004. Straw management in direct seeding winter and spring Brassica crops. Poster presented at the 2004 Direct Seed Conference, Pendleton, Oregon, January 7-9 2004.

Wittman, N, J. Brown and J.B. Davis. 2003. Straw management in direct seeding winter and spring Brassica crops. Poster presented at the Idaho and Washington Canola & Mustard Commission Meeting, Moscow, ID, March 4, 2004.

Wittman, N., 2003. Straw management in direct seeded spring Brassica crops. Presented at the University of Idaho, Canola, Rapeseed & Mustard Field Day, July 7, 2004.

Wittman, N, J. Brown and J.D. Davis. 2003. Straw management in direct seeding winter and spring Brassica crops. Poster presented at the 2003 Direct Seed Conference, Spokane Washington, January 2003.

Wittman, N, J. Brown and J.D. Davis. 2003. Straw management in direct seeding winter and spring Brassica crops. Poster presented at the 2003 American Canola Council Conference, Washington D.C., February 2003.

Wittman, N., 2003. Straw management in direct seeded spring Brassica crops. Presented at the University of Idaho, Plant Science Field Day, July 1, 2003.

Table 1. Plant emergence counts of early planted winter straw management trials planted fall 2002 with 9 and 18-inch row spacing, low and high starter fertilizer and planted with Great Plains (GP) double disk drill or Flexi-Coil (FC) shank drill.

Row Spacing	Starter fertilizer	No-treatment		Burn		Harrow		Chop	
		GP	FC	GP	FC	GP	FC	GP	FC
		plants yd^{-1}							
9-inch	Low	0	1.3	0.3	3.3	3.7	0.3	0	0
	High	0	2.0	0.7	4.7	0.3	2.7	0	0
18-inch	Low	0.3	0.7	0	2.7	3.0	2.7	0	0
	High	0	2.3	0	5.3	1.0	1.7	0	0
LSD 5% within table 1.22									

Table 2. Plant stand counts and seed yield of 'Athena' winter canola planted on 9 and 18-inch row spacing with high and low starter fertilizer and using the Great Plains (GP) double disc opener or the Flexi-Coil (FC) shank opener. Trials planted early (September 27) and late (October 5) in Fall 2002.

Row spacing	Planter	Starter Fertilizer	Plant stand		Seed Yield	
			Early	Late	Early	Late
			plants yd^{-2}		lb $acre^{-1}$	
9-inch	GP	Low	319^{d}	604^{b}	3.2^{c}	0.2^{b}
		High	486^{d}	51^{d}	6.6^{bc}	2.4^{b}
	FC	Low	1877^{a}	962^{a}	33.0^{a}	4.2^{ab}
		High	1816^{a}	260^{c}	31.4^{a}	1.0^{b}
18-inch	GP	Low	1704^{a}	332^{c}	16.4^{b}	1.8^{b}
		High	666^{c}	152^{c}	5.0^{bc}	1.8^{b}
	FC	Low	1981^{a}	1080^{a}	39.0^{a}	8.0^{a}
		High	1217^{b}	399^{b}	37.6^{a}	1.4^{b}
Mean			1258	471	21.5	2.6
LSD 5%			275	350	14.3	5.2

Table 3. Plant emergence counts averaged of early planted winter straw management trials planted Fall 2002 with 9 and 18-inch row spacing, low and high starter fertilizer rates and two cultivars (Ericka and Athena).

Row Spacing	Starter fertilizer	No-treatment		Burn		Harrow		Chop	
		Ericka	Athena	Ericka	Athena	Ericka	Athena	Ericka	Athena
		plants yd^{-1}							
9-inch	Low	19	19	24	30	33	13	22	19
	High	23	9	14	21	9	18	16	6
18-inch	Low	25	18	28	30	43	31	21	18
	High	30	26	37	23	29	30	17	19
LSD 5% within table 16.9									

Table 4. Plant emergence counts of early planted winter straw management trials planted Fall 2002 with 9 and 18-inch row spacing, low and high starter fertilizer rates and two cultivars (Ericka and Athena).

Row Spacing	Starter fertilizer	No-treatment		Burn		Harrow		Chop	
		Ericka	Athena	Ericka	Athena	Ericka	Athena	Ericka	Athena
		Plants yd $^{-1}$							
9-inch	Low	15	9	16	15	10	7	9	5
	High	16	11	23	6	22	11	7	4
18-inch	Low	22	19	24	18	19	14	15	11
	High	24	18	21	20	19	23	15	13
No significant differences within the table									

Table 5. Plant emergence counts of early planted winter straw management trials planted in Fall 2002 with 9 and 18-inch row spacing, low and high starter fertilizer rates and two cultivars (Ericka and Athena).

Row Spacing	Starter fertilizer	No-treatment		Burn		Harrow		Mow	
		Ericka	Athena	Ericka	Athena	Ericka	Athena	Ericka	Athena
		Plants yd $^{-1}$							
9-inch	Low	15	9	16	15	10	7	9	5
	High	16	11	23	6	22	11	7	4
18-inch	Low	22	19	24	18	19	14	15	11
	High	24	18	21	20	19	23	15	13
No significant differences within the table									

Table 6. Plant emergence counts of three cultivars planted after three different previous crops planted in Fall 2004.

Cultivar	Previous crop			Mean
	Chem. Fallow	Pea	Spring wheat	
	plants m^{-1}			
Athena	20.7	11.8	11.3	14.7 [a]
Ericka	11.2	12.1	6.1	9.8 [b]
Salute	19.7	9.5	9.1	12.8 [ab]
Mean	17.2 [a]	11.2 [b]	8.9 [c]	

Table 7. Seed yield of three cultivars planted after three different previous crops planted in Fall 2004 and harvested in 2005.

Cultivar	Previous crop			Mean
	Chem. Fallow	Pea	Spring wheat	
	plants m^{-1}			
Athena	1742	1523	1098	1455 [a]
Ericka	1117	1156	701	992 [b]
Salute	957	1081	840	969 [b]
Mean	1282 [a]	1253 [a]	880 [b]	

Table 8. Plant stand counts for straw treatments and species mean of plant stand counts from spring straw management trials.

Species	Treatment				Mean
	No-treatment	Burn	Harrow	Chop	
	plants yd^{-2}				
Pacific Gold	11.2	19.0	15.0	18.4	15.9[b]
Sunrise	10.3	11.0	11.2	12.0	11.1[c]
IdaGold	13.7	20.2	16.6	18.5	17.3[a]
Mean	11.7[c]	16.8[a]	14.3[b]	16.3[a]	

Means with different superscript letters are significantly different (P<0.05)

Table 9. Plant stand counts for different straw treatment and seeding rate of from spring straw management trials in 2003.

Seeding rate	Treatment				Mean
	No-treatment	Burn	Harrow	Chop	
	plants yd^{-2}				
Low	7.1	10.1	9.6	10.6	9.4[b]
High	16.3	23.4	19.0	22.0	20.2[a]
Mean	11.7[c]	16.8[a]	14.3[b]	16.3[a]	

Means with different superscript letters are significantly different (P<0.05)

Table 10. Plant height for different straw treatment and crop species trials in 2003.

Species	Treatment				Mean
	No-treatment	Burn	Harrow	Chop	
	inches				
Pacific Gold	47	45	47	48	47[a]
Sunrise	41	42	40	44	41[b]
IdaGold	37	35	36	37	36[c]
Mean	41	41	41	43	

Means with different superscript letters are significantly different (P<0.05)

Table 11. Seed yield for different straw treatment and species trials in 2003.

Species	Treatment				Mean
	No-treatment	Burn	Harrow	Chop	
	lb acre^{-1}				
Pacific Gold	1059	993	1039	968	1014[a]
Sunrise	890	718	738	960	842[b]
IdaGold	923	741	855	897	897[b]
Mean	957[a]	838[b]	877[ab]	942[a]	

Means with different superscript letters are significantly different (P<0.05)

Table 12. Chaff in harvested seed from spring straw management trials in 2003.

Species	Treatment				Mean
	No-treatment	Burn	Harrow	Chop	
	lb/acre				
Pacific Gold	438	356	396	320	378[b]
Sunrise	650	614	510	651	606[a]
IdaGold	816	571	665	751	701[a]
Mean	635	514	524	574	

Means with different superscript letters are significantly different (P<0.05)

Table 13. Seed oil content from spring straw management trials in 2003.

Species	Treatment				Mean
	No-treatment	Burn	Harrow	Chop	
	%				
Pacific Gold	34.9	35.8	34.7	34.2	34.9[b]
Sunrise	35.5	38.1	30.1	36.9	37.1[a]
IdaGold	25.5	26.1	25.8	25.9	25.9[c]
Mean	32.0	22.4	32.9	32.3	

Means with different superscript letters are significantly different (P<0.05)

Table 14. Plant stand counts for different straw treatments and cultivars from spring straw management trials in 2004.

Species/ Cultivar	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	plants yd^{-2}				
Pacific Gold	19.1	19.1	19.1	18.3	18.9 [a]
Sunrise	12.6	13.4	15.1	16.7	14.5 [c]
IdaGold	16.3	18.1	17.5	17.4	17.3 [b]
Mean	16.0 [b]	16.9 [ab]	17.3 [ab]	17.4 [a]	

Means with different superscript letters are significantly different (P<0.05)

Table 15. Plant stand counts for different straw treatments and seeding rates from spring straw management trials in 2004.

Seeding rate[1]	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	plants yd^{-2}				
Low	12.8	13.0	12.9	12.9	12.9 [b]
High	21.0	20.6	21.5	22.0	21.3 [a]
Mean	16.0 [b]	16.9 [ab]	17.3 [ab]	17.4 [a]	

Means with different superscript letters are significantly different (P<0.05)
[1] Low seed rate was 2.5lb, 4lb and 5lb/acre for Pacific Gold, Sunrise and IdaGold, respectively. High seed rate was 5lb, 8lb, and 10lb, for Pacific Gold, Sunrise and IdaGold, respectively.

Table 16. Plant height from straw treatment and species from spring straw management trials in 2004.

Species/ Cultivar	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	inches				
Pacific Gold	59	65	62	63	62 [a]
Sunrise	46	50	49	48	48 [c]
IdaGold	48	55	52	51	52 [b]
Mean	51 [c]	56 [a]	54 [b]	54 [b]	

Means with different superscript letters are significantly different (P<0.05)

Table 17. Seed yield for straw treatment and species from spring straw management trials in 2004.

Species/ Cultivar	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	lb acre^{-1}				
Pacific Gold	3172	3249	3213	3227	3215 [a]
Sunrise	2143	1907	2292	2039	2095 [c]
IdaGold	2733	2789	2819	2641	2746 [b]
Mean	2683 [b]	2649 [b]	2779 [a]	2631 [b]	

Means with different superscript letters are significantly different (P<0.05)

Table 18. Seed yield for straw treatment and seeding rate from spring straw management trials in 2004.

Seeding rate[1]	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	lb acre^{-1}				
Low	2604	2563	2515	2659	2585 [b]
High	2764	2733	2900	2746	2786 [a]
Mean	2683 [b]	2649 [b]	2779 [a]	2631 [b]	

Means with different superscript letters are significantly different (P<0.05)
[1] Low seed rate was 2.5lb, 4lb and 5lb/acre for Pacific Gold, Sunrise and IdaGold, respectively. High seed rate was 5lb, 8lb, and 10lb, for Pacific Gold, Sunrise and IdaGold, respectively.

Table 19. Seed yield from species and seeding rate from spring straw management trials in 2004.

Seeding rate[1]	Species/Cultivar			Mean
	Pacific Gold	Sunrise	IdaGold	
	lb acre^{-1}			
Low	3157	1906	2692	2585 [b]
High	3274	2285	2799	2786 [a]
Mean	3215 [a]	2095 [c]	2746 [b]	

Means with different superscript letters are significantly different (P<0.05)
[1] Low seed rate was 2.5lb, 4lb and 5lb/acre for Pacific Gold, Sunrise and IdaGold, respectively. High seed rate was 5lb, 8lb, and 10lb, for Pacific Gold, Sunrise and IdaGold, respectively.

Table 20. Site by species and seeding rate of seed yield from straw management trials in 2004.

Species/ Cultivar	Seed Rate[1]	Moscow	Craigmont	Genesee	Pendleton
		---------- lb acre^{-1} ----------			
Pacific Gold	Low	1223	2506	4133	4763
	High	1318	3043	4112	4624
Sunrise	Low	843	1355	2439	2986
	High	1140	2100	2815	3084
IdaGold	Low	1910	2096	3132	3629
	High	2091	2062	3128	3915

[1] Low seed rate was 2.5lb, 4lb and 5lb/acre for Pacific Gold, Sunrise and IdaGold, respectively. High seed rate was 5lb, 8lb, and 10lb, for Pacific Gold, Sunrise and IdaGold, respectively.

Table 21. Oil content from straw treatment and species from spring straw management trials in 2004.

Species	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	---------- % ----------				
Pacific Gold	33.5	33.5	33.9	33.7	33.6 [b]
Sunrise	35.2	35.7	36.1	36.4	35.9 [a]
IdaGold	26.1	26.1	26.2	26.0	26.1 [c]
Mean	31 6 [c]	31.8 [bc]	32.0 [ab]	32.1 [a]	

Means with different superscript letters are significantly different (P<0.05)

Table 22. Plant stand counts from straw treatment and species from spring straw management trials in 2005.

Species/ Cultivar	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	---------- plants yd^{-2} ----------				
Pacific Gold	17.7	18.1	17.6	18.0	17.9 [ab]
Sunrise	17.3	17.8	17.6	17.3	17.5 [b]
IdaGold	18.0	18.5	18.4	17.8	18.1 [a]
Mean	17.7	18.1	17.8	17.7	

Means with different superscript letters are significantly different (P<0.05)

Table 23. Plant stand counts from species and seeding rate from spring straw management trials in 2005.

Seeding rate[1]	Species			Mean
	Pacific Gold	Sunrise	IdaGold	
	plants yd^{-2}			
Low	16.9	17.0	17.1	17.0 [b]
High	18.8	18.1	19.1	18.7 [a]
Mean	17.9 [ab]	17.5 [b]	18.1 [a]	

Means with different superscript letters are significantly different (P<0.05)
[1] Low seed rate was 2.5lb, 4lb and 5lb/acre for Pacific Gold, Sunrise and IdaGold, respectively. High seed rate was 5lb, 8lb, and 10lb, for Pacific Gold, Sunrise and IdaGold, respectively.

Table 24. Plant height after flowering from straw treatment and species from spring straw management trials in 2005.

Species/ Cultivar	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	inches				
Pacific Gold	59	65	62	63	58 [a]
Sunrise	46	50	49	48	42 [b]
IdaGold	48	55	52	51	47 [b]
Mean	52 [a]	50 [b]	50 [b]	50 [b]	

Means with different superscript letters are significantly different (P<0.05)

Table 25. Seed yield from straw treatment and species from spring straw management trials in 2005.

Species/ Cultivar	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	lb $acre^{-1}$				
Pacific Gold	1377	1072	1147	1101	1174 [a]
Sunrise	843	667	736	748	749 [b]
IdaGold	1223	1189	1238	1133	1196 [a]
Mean	1148 [a]	976 [b]	1040 [b]	994 [b]	

Means with different superscript letters are significantly different (P<0.05)

Table 26. Seed yield from sites and species from straw management trials in 2005.

Species/ Cultivar	Genesee	Pendleton	Mean
	---------- lb acre^{-1} ----------		
Pacific Gold	1528	820	1174 [a]
Sunrise	1348	149	749 [b]
IdaGold	1463	928	1196 [a]
Mean	1147 [a]	632 [b]	

[1] Low seed rate was 2.5lb, 4lb and 5lb/acre for Pacific Gold, Sunrise and IdaGold, respectively. High seed rate was 5lb, 8lb, and 10lb, for Pacific Gold, Sunrise and IdaGold, respectively.

Table 27. Seed yield from straw treatment and species from spring straw management trials averaged over all locations in 2003, 2004 and 2005.

Species/ Cultivar	Treatment				Mean
	No-treatment	Burn	Harrow	Mow	
	---------- lb acre^{-1} ----------				
Pacific Gold	2475	2417	2436	2408	2435 [a]
Sunrise	1917	1756	1984	1804	1865 [c]
IdaGold	2285	2231	2278	2194	2247 [b]
Mean	2229 [a]	2138 [b]	2235 [a]	2139 [b]	

Means with different superscript letters are significantly different ($P<0.05$)