# Cover Crops Can Improve Potato Tuber Yield and Quality

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Additional index words. tuber size distribution, tuber external defects

**Summary. There is the need to develop potato (*Solanum tuberosum*) cropping systems with higher yields and crop quality. Field studies were conducted with cover crops grown under limited irrigation (<8 inches) to assess the effects of certain types of cover crops on potato tuber yield and quality. On a commercial farm operation before the 2006 and 2007 potato season, mustard (*Brassica* sp.), canola (*Brassica napus*), and two cultivars of sorghum-sudangrass (*Sorghum bicolor* × *S. sudanense*) were planted. A wet fallow ground treatment where no cover crop was planted was used as a control. Before the 2008 season, barley (*Hordeum vulgare*), barley plus applied compost, sunflower (*Helianthus annus*), pea (*Pisum sativum*), and annual ryegrass (*Lolium multiflorum*) cover crops were added. The results of these 2006–08 studies showed that cover crops have the potential to increase potato tuber yield and quality, as measured by tuber size (larger tubers) and appearance (e.g., tubers with reduced defects such as cracks, knobs, and misshapes). In 2 of the 3 years, most of the cover crops, especially sorghum-sudangrass, increased yields and tuber quality. Positive results from sorghum-sudangrass suggest there is potential to harvest hay from cover crops and still obtain tuber benefits.**

There have been reports of cover crops increasing the yield of the following crops (Clark, 2007; Dabney et al., 2010; Delgado et al., 2007). However, there is a need for additional research on the potential benefits that cover crops may have on the yields of the following potato crop.

There have been studies on the effect of nitrogen (N) fertilizer inputs and N cycling from cover crops on yields. For example, Neeteson (1988) reported higher potato yields at low N fertilizer rates following leguminous crops that have a lower carbon (C):N ratio and a higher N cycling (N mineralization) potential, such as red clover (*Trifolium pratense*) and alfalfa (*Medicago sativa*). Conversely, Neeteson (1988) reported lower yields were observed for potato following oat (*Avena sativa*), which is a cover crop with higher C:N ratio and lower potential to mineralize N. Neeteson (1988) found that at optimal N fertilizer rates, potato tuber yields were slightly lower following legumes.

Results from studies conducted by Sincik et al. (2008) indicated that potato following legume cover crops produced ≈36% to 38% higher tuber yields compared with potato following winter wheat (*Triticum aestivum*) when zero N was applied. In other legume studies, Odland and Sheehan (1957) and Emmond and Ledingham (1972) reported higher potato yields following legumes than non-legumes crops, but Murphy et al. (1967) found no yield benefits following legumes. The authors of the present study suggest that these effects of legumes or non-legume cover crops on tuber yield responses could have been in part due to potential responses of potato cultivars to the increased availability of N. For example, Essah and Delgado (2009) found that excessive application of N fertilizer reduced potato tuber yields and tuber quality and that this response was dependent on the type of potato cultivar. In other words, in cases where the amount of N is increased to higher levels than needed, a negative effect could then be observed (Essah and Delgado, 2009). Further, when N is applied in better synchronization with the N demands of a given potato cultivar (and the N that is cycled is accounted for when applying N), tuber yields could be increased (Essah and Delgado, 2009). Since cover crops have the potential to affect the N balance of the following crop (Delgado, 1998; Delgado et al., 2001, 2010), this could be one of the factors that could potentially contribute to effects on tuber yields and quality (Delgado et al., 2007; Essah and Delgado, 2009).

Cover crops can be good soil scavengers of N and they can cycle significant amounts of the recovered N to the following crop (Collins et al., 2007; Delgado et al., 2004, 2010; Seo et al., 2006; Varco et al., 1989). Vyn et al. (2000) conducted studies in Canada and found that cover crops, such as annual ryegrass, oat, oilseed radish (*Raphanus sativus*), or even red clover, could serve as scavenger crops that can recover residual soil nitrate and potentially cycle it to the following crop.

Delgado et al. (2007) reported other benefits from summer cover crops grown with limited irrigation and observed a 12% to 30% increase in total yield and marketable tubers when potato followed sorghum-sudangrass, with a greater increase in large tubers. Cover crops that have been found to provide soil disease suppression of verticillium wilt (*Verticillium dahliae*) of potato include barley, corn (*Zea mays*), rape (*Brassica rapa*), oat, ryegrass, sudangrass (*Sorghum sudanense*), and wheat, with sudangrass showing the greatest potato yield response for marketable-size tubers (Davis et al., 1994). The studies by Davis et al. (1994) clearly show that there are several other parameters that can impact tuber yield and quality, such as

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**Units**

| To convert U.S. to SI, multiply by | U.S. unit | SI unit | To convert SI to U.S., multiply by |
|---|---|---|---|
| 0.3048 | ft | m | 3.2808 |
| 2.54 | inch(es) | cm | 0.3937 |
| 25.4 | inch(es) | mm | 0.0394 |
| 28.3495 | oz | g | 0.0353 |
| 2.2417 | ton/acre | $Mg \cdot ha^{-1}$ | 0.4461 |

disease suppression, in addition to the effects of nutrient availability and cycling of N from the cover crop.

In most studies conducted on cover crops and potato performance, the effect of the cover crop on tuber size distribution and on tuber quality is not well documented. There remains a need for studies on the effect of different cover crops on potato total tuber yield and also on potato tuber size distribution and tuber quality. The goal of the present study was to analyze the effects of several cover crops on potato tuber yield, potato tuber size distribution, and tuber quality, as measured by tuber external and internal defects.

## Materials and methods

The present study was conducted at the San Luis Valley in south-central Colorado (lat. 37°40′N, long. 106°9′W, 2310 m altitude). Field studies were conducted under commercial grower operations from 2006 to 2008, using the traditional best management practices recommended by Colorado State University (S.Y.C Essah, unpublished data). Cover crops and potato were grown under center-pivot irrigation over a coarse-textured sandy soil with low soil organic matter (<1.5%). Each year, a randomized complete-block design with five replicated plots (35 ft long by 12 ft wide) was established to plant the cover crops. The cover crop plots were established on a commercial field where the rest of the field was planted to sorghum-sudangrass, except the randomized block area. Limited irrigation was applied each year to minimize irrigation use cost. Three to five irrigation events were applied for a total irrigation of ≈7 inches.

Cover crops planted before the 2006 and 2007 ‘Rio Grande Russet’ potato planting included: 1) ‘Super Sweet’ sorghum-sudangrass, 2) ‘Sordan 79’ sorghum-sudangrass, 3) ‘Sordan 79’ with the tops removed for hay, 4) mustard, and 5) canola. A wet fallow ground treatment was included as a control, where no cover crops were planted, but the same amount of irrigation was applied as the treatments with cover crops. Additional cover crops that were added to the study to precede the 2008 ‘Russet Norkotah’ planting included: 1) barley, 2) barley plus applied compost, 3) sunflower, 4) pea, 5) annual ryegrass, and the previous cover crops and fallow system used for the previous years of 2006 and 2007. Applied compost was at the rate of 4 tons/acre.

Potato plots were harvested for the 2006, 2007, and 2008 treatments. Each randomized complete-block was set up so that each plot had four rows with between row spacing of 33 inches, with tubers planted at in-row seed spacing of 11 to 12 inches. The potato crop was planted between 10 and 15 May and harvested between 15 and 20 Sept. each year by harvesting the two middle rows of each plot using an experimental plot potato digger at the farmers field, the week before commercial harvesting operations at the field site started. For each plot, total tuber yield was measured and tubers were sorted into various size distribution groups based on tuber weight (<4 oz, >4 oz, >10 oz, 4–10 oz, and 10–16 oz). Size distribution groups are very important because different markets demand different size groups. Also, in the fresh market industry larger tubers attract premium price. Additionally, tuber external (growth cracks, knobs, and misshapes) and internal (hollow heart and brown center) defects were evaluated. Tuber internal defects were evaluated by cutting into half all harvested tubers that were 8 oz or more in weight.

Statistical analysis was conducted using analysis of variance [ANOVA (SAS version 9.2; SAS Institute, Cary, NC)]. ANOVA was performed for total tuber yield, tuber size distribution groups, and tuber quality parameters. Differences among treatment means were compared using Fisher’s protected least significant difference (LSD) test at the 0.05 level of probability.

## Results and discussion

**TUBER YIELD AND TUBER SIZE DISTRIBUTION.** For 2006, ‘Rio Grande Russet’ tubers responded to cover crop treatments compared with a wet fallow system ($P < 0.05$, Table 1). In 2006, yield increased and tuber size increased when potato followed ‘Sordan 79’ sorghum-sudangrass with all of the aboveground biomass incorporated, or even when the aboveground ‘Sordan 79’ biomass was harvested for hay. Total tuber yields and yields of marketable-size (>4 oz) tubers were increased with both ‘Sordan 79’ treatments. Larger tubers (>10 oz and 10–16 oz) were produced in both ‘Sordan 79’ treatments compared with the wet fallow treatment.

In 2006, when the size of the tubers following both sorghum-sudangrass cultivars was compared with the size of the tubers following canola and mustard, it was found that both sorghum-sudangrass cultivars contributed to higher total and marketable-size (>4 oz) tuber yields, as well as to the yield of larger (>10 oz) tubers than the canola and mustard cover crops. Although canola, mustard, and wet fallow total yield and marketable-size yields were not significantly different among themselves, the canola cover crop contributed to larger tubers (>10 oz and 10–16 oz) than the wet fallow and mustard. In summary, in 2006,

**Table 1. Effects of preceding cover crop on tuber yield and tuber size distribution of ‘Rio Grande Russet’ potato grown in 2006 at the San Luis Valley in south-central Colorado.**

| | Tuber yield (Mg·ha$^{-1}$)[z] | | | | | |
|---|---|---|---|---|---|---|
| Treatment | Total | <4 oz | >4 oz | >10 oz | 4–10 oz | 10–16 oz |
| Wet fallow[y] | 47.0 | 9.3 | 37.7 | 6.7 | 31.0 | 6.4 |
| Sorghum-sudangrass | 50.3 | 9.5 | 40.8 | 10.9 | 30.0 | 10.5 |
| Mustard | 45.3 | 10.0 | 35.3 | 7.9 | 27.4 | 6.7 |
| ‘Sordan 79’ sorghum-sudangrass | 51.3 | 8.3 | 43.1 | 15.5 | 27.6 | 14.3 |
| ‘Sordan 79’ sorghum-sudangrass with hay removed | 51.7 | 7.8 | 43.9 | 12.2 | 31.7 | 11.0 |
| Canola | 44.1 | 8.1 | 36.0 | 11.0 | 25.0 | 10.7 |
| LSD[x] | 3.8 | NS | 4.0 | 2.7 | 2.4 | 2.6 |
| CV (%) | 5.9 | 26.7 | 7.7 | 19.2 | 6.2 | 19.9 |

[z]<4 oz = small tubers that are not marketable in the fresh market, >4 oz = marketable tubers, >10 oz = large marketable size tubers, 4–10 oz = medium size marketable tubers, 10–16 oz = large marketable size tubers without the jumbos; 1 oz = 28.3495 g, 1 Mg·ha$^{-1}$ = 0.4461 ton/acre.
[y]Control treatment (bare ground) with no cover crop planted.
[x]Least significant difference at $P < 0.05$ comparing means between cover crops and wet fallow (control); NS = no significant difference.

the sorghum-sudangrass cultivar contributed to higher yields and larger tubers and the canola contributed to larger tubers than potato following a wet fallow system.

In 2007, among treatments there were no significant differences ($P$ < 0.05) in total and marketable-size (>4 oz) tuber yields, and there were no significant differences in terms of tuber size (>10 oz, 4–10 oz, 10–16 oz) (Table 2). Although there were no significant differences in the production of large tubers, there was a difference in the production of economic size tubers with wet fallow resulting in the highest production of small tubers (<4 oz) when compared with tubers following 'Super Sweet' sorghum-sudangrass, mustard, or 'Sordan 79' sorghum-sudangrass with all aboveground biomass harvested for hay. In summary, in 2007, the wet fallow resulted in greater production of small tubers; however, these small tubers are not marketable and have low commercial value ($P$ < 0.05, Table 2).

In 2008, 'Russet Norkotah' tuber production and tuber size groups responded to cover crop treatments compared with a wet fallow system ($P$ < 0.05, Table 3). In this year, both sorghum-sudangrass cultivars had a positive impact on tuber production and tuber size. 'Sordan 79' increased total tuber yield and quality compared with wet fallow. Total yield production was higher following the 'Sordan 79' with all aboveground biomass incorporated or harvested for hay treatments than following a wet fallow system. Marketable-size tuber yields (>4 oz) and yields of larger tubers (>10 oz and 10–16 oz) following 'Sordan 79' with all aboveground biomass harvested for hay were higher than when following wet fallow. Additionally, when production followed the 'Super Sweet', there was also an increase in the quantity of larger tubers (>10 oz and 10–16 oz) compared with when following a wet fallow system.

Potato following a barley or ryegrass cover crop had higher total and marketable-size (>4 oz) tuber yields than when following wet fallow. The barley and ryegrass cover crops also contributed to the production of larger tubers (>10 oz and 10–16 oz) compared with the wet fallow system. Potato following a barley cover crop that received compost, or canola, sunflower, or pea cover crops also produced larger tubers (>10 oz and 10–16 oz) compared with a wet fallow system.

When potato followed a ryegrass or sunflower cover crop, more large size tubers (>10 oz and 10–16 oz) were produced compared with when it followed a barley cover crop. Potato following 'Sordan 79' with all aboveground biomass harvested for hay, or the pea cover crop, had increased large size tubers (10–16 oz) when compared with potato following barley. The barley and compost treatment had increases of large tubers (10–16 oz) when compared with barley alone; however, barley and compost had reduced total and marketable tuber production when compared with barley alone.

Mustard did not improve the production of larger (>10 oz) tubers when compared with wet fallow or barley. Mustard did not improve total tuber yields or marketable yields, and total and marketable tuber yields with mustard were lower than with barley.

**Tuber external and internal defects.** For 2006, 'Rio Grande Russet' responded to cover crop treatments with improved tuber quality,

**Table 2. Effects of preceding cover crop on tuber yield and tuber size distribution of 'Rio Grande Russet' potato grown in 2007 at the San Luis Valley in south-central Colorado.**

| | Tuber yield (Mg·ha$^{-1}$)$^z$ | | | | | |
|---|---|---|---|---|---|---|
| **Treatment** | **Total** | **<4 oz** | **>4 oz** | **>10 oz** | **4–10 oz** | **10–16 oz** |
| Wet fallow$^y$ | 48.6 | 13.6 | 35.0 | 6.2 | 28.8 | 6.2 |
| Sorghum-sudangrass | 50.1 | 11.4 | 38.7 | 5.0 | 33.8 | 5.0 |
| Mustard | 44.6 | 10.3 | 34.3 | 4.0 | 30.3 | 4.0 |
| 'Sordan 79' sorghum-sudangrass | 47.4 | 12.2 | 35.1 | 4.1 | 31.0 | 3.8 |
| 'Sordan 79' sorghum-sudangrass with hay removed | 48.0 | 11.7 | 36.3 | 5.9 | 30.5 | 5.5 |
| Canola | 48.9 | 12.9 | 36.0 | 3.8 | 32.2 | 3.8 |
| LSD$^x$ | NS | 1.7 | NS | NS | NS | NS |
| CV (%) | 5.8 | 10.8 | 9.6 | 32.9 | 10.4 | 38.7 |

$^z$<4 oz = small tubers that are not marketable in the fresh market, >4 oz = marketable tubers, >10 oz = large marketable size tubers, 4–10 oz = medium size marketable tubers, 10–16 oz = large marketable size tubers without the jumbos; 1 oz = 28.3495 g, 1 Mg·ha$^{-1}$ = 0.4461 ton/acre.

$^y$Control treatment (bare ground) with no cover crop planted.

$^x$Least significant difference at $P$ < 0.05 comparing means between cover crops and wet fallow (control); NS = no significant difference.

**Table 3. Effects of preceding cover crop on tuber yield and tuber size distribution of 'Russet Norkotah' potato grown in 2008 at the San Luis Valley in south-central Colorado.**

| | Tuber yield (Mg·ha$^{-1}$)$^z$ | | | | | |
|---|---|---|---|---|---|---|
| **Treatment** | **Total** | **<4 oz** | **>4 oz** | **>10 oz** | **4–10 oz** | **10–16 oz** |
| Wet fallow $^y$ | 50.1 | 13.1 | 37 | 1.8 | 35.2 | 1.8 |
| Barley | 58.8 | 14.7 | 44.1 | 3.8 b | 40.2 | 3.1 |
| Barley and compost applied | 46.5 | 8.4 | 38.1 | 4.9 | 33.2 | 4.5 |
| Sunflower | 52 | 10.7 | 41.3 | 6.2 | 35.1 | 6.2 |
| 'Sordan 79' sorghum-sudangrass | 57.9 | 17.3 | 40.6 | 2.1 | 38.5 | 2.1 |
| 'Sordan 79' sorghum-sudangrass with hay removed | 63 | 15.6 | 47.5 | 5.1 | 42.4 | 4.3 |
| Sorghum-sudangrass | 48.6 | 11.1 | 37.5 | 4.5 | 33.1 | 4.1 |
| Canola | 503 | 11.8 | 38.5 | 4.2 | 34.3 | 4.2 |
| Mustard | 47 | 9.1 | 37.9 | 2.8 | 35.1 | 2.5 |
| Pea | 55.6 | 14.8 | 40.8 | 5.2 | 35.5 | 5.2 |
| Ryegrass | 57.2 | 11.8 | 45.4 | 6.3 | 39.1 | 6.3 |
| LSD$^x$ | 6.0 | 2.2 | 5.8 | 1.5 | 5.7 | 1.2 |
| CV (%) | 8.8 | 13.0 | 11.1 | 27.9 | 12.2 | 22.9 |

$^z$<4 oz = small tubers that are not marketable in the fresh market, >4 oz = marketable tubers, >10 oz = large marketable size tubers, 4–10 oz = medium size marketable tubers, 10–16 oz = large marketable size tubers without the jumbos; 1 oz = 28.3495 g, 1 Mg·ha$^{-1}$ = 0.4461 ton/acre.

$^y$Control treatment (bare ground) with no cover crop planted.

$^x$Least significant difference at $P$ < 0.05 comparing means between cover crops and wet fallow (control).

represented by a reduced percentage of tuber external defects ($P < 0.05$, Table 4). In 2006, the treatment with the higher percentage of external defects was the wet fallow treatment; with over 3% of the tubers produced, following this treatment, having external defects. 'Super Sweet' sorghum-sudangrass, mustard, 'Sordan 79' sorghum-sudangrass with all aboveground biomass harvested for hay, and canola all had reduced percentage of external defects such as cracks, knobs, and misshapes, when compared with the wet fallow treatment. Most of the cover crops had reduced external defects by 50%, bringing the percentage down to ≈1.5% or lower. Mustard had nearly no external defects, with ≈0.3%.

For 2007, the external defects data were not presented since there were minimal external defects at the site (across all treatments <0.5%). Only 'Super Sweet' and 'Sordan 79' sorghum-sudangrass showed any external defects, which were <0.5%. All other treatments had zero external defects.

For 2008, 'Russet Norkotah' also responded to cover crop treatments compared with a wet fallow system. In this year, the treatment with the highest rate of external defects was the wet fallow treatment, with close to 2% defects (Table 4). On average, all of the cover crops reduced the percentage of external defects by ≈50%, with only 1% or less of the tubers showing external defects. 'Sordan 79' sorghum-sudangrass and mustard resulted in a lower percentage of external defects than the barley.

In these studies, no hollow heart or brown center (internal defects) were observed in any of the tubers harvested.

**SUMMARY.** Field studies were conducted under commercial farm operations to assess the effects of different cover crops on the yields and quality of the potato tubers that followed, as measured by tuber size and appearance (e.g., reduced percentage of cracks, knobs, and misshapes). These studies were conducted from 2006 to 2008, and on average cover crops provided a significant advantage over wet fallow, contributing to increased yields, larger tubers, and better tuber quality (tubers with less external defects) ($P < 0.05$, Table 5). In two of the three studies, the sorghum-sudangrass showed an advantage in increasing tuber yields and quality, providing the farmer with additional income compared with a wet fallow system ($P < 0.05$, Table 5). Only for two of the three studies did we report tuber external defects, since in one study the percentage of external defects for all treatments was less than 0.5%. For the two studies with measurable external defects above 2% for some treatments, the cover crops were beneficial and reduced the percentage of tuber external defects compared with the wet fallow. For these two studies, cover crops reduced external defects on average by 50% over the wet fallow, helping to minimize the potential for losses in profit. It is important to note that the use of canola, mustard, and 'Sordan 79' reduced external defects in the tubers that followed, compared with tubers that followed the use of barley. Across these three field studies, the mustard did not provide as great of an advantage over the wet fallow.

The results presented in this article are in agreement with the Delgado et al. (2007) finding that sorghum-sudangrass can contribute to higher yields and larger tubers. Additionally, the present study shows that there are several other cover crops in addition to sorghum-sudangrass that can provide tuber production and quality advantages.

Looking at the tuber responses as far as production (yields), size, and quality (tuber defects), during 2006, positive effects were achieved when potato followed either sorghum-sudangrass cultivar. Even when the aboveground biomass for 'Sordan 79' was removed for hay, there was still a positive response in potato tuber production and quality. The results suggest that both the belowground material and the aboveground litter left behind after harvesting the cover crop for hay are playing an important role, potentially contributing to soil biological and biogeochemical factors that may be providing the mechanism for the potato physiological response.

Additionally, several cover crops such as the ryegrass and 'Sordan 79' with all the aboveground biomass harvested for hay also showed the potential to produce the same marketable-size yields with larger tubers and better tuber quality (tubers with less external defects) than the barley cover crop. Delgado et al. (2007) found a correlation between tuber yields and the nutrient content of the preceding cover crop. Davis et al. (2010) found that the preceding cover crops affected soil biology, contributing to yield responses. The underlying mechanisms that are causing these physiological responses by the potato crop are unknown and are beyond the scope of this article. However, the responses of potato following a grain cover crop, a leguminous crop, or even a grain cover crop with compost, all of which are presented in this article, suggest that the mechanisms are very complex. Additional research in this area will be needed to model some of these physiological responses and to better understand the

**Table 4. Effects of preceding cover crop on tuber external defects of 'Rio Grande Russet' and 'Russet Norkotah' potato grown in 2006 and 2008, respectively, at the San Luis Valley, south-central Colorado.**

| Treatment | Tuber external defects (%)[z] 2006 | 2008 |
|---|---|---|
| Wet fallow[y] | 3.1 | 1.8 |
| Barley | — | 0.9 |
| Barley and compost applied | — | 0.9 |
| Sunflower | — | 0.6 |
| 'Sordan 79' sorghum-sudangrass | 2.3 | 0.2 |
| 'Sordan 79' sorghum-sudangrass with hay removed | 1.7 | 0.8 |
| Sorghum-sudangrass | 1.4 | 0.9 |
| Canola | 1.1 | 0.7 |
| Mustard | 0.3 | 0.2 |
| Pea | — | 1.0 |
| Ryegrass | — | 0.9 |
| LSD[x] | 0.8 | 0.5 |
| CV (%) | 43.6 | 52.2 |

[z]Includes growth cracks, knobs, and misshapes.
[y]Control treatment (bare ground) with no cover crop planted.
[x]Least significant difference at $P < 0.05$ comparing means between cover crops and wet fallow (control).

**Table 5. Summary of the general trend with respect to the effects of preceding cover crop, 'Sordan 79' sorghum-sudangrass with aboveground biomass removed for hay treatment, the barley and compost applied treatment, and the wet fallow (bare ground) on 'Rio Grande Russet' (2006 and 2007) and 'Russet Norkotah' (2008) potato grown at the San Luis Valley in south-central Colorado.**

| | Trend[z] | | | | |
|---|---|---|---|---|---|
| Treatment | 2006 | 2007 | 2008 | 2008 | 2008 |
| Wet fallow[y] | baseline | baseline | baseline | ↓P: ↓Q: D↑ | =P: ↓Q: ↑D↑ |
| Barley | — | — | ↑P: ↑Q: ↓D | baseline | ↑P: =Q: =D= |
| Barley and compost applied | — | — | =P: ↑Q: ↓D | ↓P: ↑Q: =D | baseline |
| Sunflower | — | — | =P: ↑Q: ↓D | =P: ↑Q: =D | =P: ↑Q: =D |
| 'Sordan 79' sorghum-sudangrass | =P: ↑Q: =D | =P: =Q: =Dz | ↑P: =Q: ↓D | =P: ↓Q: ↓D | ↑P: ↓Q: ↓D |
| 'Sordan 79' sorghum-sudangrass with hay removed | ↑P: ↑Q: ↓D | =P: =Q: =Dz | ↑P: ↑Q: ↓D | =P: ↑Q: =D | ↑P: =Q: =D |
| Sorghum-sudangrass | =P: ↑Q: ↓D | =P: =Q: =Dz | =P: ↑Q: ↓D | ↓P: =Q: =D | =P: =Q: =D |
| Canola | =P: ↑Q: ↓D | =P: =Q: =Dz | =P: ↑Q: ↓D | ↓P: =Q: =D | =P: =Q: =D |
| Mustard | =P: =Q: ↓D | =P: =Q: =Dz | =P: =Q: ↓D | ↓P: =Q: ↓D | =P: ↓Q: ↓D |
| Pea | — | — | =P: ↑Q: ↓D | =P: ↑Q: =D | ↑P: =Q: =D |
| Ryegrass | — | — | ↑P: ↑Q: ↓D | =P: ↑Q: =D | ↑P: ↑Q: =D |

[z]P = production; an arrow pointing upwards for production (↑P) indicates total tuber and/or marketable tuber production was increased. Q = tuber quality as determined by size; an arrow pointing upwards for tuber quality (↑Q) indicates that larger tubers were produced [>10 oz and/or 10–16 oz (1 oz = 28.3495 g)]. D = external defects; an arrow pointing downward for external defects (↓D) indicates that the external defects were reduced. Dz = there were no external defects in the whole study that were measureable (<0.5% external defects in all treatments). No change from the baseline is indicated by =. Arrows reflect effects at $P < 0.05$. An arrow pointing downward for P or Q indicates a downward production and quality, respectively. An = sign means no change. Table shows the general trends of the effects of cover crop treatments, the 'Sordan 79' sorghum-sudangrass with aboveground biomass removed for hay treatment, the barley and compost applied treatment, and the wet fallow (control) treatment.
[y]Control treatment (bare ground) with no cover crop planted.

soil–plant interface in cover crop–potato systems.

## Conclusion

The purpose of the 2006–08 studies was to evaluate the effects of certain types of cover crops on tuber yield, as well as to obtain new, additional information on the effects of cover crops on tuber size distribution and external defects. The results suggest that although there is not yet a clear understanding of the mechanism (possible mechanisms could include but are not necessarily limited to soil biology, suppression of diseases, biogeochemistry pathways and availability of macro and micro nutrients, and the physiological responses by the potato at the root, tuber and aboveground), cover crops can potentially improve potato tuber yields and quality and minimize external tuber defects. Additionally, positive results from the sorghum-sudangrass crop suggest that there is even potential to use cover crops for hay production while still keeping the tuber quality benefits of these crops.

Again, although the mechanism behind these effects is not yet certain, we propose that cover crops may impact soil biology and biogeochemical processes that impact the soil–root–plant system. The unique responses presented in this article raise the question of how the potato plant receives a signal to physiologically respond with higher yields and better-quality tubers. There is the need for additional research on the soil–plant–microbiological interactions. This is a complex system; for example, Manter et al. (2010) reported that soil microbes inside the root were correlated with tuber yields. More information is needed to understand how we can manage systems to continue to achieve greater production and higher-quality tubers, and the potential economic benefits for farms that may result. It is clear from this study that the tested cover crops are generating a positive, or in some instances, a negative effect on potato tuber yields and quality, and additional research is needed to understand the underlying mechanisms of these effects.

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