

Response of Red Potato to Crop Rotation and Green Manure, 2013

By Samuel YC Essah and Merlin Dillon

Assisted by Rob Davidson and Andrew Houser

Colorado State University

San Luis valley Research Center

Introduction:

Green manure crops are grown in San Luis Valley potato production for a number of reasons. These include: reducing groundwater pumping, reducing soil-borne diseases and reducing nematode infestations. Cash crops are forgone in return for other benefits. In some cases, improving the soil health by growing a green manure crop may increase potato yields and potato gross income.

Longer rotations should benefit potato production by reducing soil-borne diseases. Still, SLV growers have done very well with a 2-year Potato/Grain rotation. This project was developed to determine which rotation crops and green manures would produce the most benefits to potato production.

Results:

Tuber Yield and Tuber Size Distribution

In this multi-year study with one year results planted to Colorado Rose (red), a 2-yr rotation treatment (#2) where winter rye was planted after potatoes and soil incorporated in mid-May followed by sudangrass green manure significantly increased total yield and the yield of every size category (Table 1). Total yield was increased by 37% compared to the conventional Barley/Potato, 2-yr rotation (#1). In addition, Treatment #2 (2 yr rye GM-sudangrass GM/Potato rotation) increased 4-10oz yield 22%. Three-yr rotations of barley/canola/potato (#4), Barley/Canola+Manure/Potato (#8), and Barley/Mustard GM/Potato (#9) increased the yield of 4-10 oz tubers by 19%, 19%, and 18%, respectively. The lowest total yield was for the Barley/cocktail GM/potato rotation (#10). This 3-yr rotation reduced total yield by 19 % (Table 1).

Tuber Diameter

Red potatoes are customarily sized and sold by tuber diameter. Colorado Rose tuber diameter responded to crop rotation and preceding green manure crop. Tubers in the 2-4 inch, >2 inch-10 oz, and >10 oz inch categories all showed higher yields when preceded by Treatment #2, 2-yr rotation rye GM-sudangrass GM/Potato (Table 2). These yield increases were 26%, 22%, and 36%, respectively. Also found in the top yield group for the >2in-10 oz diameter group were (#4) barley/canola/potato, (#8) barley/canola+manure/potato, (#9) and barley/mustard GM/potato. The lowest tuber yield in the <2-10oz category was (#10) Barley/cocktail GM/potato.

Tuber Quality

Treatments with the highest percentage of external defects (growth cracks, knobs, and misshapes) were barley/cocktail GM/potato (#10), barley/potato (#1), rye GM-sudangrass GM/potato (#2) and (#3) wet fallow/potato (Table 3). All other treatments produced less than 2% external defects.

The maximum percentage hollow heart (1.4%) was observed in tubers grown following rye GM-sudangrass Gm/potato (#2) or the wet fallow/potato treatment (#3)(Table 3). However, this amount of hollow heart is not enough to cause marketing problems.

Gross Income

Potato income is much higher for those growers' able to successfully produce red potatoes. Gross income does not include any production costs. Simply add the income from each size group to get the total income for each treatment. Great differences in income resulted from the crop rotations and green manure crops preceding red potatoes. Treatment #2 produced the highest income by far (\$9328/ac). This resulted from producing tubers in the highest yield group for each size category. This is a wonderful rotation has other advantages; saving soil by keeping the soil covered for nearly all the time in the two year rotation and also saving groundwater since irrigating the rye and the sudangrass use less water than conventional barley.

Treatment #9 produced \$7220/acre resulting from high yields in the first two size categories. Treatment #3 produced \$6852/acre which was also a result of high yields from the <2 in and group b for the other two size categories. Treatment #1, conventional Potato/barley, produced \$6768/acre because of adequate yields of 2 in – 10 oz and premium sizes (>10 oz).

Low gross income was produced by treatments #4, #5, #6, and #10. These treatments all had poor yield in at least one size category which reduced the gross income.

Potato Disease

Crop rotation/green manure treatments had little effect on Black Scurf and Silver Scurf. Differences were non-significant for Black Scurf and Silver Scurf (Table 5). However, total % tubers with Powdery Scab and Powdery Scab severity index were significant at 10%. This indicates that 2/3 of the 2-year rotations resulted in high levels of powdery scab. None of the 3-yr rotations had elevated levels of powdery scab. Note: it should be considered that the 2-yr rotations are grown in a separate land block for irrigation purposes. This block may have had more powdery scab. Still, the Wet Fallow/Potato (#3) was also grown in this block and produced zero scab.

The rotations which did result in high and statistically significant levels of powdery scab were (#1) Barley/Potato and (#2) Rye GM-sudangrass GM/Potato. Treatment #1 was rated 20% tubers infected and 40 severity index. Treatment #2 (rye GM-sudangrass GM/Potato) was rated 17.5% tubers infected and 42.5 severity index. This compares to 0.0 for most of the other treatments. These are results from only one year; however, this seems to be an important finding.

Notes: Fertilizer provided by Stones Farm Supply and Monte Vista CO-OP, Center. Herbicides provided by DP Ag Services, Don Henderson. Compost and manure provided by Compost Technologies. Compost applied only once which was prior to barley, 4 ton/acre, in 2011. Manure applied only once which was prior to barley, 20 ton/acre, in 2011. Probably, more than one applications should be applied before expecting to improve potato yield or suppress potato diseases.

Table 1. Effect of rotation crop and preceding green manure on tuber yield and tuber size distribution of Colorado Rose, 2013.

Rotation/Green Manure Treatments ^{1/}	Total	< 4oz	> 4oz	4 - 16oz	> 6oz	6 - 16oz	4 - 10oz	10 - 16oz	> 10oz	> 16oz	Yield (cwt/ac)	
2-yr. Rotations												
1. Barley/Potato	419cd	67d	352bc	316bcd	280bc	243b	202c	113bc	150b	37bc		
2. Rye GM-Sudangrass GM/Potato	573a	90ab	483a	411a	410a	339a	247a	164a	236a	72a		
3. Wet Fallow/Potato	424cd	78bcd	346cd	316bcd	274bcd	245b	193c	124b	153b	29cd		
3-yr. Rotations												
4. Barley/Canola/Potato	413cd	79bcd	334cd	314bcd	249cdef	229b	240ab	73ef	93f	20de		
5. Barley/Sudangrass GM/Potato	397d	77bcd	320d	290d	264bcde	234b	203c	87def	117def	30cd		
6. Barley/Camelina/Potato	356e	70cd	286e	259e	220f	193c	160d	100cd	127bcd	27cd		
8. Barley/Canola+Manure/Potato	406d	75bcd	331cd	298cd	258cde	225b	213bc	85def	118cdef	33c		
7. Barley/Canola+Compost/Potato	439bc	105a	335cd	326bc	256cde	247b	240ab	86def	95ef	9e		
9. Barley/Mustard GM/Potato	466b	89abc	377b	330b	294b	246b	238ab	92cd	139bcd	47b		
10. Barley/cocktail GM/Potato	339e	69cd	270e	188f	230ef	149d	122e	67f	148bc	82a		
11. Rye GM/cocktail GM/Sudan GM/P	394d	76bcd	318d	303bcd	242def	228b	193c	110bc	125bcde	14e		
LSD (%)	31	20	31	30	35	30	28	23	30	12		
CV (%)	5	18	6	7	9	9	10	15	15	22		

^{1/} Crops not shown as green manure (GM) are cash crops. Slash indicates years; some rotations are 2-yr and others 3-yr. Wet Fallow was irrigated without any crop but weeds controlled. Cocktail GM was 5 different crops planted together and incorporated as green manure. Cocktail green manure includes these 5 crops: hybrid sorghum-sudangrass (sudangrass), Ethiopian cabbage, brown mustard, oilseed radish, and forage turnip. The Rye-GM-Sudangrass GM/P was a 2-yr rotation with rye planted immediately after potato harvest and incorporated as green manure in mid-May, then planted to sudangrass in early June, then green manured in late August.

Table 2. Effect of rotation crop and preceding green manure crops on tuber diameter of Colorado Rose, 2013.

Green Manure/Rotation Crop Treatment ^{1/}	Tuber Diameter (ins.)			Yield (cwt/ac)
	> 2ins. dia.	< 2ins. dia.	2 – 4ins. dia.	
2-yr. Rotations				
1.Barley/Potato	376cde	44a	371cd	150bc
2.Rye GM-Sudangrass GM/Potato	524a	48a	504a	236a
3.Wet Fallow/Potato	379cd	45a	369cd	153b
3-yr. Rotations				
4.Barley/Canola/Potato	371cde	42a	365cd	93e
5.Barley/Sudangrass/Potato	354de	43a	354d	117de
6.Barley/Camelina/Potato	320f	39a	314e	127cd
8.Barley/Canola+Manure/Potato	365cde	41a	358d	118de
7.Barley/Canola+Compost/Potato	386c	52a	386bc	95e
9. Barley/Mustard GM/Potato	419b	45a	406b	139bcd
10.Barley/cocktail GM/Potato	302f	37a	281f	148bc
11.Rye GM/cocktail GM/Sudan GM/P	349e	44a	349d	125cd
LSD (%)	29	17	28	26
CV (%)	5	26	5	13

^{1/} Crops not shown as green manure (GM) are cash crops. Slash indicates years; some rotations are 2-yr and others 3-yr. Wet Fallow was irrigated without any crop but weeds controlled. Cocktaail GM was 5 different crops planted together and incorporated as green manure. Cocktail green manure includes these 5 crops: hybrid sorghum-sudangrass (sudangrass), Ethiopian cabbage, brown mustard, oilseed radish, and forage turnip. The Rye-Gm-Sudangrass GM/P was a 2-yr rotation with rye planted immediately after potato harvest and incorporated as green manure in mid-May, then planted to sudangrass in early June, then green manured in late August.

Table 3. Effect of rotation crop and preceding green manure crops on tuber quality of Colorado Rose, 2013.

Crop Rotation/Green Manure Treatment ^{1/}	%			Specific Gravity
	External Defects	Hollow Heart		
<u>2-yr. Rotations</u>				
1.Barley/Potato	2.3ab	0c		1.083abc
2.Rye GM-Sudangrass GM/Potato	2.1abc	1.4a		1.083abc
3. Wet Fallow/Potato	1.8bc	1.4a		1.081cd
<u>3-yr. Rotations</u>				
4.Barley/Canola/Potato	0.6d	0c		1.083abc
5.Barley/Sudangrass/Potato	0.7d	0c		1.085a
6.Barley/Camelina/Potato	0.6d	0c		1.083ab
8.Barley/Canola+Manure/Potato	0.5d	0c		1.082bc
7.Barley/Canola+Compost/Potato	1.2cd	0c		1.079d
9. Barley/Mustard GM/Potato	0.4d	0c		1.082bc
10.Barley/cocktail GM/Potato	3.0a	0.7b		1.083abc
11.Rye GM/cocktail GM/Sudan GM/P	1.3	0		1.083
LSD (%)	1.1	0.5		0.003
CV (%)	57	113		0.173

^{1/} Crops not shown as green manure (GM) are cash crops. Slash indicates years; some rotations are 2-yr and others 3-yr. Wet Fallow was irrigated without any crop but weeds controlled. Cocktail GM was 5 different crops planted together and incorporated as green manure. Cocktail green manure includes these 5 crops: hybrid sorghum-sudangrass (sudangrass), Ethiopian cabbage, brown mustard, oilseed radish, and forage turnip. The Rye-Gm-Sudangrass GM/P was a 2-yr rotation with rye planted immediately after potato harvest and incorporated as green manure in mid-May, then planted to sudangrass in early June, then green manured in late August.

Table 4. Effect of rotation/green manure crop on tuber size and gross income of Colorado Rose (red potato), 2013.

Rotation Crops/Green Manure **< 2 inch** **2 inch-10 oz** **>10 oz** **Potato Gross Income**

Treatment^{1/}	cwt/acre			\$/acre²
2.Rye GM-Sudangrass GM/P	48a	288a	236a	\$9328
9.Barley/Mustard GM/Potato	45a	280a	139bcd	\$7220
3.Wet Fallow/Potato	45a	226b	153b	\$6852
1.Barley/Potato	44a	226b	150bc	\$6768
8.Barley/Canola+Manure/Potato	52a	292a	95e	\$6652
7.Barley/Canola+Compost/Potato	41a	248b	118de	\$6320
11.Rye GM/cocktail GM/SudanGM/P	44a	225b	125cd	\$6256
5.Barley/Sudangrass GM/Potato	43a	236b	117de	\$6204
4.Barley/Canola/Potato	42a	277a	93e	\$6192
6.Barley/Camelina/Potato	39a	194c	127cd	\$5804
10.Barley/cocktail GM/Potato	37a	154d	148bc	\$5696

^{1/} Crops not shown as green manure (GM) are cash crops. Slash indicates years; some rotations are 2-yr and others 3-yr. Wet Fallow was irrigated without any crop but weeds controlled. Cocktail GM was 5 different crops planted together and incorporated as green manure. Cocktail green manure includes these 5 crops: hybrid sorghum-sudangrass (sudangrass), Ethiopian cabbage, brown mustard, oilseed radish, and forage turnip. The Rye-Gm-Sudangrass GM/P was a 2-yr rotation with rye planted immediately after potato harvest and incorporated as green manure in mid-May, then planted to sudangrass in early June, then green manured in late August.

^{2/} Potato gross income considers only income from potatoes. Income calculated from Jan., 2013, prices; <2in@\$24/cwt, 2in-10oz@\$12/cwt, and >10oz@\$20/cwt. Prices for red potatoes are usually higher than for russets and prices are fairly stable year to year.

Gross income does not include any production costs. Simply add the income from each size group to get the total income for each treatment. Great differences in income resulted from the crop rotations and green manure crops preceding red potatoes.

Table 5. Effects of Crop Rotation/Green Manure on Potato Disease Ratings, Colorado Rose, 2013. EPA & NRCS GM project
 SLV Research Center, Colorado State University

Sample collection: A 10 tuber sample was evaluated for disease incidence and severity after harvest from each plot
Disease Evaluation: Diseases were evaluated on October 24, 2013 by Robert Davidson and Andrew Houser

Trt #	Crop Rotation/Green Manure	Total % of									
		Black Scurf (Rating 1) ^a	Black Scurf (Rating 2) ^a	Black Scurf (Rating 3) ^a	Black Scurf (Rating 4) ^a	tubers with black scurf	tubers with a high black scurf rating ^b	Total % of tubers with Silver Scurf	Total % of tubers with powdery scab	Powdery scab severity index ^c	
1	Barley/Potato	37.5	12.5	15.0	0.0	65.0	27.5	37.5	20.0	40.0	
2	Rye GM-Sudangrass GM/Potato	40.0	12.5	15.0	0.0	67.5	27.5	20.0	17.5	42.5	
3	Wet Fallow/Potato	17.5	25.0	2.5	0.0	45.0	27.5	37.5	0.0	0.0	
4	Barley/Canola/Potato	42.5	27.5	10.0	0.0	80.0	37.5	35.0	0.0	0.0	
5	Barley/Sudangrass GM/Potato	45.0	15.0	12.5	0.0	72.5	27.5	17.5	2.5	5.0	
6	Barley/Camolina/Potato	32.5	17.5	2.5	2.5	55.0	22.5	35.0	0.0	0.0	
7	Barley/Canola+Compost/Potato	35.0	22.5	12.5	0.0	70.0	35.0	30.0	0.0	0.0	
8	Barley/Canola+Manure/Potato	37.5	12.5	5.0	0.0	55.0	17.5	40.0	0.0	0.0	
9	Barley/Mustard GM/Potato	20.0	27.5	10.0	0.0	57.5	37.5	15.0	0.0	0.0	
10	Barley/cocktail GM/Potato	45.0	22.5	15.0	0.0	82.5	37.5	20.0	0.0	0.0	
11	Rye GM -cocktail GM/Sudan GM/P	25.0	20.0	2.5	0.0	47.5	22.5	20.0	0.0	0.0	
CV		50.30	66.50	130.84	663.33	40.090	68.680	53.960	296.840	285.210	
F value		0.305	0.609	0.679	0.465	0.495	0.890	0.162	0.078	0.054	
LSD (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	

^aFor the Black scurf and Powdery scab results, a severity rating was also determined for each tuber with disease symptoms.

Severity rating for Black Scurf and Powdery Scab: 1 = < 1% SA of tuber covered, 2 = 1-5% SA covered, 3 = 5-25% of SA covered, 4 = >25% SA covered.

^bPercent of tubers with a black scurf severity of 2, 3 and 4.

^cFor Powdery Scab, the total % of tubers with powdery scab lesions was multiplied by the overall severity rating.

^dCrops not shown as green manure (GM) are cash crops. Slash indicates years; some rotations are 2-yr and others 3-yr. Wet Fallow was irrigated without any crop but weeds controlled. Cocktail GM was 5 different crops planted together and soil incorporated as green manure. These included hybrid sorghum-sudangrass (sudangrass), Ethiopian cabbage, brown mustard, oilseed radish, and forage turnip.