|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 5. Cover crop treatment biomass yield and quality at Ft. Ellis, MT and NGV, MT | | | | | | |
| Treatment | Pre-termination Biomass | | Post-termination Biomass | | Pre-termination C:N\* | |
|  | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
|  |  |  |  |  |  |  |
| *P*-values | *0.16* | ***<0.01*** | ***<0.01*** | *0.43* | *0.10* | ***<0.01*** |
|  |  |  |  |  |  |  |
|  | ------ Mg ha-1 ------ | | -------- Mg ha-1 -------- | |  | |
|  |  | |  | |  | |
| Cool Graze | 4.65 | 2.59 | 1.41 | 0.22 | 18.3 | 17.8 |
| Cool Spray | 4.33 | 2.32 | N/A | N/A | N/A | N/A |
| Warm Graze | 4.04 | 1.10 | 1.43 | 0.16 | 15.0 | 12.0 |
| Warm Spray | 4.22 | 1.02 | N/A | N/A | N/A | N/A |
| Warm Hay | 4.09 | 1.14 | 0.28 | 0.27 | 14.8 | 12.8 |
|  |  |  |  |  |  |  |
|  |  | | | | | |
| Contrasts | ------------------------------------- *P-values* ---------------------------------- | | | | | |
|  |  | | | | | |
| Cool v. Warm | ***0.03*** | ***<0.01*** | *N/A* | *N/A* | ***0.04*** | ***<0.01*** |
| Spray v. Graze | *0.70* | *0.20* | *N/A* | *N/A* | *N/A* | *N/A* |
| WG v. WH | *0.48* | *0.46* | ***<0.01*** | *0.29* | *N/A* | *N/A* |
|  |  |  |  |  |  |  |
| CG = cool graze, WG = warm graze, and WH = warm hay.  \*All cover crop species combined per plot.  † Results come from an omnibus ANOVA. | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 6. Treatment *P* values and means of cover crop mixtures from grazed and hayed plots at Fort Ellis (2015) and NGV (2016), MT. Dry matter (DM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), and Relative Feed Value (RFV). | | | | | | | | | | | | | |
| Treatment | DM | CP | ADF | NDF | TDN | RFV | | DM | CP | ADF | NDF | TDN | RFV |
|  |  |  |  |  |  |  | |  |  |  |  |  |  |
| *p*-value | *0.63* | *0.02* | *0.02* | *0.01* | *0.02* | *0.02* | | *0.26* | *<0.01* | *0.02* | *0.41* | *0.02* | *0.24* |
|  |  |  |  |  |  |  | |  |  |  |  |  |  |
|  | --------------------------- 2015 ----------------------- | | | | | | | --------------------------- 2016 ------------------------- | | | | | |
|  |  |  | | | | |  |  |  | | | |  |
| CG | 907 | 158 | 426 | 526 | 540 | | 99 | 901 | 155 | 351 | 475 | 625 | 121 |
| WG | 908 | 229 | 370 | 488 | 604 | | 115 | 889 | 224 | 274 | 475 | 711 | 149 |
| WH | 914 | 185 | 370 | 561 | 604 | | 100 | 899 | 212 | 303 | 430 | 680 | 130 |
|  |  |  |  |  |  | |  |  |  |  |  |  |  |
| LSDtreat | NS | 41 | 37 | 39 | 42 | | 11 | NS | 28 | 49 | NS | 54 | NS |
|  |  |  |  |  |  | |  |  |  |  |  |  |  |
| Contrast | ------------------------------------------------------ *p-*values ------------------------------------------------------- | | | | | | | | | | | | |
|  |  | | | | | | | | | | | | |
| Warm v. Cool | *0.58* | ***<0.01*** | ***<0.01*** | *0.94* | ***<0.01*** | | *0.07* | *0.31* | ***<0.01*** | ***0.01*** | *0.50* | ***0.01*** | *0.20* |
|  |  |  |  |  |  | |  |  |  |  |  |  |  |
| CG = cool graze, WG = warm graze, and WH = warm hay  RFV Index = DDM x DMI / 1.29, where:  DDM = Digestible Dry Matter = 88.9 – (0.779 x %ADF) on a dry matter basis  DMI = Dry Matter Intake = 120 / %NDF on a dry matter basis | | | | | | | | | | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 7. Soil penetration resistance measured Apr 13 2016 prior to wheat planting, following 2015 cover crop treatments, Fort Ellis, MT | | | | |
|  | Depth (cm) | | | |
| Treatment | 0 - 7.5 | 7.5 - 15 | 15 - 22.5 | 22.5 - 30 |
|  |  | | | |
| *p*-values | *0.15* | ***<0.01*** | ***<0.01*** | *0.26* |
|  |  |  |  |  |
|  | ---------------------------kg cm-1----------------------- | | | |
|  |  | | | |
| Fallow | 7.2 | 8.2 | 7.9 | 8.0 |
| Cool Graze | 7.0 | 10.6 | 10.9 | 9.3 |
| Cool Spray | 8.3 | 10.0 | 9.5 | 9.4 |
| Warm Graze | 6.3 | 8.9 | 9.1 | 9.1 |
| Warm Spray | 6.3 | 9.4 | 8.9 | 8.1 |
| Warm Hay | 7.5 | 8.6 | 7.8 | 8.3 |
|  |  |  |  |  |
| LSDtreat | NS | 1.1 | 1.5 | NS |
|  |  |  |  |  |
| Contrast | ------------------------ *p*-values*----------------------* | | | |
|  |  | | | |
| Fallow v. All | *0.33* | ***<0.01*** | ***0.03*** | *0.17* |
| Cool v. Warm | *0.10* | ***<0.01*** | ***<0.01*** | *0.09* |
| Spray v. Graze | *0.28* | *0.94* | *0.13* | *0.41* |
|  |  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Table 8. Soil bulk density measured Apr 13 2016 prior to wheat planting, following 2015 cover crop treatments, Fort Ellis, MT. | | | |
|  | Depth (cm) | | |
| Treatment | 0 - 0.3 | 0.31 - 0.6 | 0.61 - 0.9 |
|  |  | | |
| *p*-values | *0.51* | *0.99* | *0.44* |
|  | | | |
|  | ----------------- kg cm3 -1 ----------------- | | |
|  |  | | |
| Fallow | 1.3 | 1.3 | 1.3 |
| Cool Graze | 1.3 | 1.4 | 1.3 |
| Cool Spray | 1.2 | 1.4 | 1.2 |
| Warm Graze | 1.3 | 1.3 | 1.3 |
| Warm Spray | 1.3 | 1.4 | 1.3 |
| Warm Hay | 1.3 | 1.4 | 1.2 |
|  |  |  |  |
| LSDtreat | NS | NS | NS |
|  |  | | |
| Contrasts | ------------------ *p*-values*-----------------* | | |
|  |  | | |
| Fallow v. All | *0.13* | *0.72* | *0.37* |
| Cool v. Warm | *0.34* | *0.86* | *0.66* |
| Spray v. Graze | *0.40* | *0.86* | *0.14* |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 9. Soil water (mm water equivalence) measured after cover crop termination, at Fort Ellis, MT, 2015, and NGV, MT, 2016. | | | | | | | | | |
|  | Fort Ellis 2015 | | | | | NGV 2016 | | | |
| Treatment | 0 to 0.3 m | 0.31 to 0.6 m | | 0.61 to 0.9 m | Total | 0 to 0.3 m | 0.31 to 0.6 m | 0.61 to 0.9 m | Total |
|  |  | | | | | | | | |
| *p-value* | ***<0.01*** | ***<0.01*** | ***<0.01*** | |  | ***<0.01*** | ***<0.01*** | ***<0.01*** |  |
|  |  | | | | | | | | |
|  | ----------------------------------------------- Soil Water mm-1 -------------------------------------------------------- | | | | | | | | |
|  |  | | | | | | | | |
| Fallow (Cool) | 9.0 | 9.1 | 8.0 | | 26 | 8.3 | 6.5 | 4.9 | 20 |
| Fallow (Warm) | 9.9 | 9.9 | 8.4 | | 28 | 7.0 | 5.8 | 5.0 | 18 |
| Cool Graze | 5.6 | 6.0 | 6.5 | | 18 | 6.2 | 3.9 | 4.0 | 14 |
| Cool Spray | 5.4 | 5.6 | 5.9 | | 17 | 6.2 | 3.8 | 3.9 | 14 |
| Warm Graze | 6.1 | 7.7 | 7.6 | | 21 | 4.7 | 4.8 | 4.5 | 14 |
| Warm Spray | 7.4 | 6.7 | 7.1 | | 21 | 4.9 | 4.7 | 4.5 | 14 |
| Warm Hay | 7.7 | 7.2 | 7.5 | | 22 | 5.3 | 5.0 | 4.7 | 15 |
|  |  |  |  | |  |  |  |  |  |
| LSD | 1.3 | 1.1 | 0.7 | |  | 0.7 | 0.7 | 0.6 |  |
|  |  |  |  | |  |  |  |  |  |
| Contrasts | ------------------------------------------------ *p -*values *--------------------------------------------------* | | | | | | | | |
|  |  | | | | | | | | |
| Fallow v. All | ***<0.01*** | ***<0.01*** | | ***<0.01*** |  | ***<0.01*** | ***<0.01*** | ***<0.01*** |  |
| Cool v. Warm | ***<0.01*** | ***<0.01*** | | ***<0.01*** |  | ***<0.01*** | ***<0.01*** | ***<0.01*** |  |
| Spray v. Graze | *0.2* | *0.6* | | *0.4* |  | *0.67* | *0.59* | *0.81* |  |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 10. Soil Nitrate-N (NO3-N) measured after cover crop termination, at Fort Ellis, MT, July 10, 2015, and NGV, MT, July 12, 2016. | | | | | | | | | |
|  | Fort Ellis 2015 | | | | | NGV 2016 | | | |
| Treatment | 0 to 0.3 m | 0.31 to 0.6 m | | 0.61 to 0.9 m | Total | 0 to 0.3 m | 0.31 to 0.6 m | 0.61 to 0.9 m | Total |
|  |  | | | | | | | | |
| *p-value* | ***<0.01*** | ***<0.01*** | *0.60* | |  | ***<0.01*** | ***<0.01*** | ***<0.01*** |  |
|  |  | | | | | | | | |
|  | ----------------------------------------------------- kg ha-1 ------------------------------------------------------------- | | | | | | | | |
|  |  | | | | | | | | |
| Fallow (Cool) | 31 | 12 | 10 | | 53 | 24 | 7 | 11 | 42 |
| Fallow (Warm) | 23 | 13 | 12 | | 48 | 30 | 12 | 12 | 54 |
| Cool Graze | 8 | 3 | 6 | | 17 | 7 | 3 | 18 | 28 |
| Cool Spray | 6 | 2 | 6 | | 14 | 10 | 3 | 5 | 18 |
| Warm Graze | 13 | 2 | 10 | | 25 | 12 | 3 | 6 | 21 |
| Warm Spray | 17 | 4 | 10 | | 31 | 14 | 5 | 8 | 27 |
| Warm Hay | 7 | 3 | 6 | | 16 | 12 | 5 | 8 | 25 |
|  |  |  |  | |  |  |  |  |  |
| LSD | 10 | 4 | NS | |  | 9 | 4 | 11 |  |
|  |  |  |  | |  |  |  |  |  |
| Contrasts | ------------------------------------------------ *p -*values *--------------------------------------------------* | | | | | | | | |
|  |  | | | | | | | | |
| Fallow v. All | ***<0.01*** | ***<0.01*** | | *0.64* |  | ***<0.01*** | *0.19* | *0.67* |  |
| Cool v. Warm | ***0.01*** | ***<0.01*** | | *0.33* |  | *0.08* | *0.07* | *0.24* |  |
| Spray v. Graze | ***<0.01*** | ***<0.01*** | | *0.22* |  | ***<0.01*** | ***<0.01*** | *0.50* |  |
| CG v WG | *0.62* | *0.75* | | *0.44* |  | *0.77* | *0.32* | *0.28* |  |
| WG v. WH | *0.22* | *0.82* | | *0.61* |  | *0.74* | *0.77* | *0.36* |  |
|  |  |  | |  |  |  |  |  |  |
| CG = cool graze, WG = warm graze, and WH = warm hay | | | | | | | | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 11. Soil water (mm water equivalence) and nitrate (kg ha-1), measured on Apr 12, 2016, prior to planting wheat and following 2015 cover crop treatments, Fort Ellis, MT. | | | | | | |
|  | Soil Water | | | Soil NO3-N | | |
| Treatment | 0 to 0.3 m | 0.31 to 0.6 m | 0.61 to 0.9 m | 0 to 0.3 m | 0.31 to 0.6 m | 0.61 to 0.9 m |
|  |  |  |  |  |  |  |
| *p*-values | 0.09 | *0.54* | *0.82* | *0.06* | ***<0.01*** | ***0.02*** |
|  |  |  |  |  |  |  |
|  | ----------------Soil Water mm-1 ---------------- | | | -------------- Soil NO3-N kg ha-1 -------------- | | |
|  |  | | |  | | |
| Fallow | 94 | 87 | 80 | 30 | 39 | 28 |
| Cool Graze | 87 | 85 | 78 | 25 | 24 | 18 |
| Cool Spray | 90 | 84 | 78 | 24 | 22 | 16 |
| Warm Graze | 90 | 86 | 77 | 18 | 14 | 12 |
| Warm Spray | 91 | 84 | 80 | 13 | 16 | 21 |
| Warm Hay | 91 | 83 | 80 | 16 | 17 | 15 |
|  |  |  |  |  |  |  |
| LSDTreat | NS | NS | NS | NS | 3.55 | 8.64 |
|  |  |  |  |  |  |  |
| Contrasts | ---------------------------------------------- *p-values-----------------------------------------------* | | | | | |
|  |  |  |  |  |  |  |
| Fallow v. All | ***0.02*** | *0.17* | *0.57* | ***0.02*** | ***<0.01*** | ***<0.01*** |
| Cool v. Warm | *0.13* | *0.93* | *0.67* | ***0.03*** | ***<0.01*** | ***<0.01*** |
| Spray v. Graze | *0.19* | *0.36* | *0.45* | *0.40* | *0.87* | *0.87* |
| WG v. WH | *0.62* | *0.40* | *0.74* | *0.70* | *0.80* | *0.80* |
|  |  |  |  |  |  |  |
| CG = cool graze, WG = warm graze, and WH = warm hay.  \*Results come from an omnibus ANOVA. | | | | | | |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 12. Soil PMN (kg NH4 ha-1) measured Apr 13, 2016 prior to wheat planting, Fort Ellis, MT. An omnibus ANVOA showed no treatment (*p* = 0.07) and a strong rep effect (*p <* 0.01). | | | | | | | | | |
| Treatment | Fallow | Cool Graze | Cool Spray | Warm Graze | | Warm Spray | | Warm Hay | |
|  |  |  |  |  | |  | |  | |
| PMN (kg NH4 ha-1) | 28.6 | 26.5 | 42.9 | 24.6 | | 40.7 | | 20.8 | |
|  |  |  |  |  | |  | |  | |
|  |  |  |  |  | |  | |  | |
| Contrast | Fallow v. All | Cool v. Warm | Spray v. Graze | | CG v. WG | | WG v. WH | |  |
|  |  |  |  | |  | |  | |  |
| *p-*values | *0.68* | *0.25* | ***0.01*** | | *0.50* | | *0.13* | |  |
|  |  |  |  | |  | |  | |  |
| CG = cool graze, WG = warm graze, and WH = warm hay. | | | | | | | | | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 13. Pre-planting soil phosphate (kg P2O5ha-1) Apr 13, 2016, prior to wheat seeding, Fort Ellis, MT. | | | | | | | | |
| Treatment | Fallow | Cool Graze | Cool Spray | Warm Graze | Warm Spray | | Warm Hay | |
|  |  |  |  |  |  | |  | |
|  | 121 | 136 | 139 | 143 | 134 | | 134 | |
|  |  |  |  |  | |  | |
| Contrast | Fallow v. All | Cool v. Warm | Spray v. Graze | CG v. WG | WG v. WH | |  | |
|  |  |  |  |  |  | |  | |
|  | ***0.03*** | *0.87* | *0.66* | *0.24* | *0.88* | |  | |
| CG = cool graze, WG = warm graze, and WH = warm hay. | | | | | | | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 14. Soil enzyme activity, measured Apr 13 2016, prior to wheat planting, For Ellis, MT. Mean treatment values of soil enzyme activity represent mg of p-nitrophenol (PN) produced per kg soil per hour. | | | | |
|  |  | Acid | Alkaline |  |
| Treatment | β-Glucosaminidase | Phosphatase | Phosphatase | β-Glucosidase |
|  |  |  |  |  |
| *p*-values | *0.21* | ***<0.01*** | *0.32* | *0.11* |
|  |  |  |  |  |
|  | ----------------------------------- Mg PN kg-1 soil h-1 --------------------------- | | | |
|  |  | | | |
| Fallow | 154 | 215 | 224 | 139 |
| Cool Graze | 204 | 377 | 291 | 209 |
| Cool Spray | 180 | 287 | 266 | 155 |
| Warm Graze | 223 | 363 | 283 | 193 |
| Warm Spray | 174 | 287 | 262 | 218 |
| Warm Hay | 164 | 235 | 279 | 168 |
|  |  |  |  |  |
| LSD | NS | 84.3 | NS | NS |
|  |  |  |  |  |
| Contrasts | ----------------------------------- *p*-values------------------------------ | | | |
|  |  | | | |
| Fallow v. All | *0.14* | ***<0.01*** | ***0.04*** | ***0.05*** |
| Cool v. Warm | *0.79* | *0.17* | *0.85* | *0.57* |
| Spray v. Graze | *0.09* | ***<0.01*** | *0.29* | *0.51* |
|  |  |  |  |  |
|  |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| Table 15. Means for cover crop treatment effects on subsequent spring wheat at three N fertilizer rates on spring wheat at Fort Ellis, MT 2016. | | |
| Source of variation\* | Wheat Yield | Wheat Seed Protein |
|  |  |  |
|  | -------------- *p*-values ------------ | |
|  |  |  |
| Treatment | *0.32* | ***0.04*** |
| Block | ***<0.01*** | ***<0.01*** |
| Fertilizer | ***<0.01*** | ***<0.01*** |
| Treatment x Fertilizer | *0.69* | *0.67* |
|  |  |  |
| Treatment | ---- Mg ha-1 ---- | ----- g kg-1 ---- |
|  |  |  |
| Fallow | 3.9 | 137 |
| Cool Graze | 3.7 | 132 |
| Cool Spray | 3.7 | 135 |
| Warm Graze | 3.7 | 133 |
| Warm Spray | 3.6 | 135 |
| Warm Hay | 3.7 | 133 |
|  |  |  |
| LSDtreat. | NS | 4 |
|  |  |  |
| Fertilizer Rate |  |  |
|  |  |  |
| 0 kg N ha-1 | 3.3 | 129 |
| 68 kg N ha-1 | 3.8 | 134 |
| 135 kg N ha-1 | 4.1 | 139 |
|  |  |  |
| LSDfert. | 0.2 | 3 |
|  |  |  |
| Contrasts | ------------ *p*-values ---------- | |
|  |  | |
| Fallow v. All | *0.06* | ***0.01*** |
| Cool v. Warm | *0.51* | *0.99* |
| Spray v. Graze | *0.32* | ***0.03*** |
| WG v. WH | *0.60* | *0.87* |
|  |  |  |
| \*Results come from omnibus ANOVA | | |

References

Acosta-Martinez, V., T.M. Zobeck, Vivien Allen. 2004. Soil Microbial, Chemical and Physical Properties in Continuous Cotton and Integrated Crop-Livestock Systems. Soil Science Society of America. 68: 1875-1884.

Acosta-Martinez, V., R. Lascano, F. Calderon, J.D. Booker, T.M. Zobeck, and D.R. Upchurch. 2011. Dryland cropping systems influence the microbial biomass and enzyme activities in a semiarid sandy soil. Biology and Fertility of Soils 47: 655-667.

Assmann, T.S., I. Anghinoni, A.P. Martins, S.E.V. Gigante de Andrade Costa, D. Cecagno, F. S. Carlos, P.Cesar de Faccio Carvalho. 2014. Soil carbon and nitrogen stocks and factions in a long-term integrated crop-livestock system under no-tillage in southern Brazil. Agriculture, Ecosystems and Environment. 190: 52-59.

Bardgett, R. D., D. A. Wardle. 2010. Ch.4: Ecosystem-level significance of aboveground consumers. *Aboveground-Belowground Linkages: Biotic Interactions, Ecosystem Processes, and Global Change*. Oxford University Press. Oxford, U.K.

Biederbeck V.O., Bouman O.T., Campbell C.A., Bailey L.D., Winkleman G.E., 1996. Nitrogen benefits from four green-manure legumes in dryland cropping systems. Can. J. Plant Sci. 76, 307-315.

Biederbeck, V.O., R.P. Zentner and C.A. Campbell. 2005. Soil microbial populations and activities as influenced by legume green fallow in a semiarid climate. Soil Biology and Biochemistry 37:1775-1784.

Dick, R.(ed.). 2011. Methods of Soil Enzymology. SSSA Book Ser. 9. SSSA and ASA. Madison, WI.

Collins, M. 1988. Composition and fiber digestion in morphological components of an alfalfa-timothy sward. Anim. Feed Sci. Tech. 19:135–143.

Hamza, M.A., W.K. Anderson. 2005. Soil compaction in cropping systems: A review of the nature, causes and possible solutions. Soil and Tillage Research. 82: 121-145.

Hatfield, P.G., R.A. Field, J.A. Hopkins, and R. W. Kott. 2000. Palatability of wethers fed an 80% barley diet processed at different ages and of yearling wethers grazed on native range. Journal of Animal Science 78:1779-1785.

Housman, M.L. 2016. Multi-Species Cover Crops in the Northern Great Plains: An Ecological Perspective on Biodiversity and Soil Health. Master’s Thesis, Montana State University, Bozeman, MT.

Jones, C., R. Kurnick, P. Miller, K. Olson-Rutz, C. Zabinski. 2015a. 2015 Montana Cover Crop Survey Results. Montana State University, Bozeman, MT.

Jones, C., P. Miller, M. Burgess, S. Tallman, M. Housman, J. O’Dea, A. Bekkerman, and C. Zabninski. 2015b. Cover Cropping in the Semi-Arid West: Effects of Termination Timing, Species, and Mixtures on Nitrogen Uptake, Yield, Soil Quality, and Economic Return. Proceedings of the Western Nutrient Management Conference, 11:39-45.

Keeney, D. 1982. Nitrogen – availability indices. In: Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties (ed. S. Segou), pp. 711–733. SSSA, Madison, WI.

Kou, S. 1996. Phosphorous. p. 869-915. In D.L. Sparks et al., (eds.). Methods of Soil Analysis, Part 3. Chemical Methods. SSSA Book Ser. 5. SSSA and ASA. Madison, WI.

McCauley, A., Jones, C., Miller, P., Burgess, M. and Zabinski, C., 2012. Nitrogen fixation by pea and lentil green manures in a semi-arid cropping system: Effect of planting and termination time. Nutr. Cycl. Agroecosys. 92: 305-314.

Miller, P.R., and J.A. Holmes. 2005. Cropping sequence effects of four broadleaf crops on four cereal crops in the northern Great Plains. Agron. J. 97:189-200.

Montana Dept. of Commerce. 2017. Census & Economic Information Center – Select Montana Agricultural Commodities Dashboard. <http://ceic.mt.gov/Economics/AgricultureDashboard.aspx>. Accessed [ 2 Jan 2017].

National Resource Conservation Service. 2009. Radishes: A new cover crop option. Crops and Soils: 14-17.

O'Dea, J.K. 2011. Greening summer fallow: Agronomic and edaphic implications of legumes in dryland wheat agroecosystems. Master's Thesis, Montana State University, Bozeman, MT.

Olsen, S.R., and L.E. Sommers. 1982. Phosphorous. p. 403-430. In A.L. Page (ed.). Methods of Soil Analysis, Part 2, 2nd Ed. Agron. Mongr. No. 9 ASA and SSA. Madison, WI.

Or, D. and J.M. Wraith. 1999. Soil water content and water potential relationships. M. Summer, ed. Handbook of Soil Science. CRC Press, Boca Raton, FL. pp A53-A85.

Parham, J.A. and Deng, S.P. 2000. Detection, quantification and characterization of b-glucosaminidase activity in soil. Soil Biol. Biochem. 32, 1183–1190.

Ruess, L. and H. Ferris. 2004. Decomposition pathways and successional changes. Nematology Monographs and Perspectives. 2: 547-556.

Sainju, U.M., B.P. Singh, W.F. Whitehead. 2002. Long-term effects tillage, cover crops, and nitrogen fertilization on organic carbon and nitrogen concentrations in sandy loam soils in Georgia, USA. Soil & Tillage Research, 63: 167-179.

Tallman, S.M., 2014. Cover crop mixtures as partial summerfallow replacement in the semi-arid northern Great Plains. Master’s Thesis, Montana State University, Bozeman, MT.

USDA Farm Service Agency. 2016. Crop Acreage Data. <https://www.fsa.usda.gov/news-room/efoia/electronic-reading-room/frequently-requested-information/crop-acreage-data/index>. Accessed [2 Jan 2017].

van Kessel, C., and C. Hartley. 2000. Agricultural management of grain legumes: has it led to an increase in nitrogen fixation? Field Crops Research. 65:165-181.

Wardle, D.A., K.I. Bonner, G.M. Barker. 2002. Linkages between plant litter decomposition, litter quality and vegetation responses to herbivores. Functional Ecology. 16: 585-595.

Wardle, D. A., R. D. Bardgett. 2004. Human-Induced changes in large herbivorous mammal density: the consequences for decomposers. Frontiers in Ecology and Environment. 2(3): 145-153.

West and Sparling.1986. Modifications to the substrate-induced respiration method to permit measurement of microbial biomass in soils of differing water contents. Journal of Microbiological Methods. 5: 177-189.