

Rocky Mountain Seed Alliance
20 to 20 in 2020

Principal Investigator:

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Co-PI's:

- Wilder Jones; Research Farmer at King's Crown Farm in Glenns Ferry, Idaho
- Don Lareau and Molly Moore; Research Farmers at Zephyros Farm in Paonia, Colorado
- Emily Lockard; Research Associate at CSU's Southwest Colorado Research Center

Scientific Council:

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Statistical Analyses

- Steve Alston, PhD Chemical/Biomedical Engineering; W.L. Gore & Associates

Rocky Mountain Seed Alliance's "20 to 20 in 2020" project investigated 20 promising ancient and heritage cereal grain varieties to measure performance for farm scale organic growing conditions and increased available seed to a minimum of 20 pounds each. Data was collected on weed suppression, lodging, disease, and pest pressure as well as yield and height and environmental conditions through farmer-driven research at two organically-certified farms located in Glenn's Ferry, Idaho (King's Crown Farm) and Paonia, Colorado (Zephyros Farm), with two additional trial sites in Southwest Colorado collecting similar data, including an organic plot at Colorado State University's Southwest Colorado Research Center (SWCRC) in Yellowjacket and the Project Director's farm, Laughing Wolf Farm (LWF) in Mancos (not organic certified, though employing organic practices throughout the ten years of operation). Supplemental data was collected through Rocky Mountain Seed Alliance's grassroots Heritage Grain Trials Program and via a new field app and platform created by [SeedLinked](#).

This project looks at the marketability of heritage grains in context with the impacts from climate, weed pressure, and pest pressures. Field research data collected from this project will be published in a forthcoming Heritage Grain Guidebook that will incorporate additional data and lab analyses from a Western SARE grant partnership and a UNFI grant. The Heritage Grain Guidebook will be freely distributed on our website, and disseminated to interested growers and partners to increase and enhance the existing knowledge available about these unique varieties.

Grain grown in the research trials is being freely offered to new farmers who are interested in trying these grains and scaling up to marketable yields. Additionally, four Grain Field Days were held at all four participating research farms, and an 8-week online Grain School was held in the fall of 2021 that attracted 58 student participants and 20 presenters who shared knowledge and expertise on growing and using heritage grains.

(1) Summary: What was accomplished, findings and potential impact

The project included 20 varieties of ancient and heritage wheat, barley and rye varieties that had proven to be most adaptive and best performing during Rocky Mountain Seed Alliance's grassroots grain trials from 2016-2020. Participant data was voluntary, and primarily observational, with some data offered on planting and harvesting dates, germination, yields, and

other general crop assessments regarding pest impacts, lodging, and climate. As farmer queries increased, we decided to conduct formal research to assess which varieties would be appropriate at a farm scale in local and regional agricultural efforts in the Mountain West.

- a. **Primary Research:** For the farmer trials, we implemented a random replication experimental block design for the grain plots. Due to limited seed stock of two of the top 20 varieties, and with interest in a facultative assessment of two of the included varieties, the final design comprised of eighteen varieties, with two that were planted in both fall and spring. Research farmers planted the following in Fall of 2020:

- | | |
|------------------|--|
| 1. Black Einkorn | 5. Turkey Red Winter Wheat |
| 2. Black Emmer | 6. Marquis Wheat (facultative trial) |
| 3. Sangaste Rye | 7. Tibetan Purple Barley (facultative trial) |
| 4. Spelt | |

Spring 2021 trials included:

- | | |
|--------------------------------|---|
| 1. Arabian Blue Barley | 8. Purple Dolma Barley |
| 2. Einkorn | 9. Red Fife or Rouge de Bourdeaux Wheat
(based on seed stock quantities) |
| 3. Emmer | 10. Sin El Pheel (durum wheat) |
| 4. Ethiopian Blue-Tinged Wheat | 11. Sonoran White Wheat |
| 5. Khorasan (durum wheat) | 12. Marquis Wheat (facultative trial) |
| 6. Iraq Durum | 13. Tibetan Purple Barley (facultative trial) |
| 7. Pima Club Wheat | |

b. **Project Findings**

The project and findings were extensive, and are shared in this report with a focus on the field data per the OFRF grant objectives. Additional lab analyses on grain quality and baking performance, as funded by additional grant research partners, will be included with the filed data in the forthcoming Grain Guidebook. The following chart summarizes the performance based on yield, vigor, and weeds. Height is offered for assessing harvesting compatibility with mechanized equipment. Winter survival matches the “Top 5” as winter varieties were more adept at outpacing weeds, which were particularly challenging in the 2021 season. Key: ID=Idaho (King’s Crown Farm in Glenn’s Ferry), Z=Zephyros Farm (Paonia, CO), LWF=Laughing Wolf Farm (Mancos, CO), and SWCRC=Southwest Colorado Research Center (Yellowjacket, CO).

Average yield - assessed per farm. Grain from each plot was harvested, weighed, and normalized by the plot area. Where multiple plots of the same grain variety were planted, the weight per area was averaged across plots to arrive at an average yield per variety. Per protocol average yield included plots where grain was planted but no grain was harvested (due to related crop failures).

Weed Competition - assessed per farm based on a subjective score ranging from 1 to 5 where 1 is minimal weed pressure and 5 is a complete crop failure from weed competition. Scores from plots of the same variety of grain were averaged to obtain an average score per variety.

Lodging - assessed per farm based on a subjective scale ranging from 1 to 5 where 1=100% of grain stems are on the ground, 3=50% of grain stems are at 45° to the ground and 5 is all grain stems are upright. Scores from plots of the same variety of grain were averaged to obtain an average score per variety.

Pest Pressure - assessed per farm based on a subjective score ranging from 1 to 5 where 1 is minimal pest impact 5 is full crop failure due to pest pressure. Scores from plots of the same variety of grain were averaged to obtain an average score per variety.

Variety	Height range* (inches)	Top yield lbs/acre	Vigor (scale 10=best)	Weeds (worst)	Winter Survival	Top 5**
Arabian Blue Barley	29-39	1337.64 (LWF)	0, 8		n/a	
Einkorn	24-36	1113.82 (ID)	0, 3-5	ID, Z, LWF	n/a	
Black Einkorn	30-38	1395.42 (ID)	7-8		yes	
Emmer	34-45	2109.09 (SWCRC)	8-10		yes	
Black Emmer	40-61	2993.91 (ID)	8-10	Z	yes	X
Ethiopian Blue-Tinged	22-40	1116.21 (LWF)	7-10	Z	n/a	
Iraq Durum	36-57	1775.48 (LWF)	10		n/a	
Khorasan (Kamut)	31-47	1606.17 (Z)	9		n/a	
Marquis Wheat	37-53	2396.10 (Z-winter)	6-8		yes	X
Pima Club Wheat	31-36	1287.31 (SWCRC)	5, 9		n/a	
Purple Dolma Barley	32-36	1113.82 (Z)	3	ID, Z, LWF	n/a	
Red Fife	40-53	1698.53 (SWCRC)			n/a	
Rouge de Bourdeaux	35-37	445.19 (LWF)	7		n/a	
Sangaste Rye	48-72	4452.27 (Z)	7-10		yes	X
Sin El Pheel (Durum)	38-44	1434.17 (Z)	8		n/a	
Sonoran White Wheat	28-49	1849.92 (Z)	7		no	
Spelt	33-41	3758.80 (Z)	7		yes	X
Tibetan Purple Barley	24-39	1678.83 (Z-winter)	0, 3-8	ID, Z, LWF	low	
Turkey Red Winter Wheat	29-44	2442.57 (SWCRC)	4-10		yes	X

*Height range is to the top of awns. **Top 5 are based on the yield, weed suppression, and vigor at site.

The Data

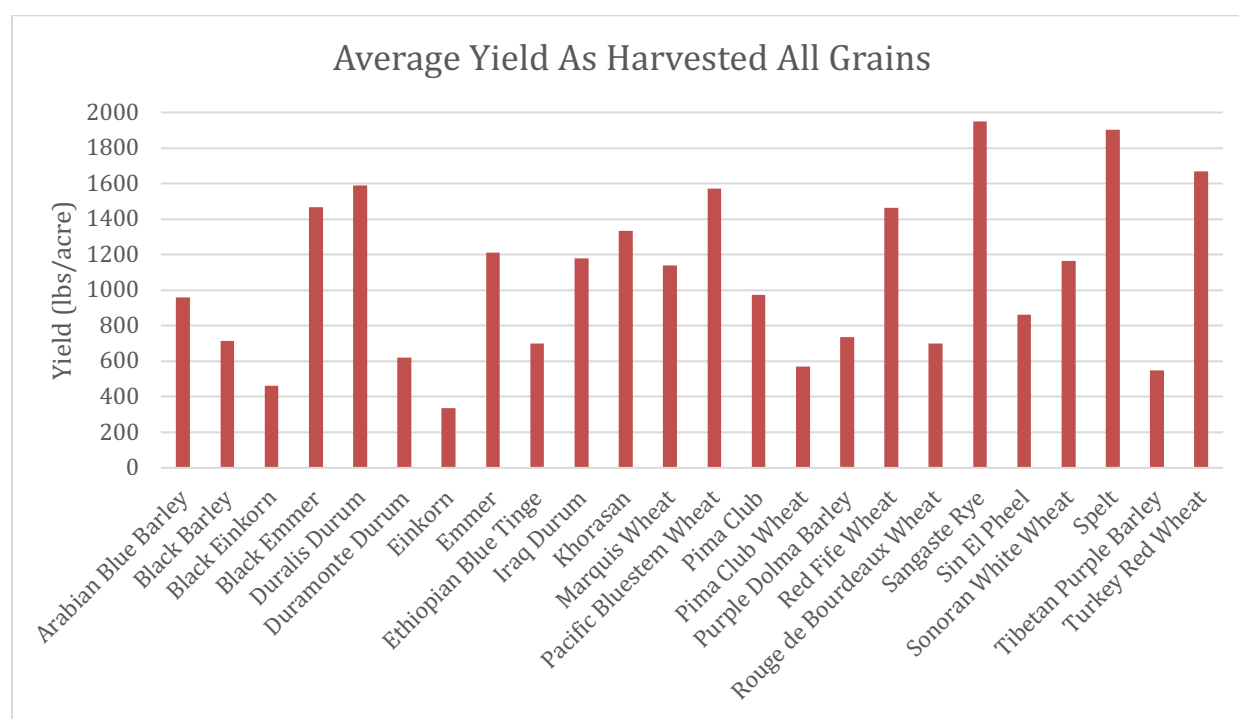
The data in this report should be evaluated together in a holistic approach. While the above chart does include yields in the “Top 5,” it also considers vigor, weed competition, and winter survivability all of which are key considerations in farming and all the more critical with changing climates, increasing pest and weed pressures, erratic temperatures and dramatic temperature swings, though other considerations are missing. Further research is needed on irrigation times and measurements, soil health and nutrient availability, and overall farm practices to further assess how these components factor into the overall results. With just one year of trials, even with four participating sites, this data is not conclusive, rather it is a snapshot of the 2021 growing season. Also, some data was not reported by each participating farm. None the less, this report offers valuable information for farmers when embarking on growing heritage grains with organic practices. Soil conditions and water regimes were possible factors in yields,

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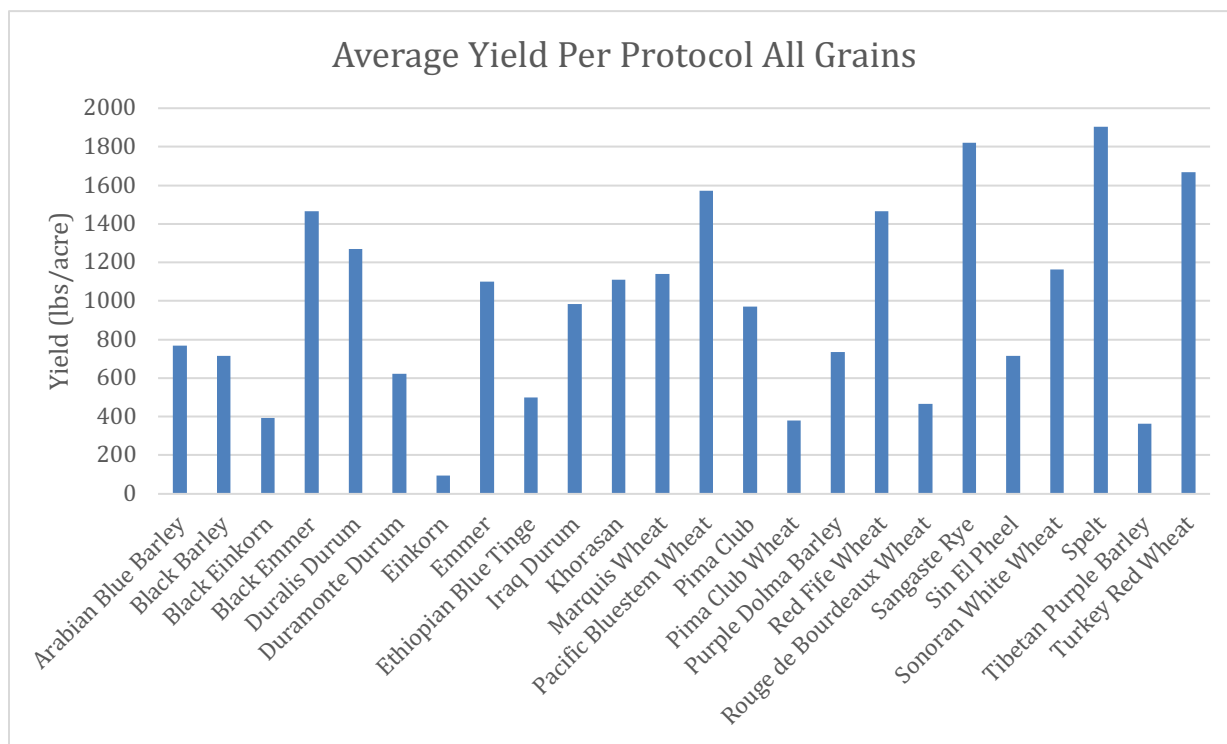
however irrigation measurements and soil samples were not taken. This would be helpful for subsequent research of these grains. Stalk nitrogen samples are currently being assessed (outside of the scope of this proposal) and will be incorporated into the final Grain Guidebook, which may offer more insight into soil nutrient availability in comparison to yields.

Yields

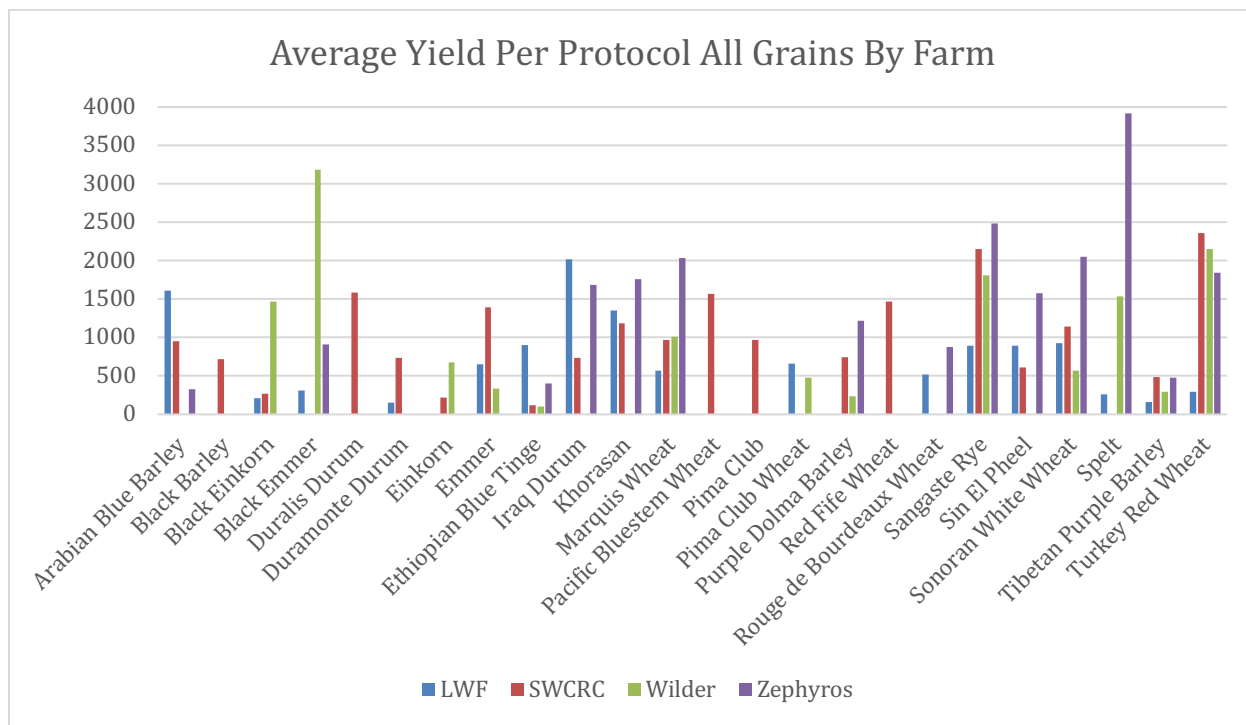
Yield data is only one of many valuable data points for growing heritage grains, however it is the top data set requested by farmers. In this project, yields vary considerably between varieties and between sites. Black Emmer, for instance, was a particularly inconsistent variety. Planted in the fall in the same size plots (4 ft. x 33 ft.) at all three farm locations, it yielded best in Idaho at 4,240 grams while at Zephyros Farm in Paonia, Colorado it yielded 1,212 grams, and at Laughing Wolf Farm in Southwest Colorado it yielded only 410 grams.



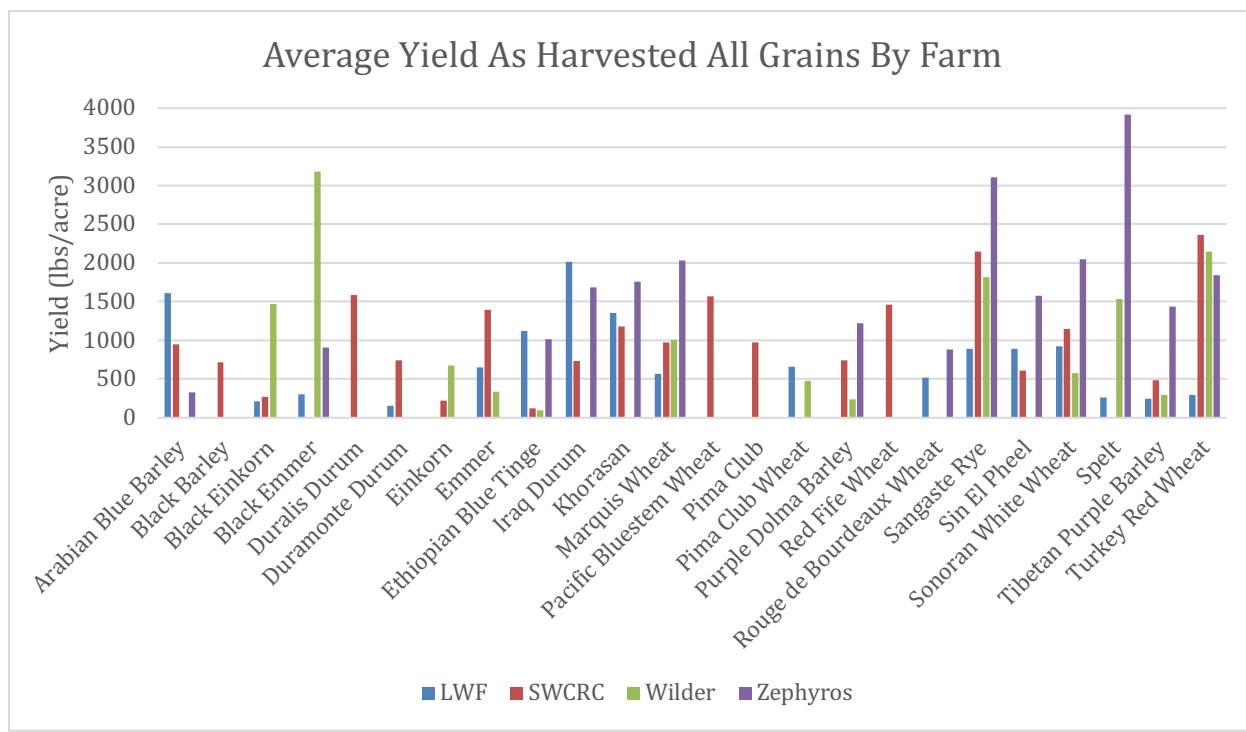
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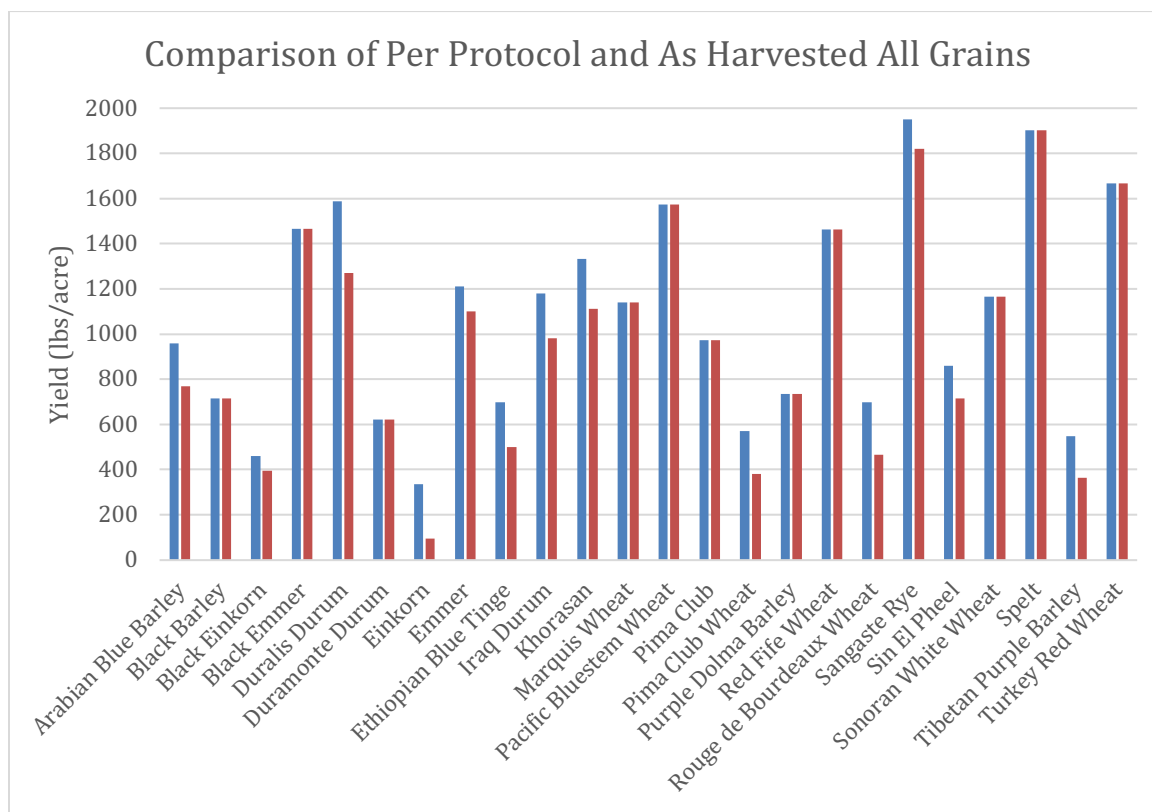
“Per Protocol” includes plots where yield was 0 lbs/acre (due to plot failures from weed competition, lodging, and disease/mildew concerns. “As Harvested” excludes plots w/ 0 yield.



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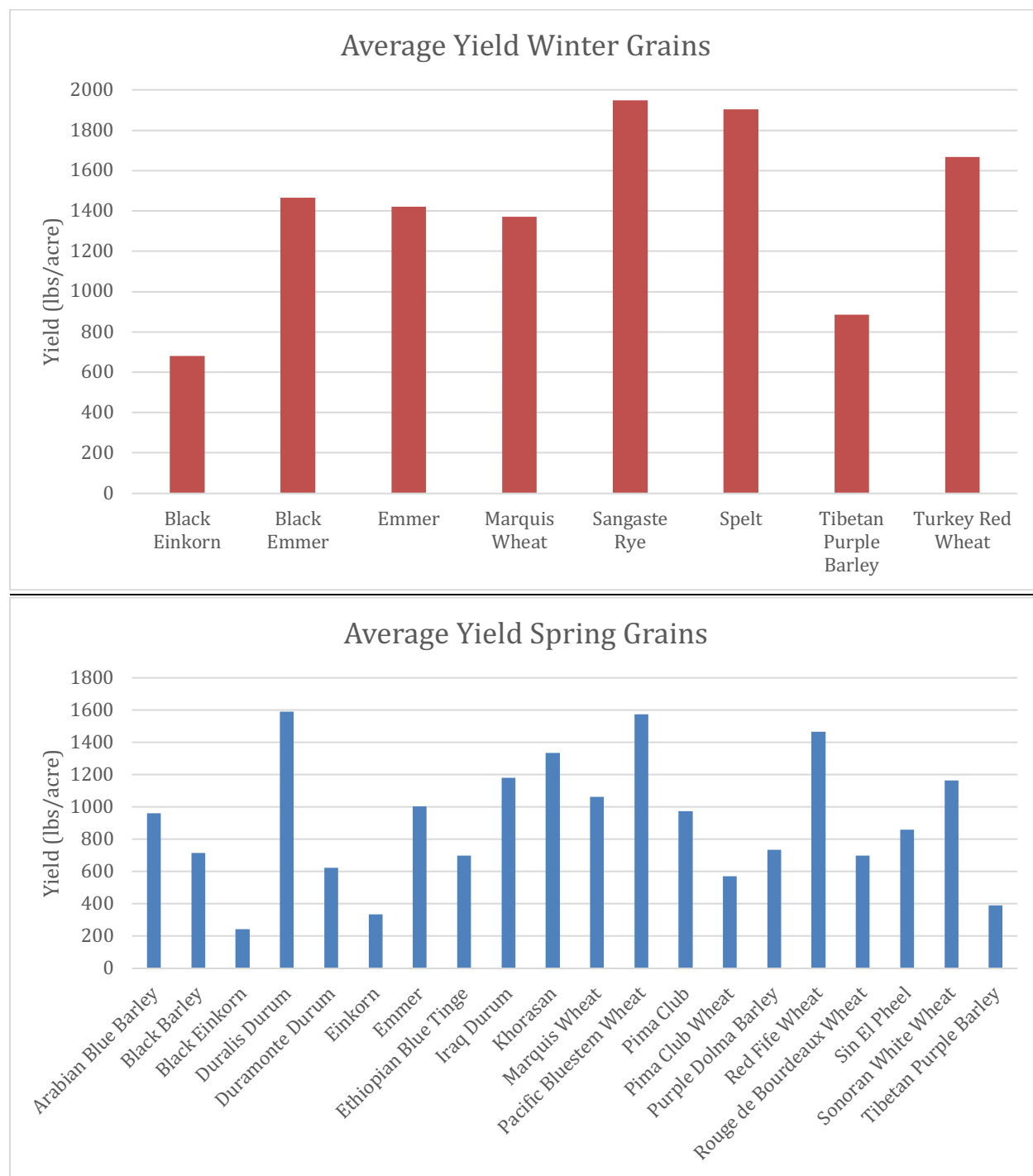
Per protocol and as harvested yields aren't too different.



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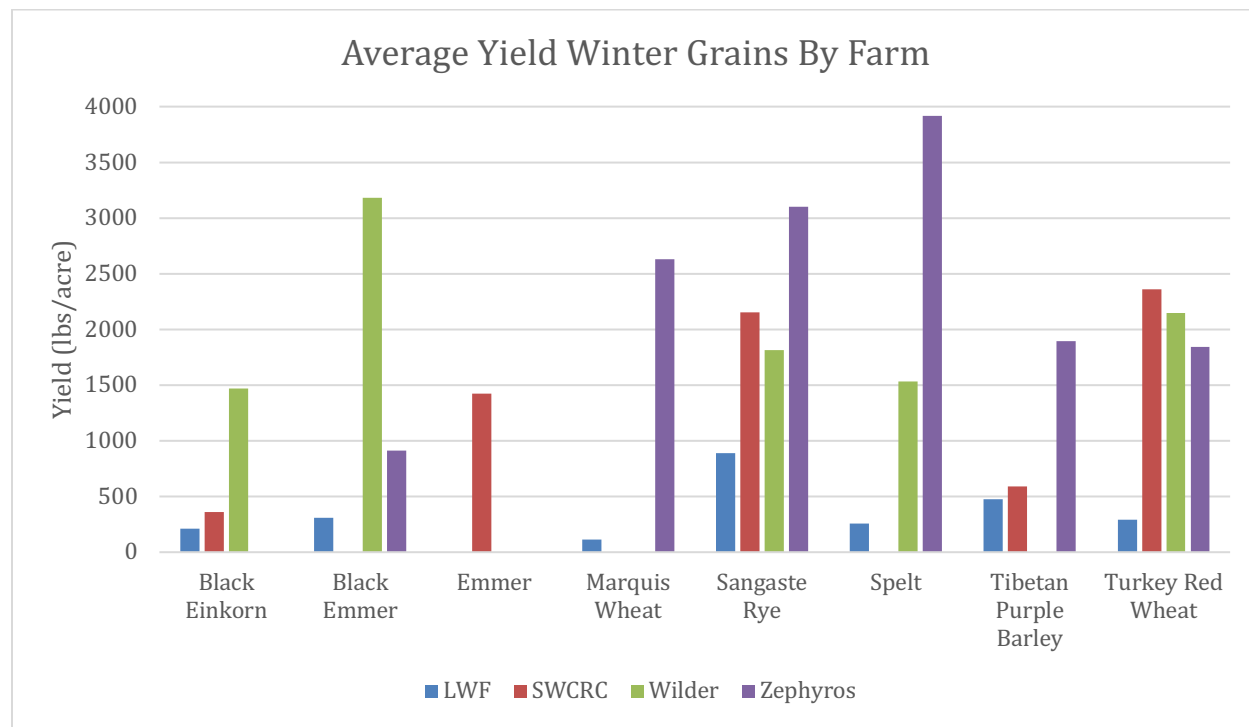
Zephyros Farm had statistically higher yields than all other participants ($p=0.007$). More supporting data is needed to further understand why such as irrigation calculations, soil samples, crop rotations and other on-farm practices, and climate data. Following is general farm info:

- Location and elevation: Western “slope” of Colorado at 5,682 feet
- Overhead and drip irrigation
- Fall planted varieties performed best with early season weed cultivation

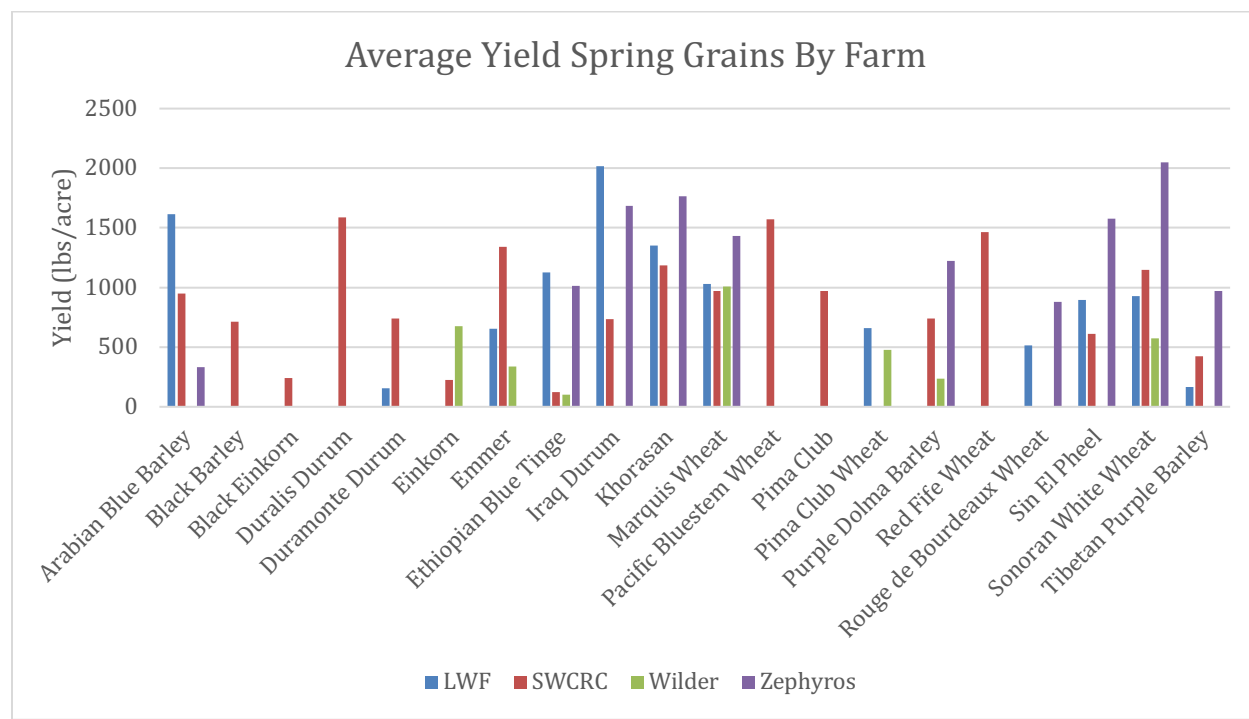


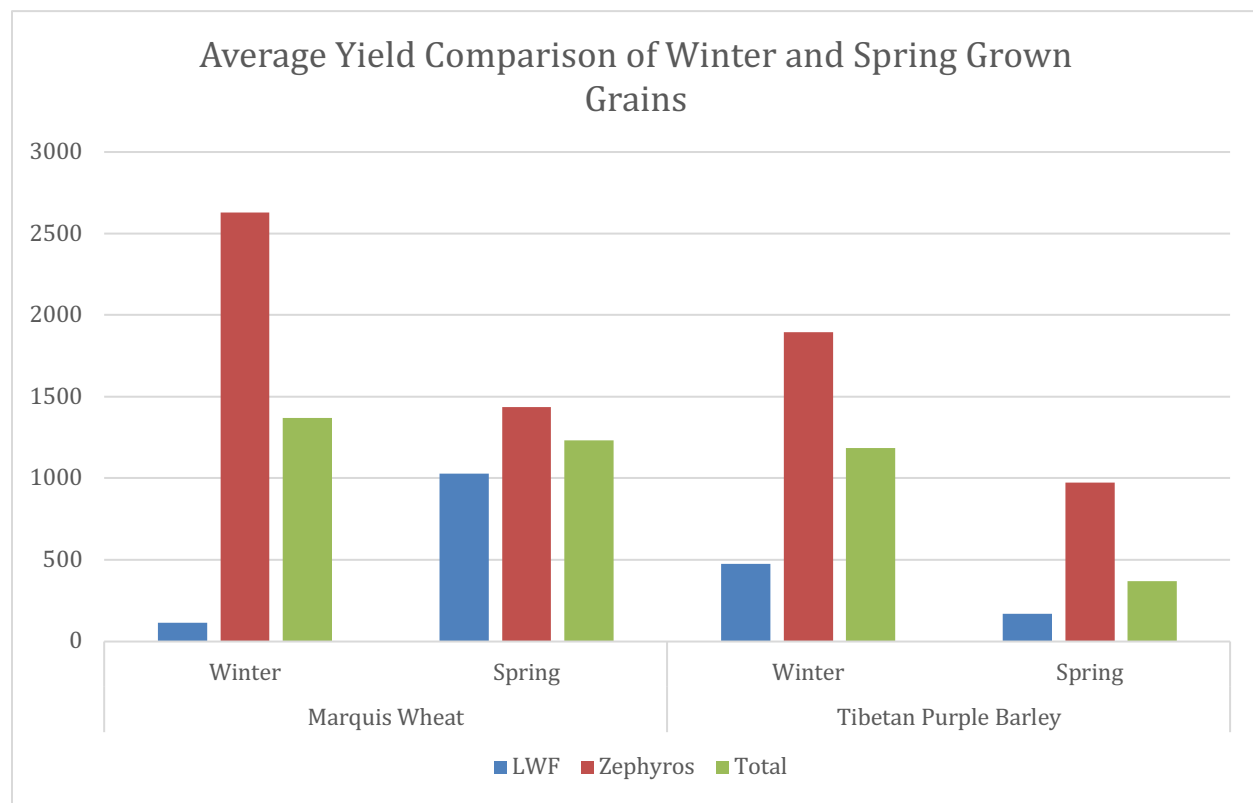
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Highest yielding varieties from the “Top 20” are Sangaste Rye, Spelt, and Turkey Red Winter Wheat. (Duralis Durum and Pacific Bluestem were additional varieties trialed at SWCRC.)



Highest yield was spelt at Zephyros Farm.





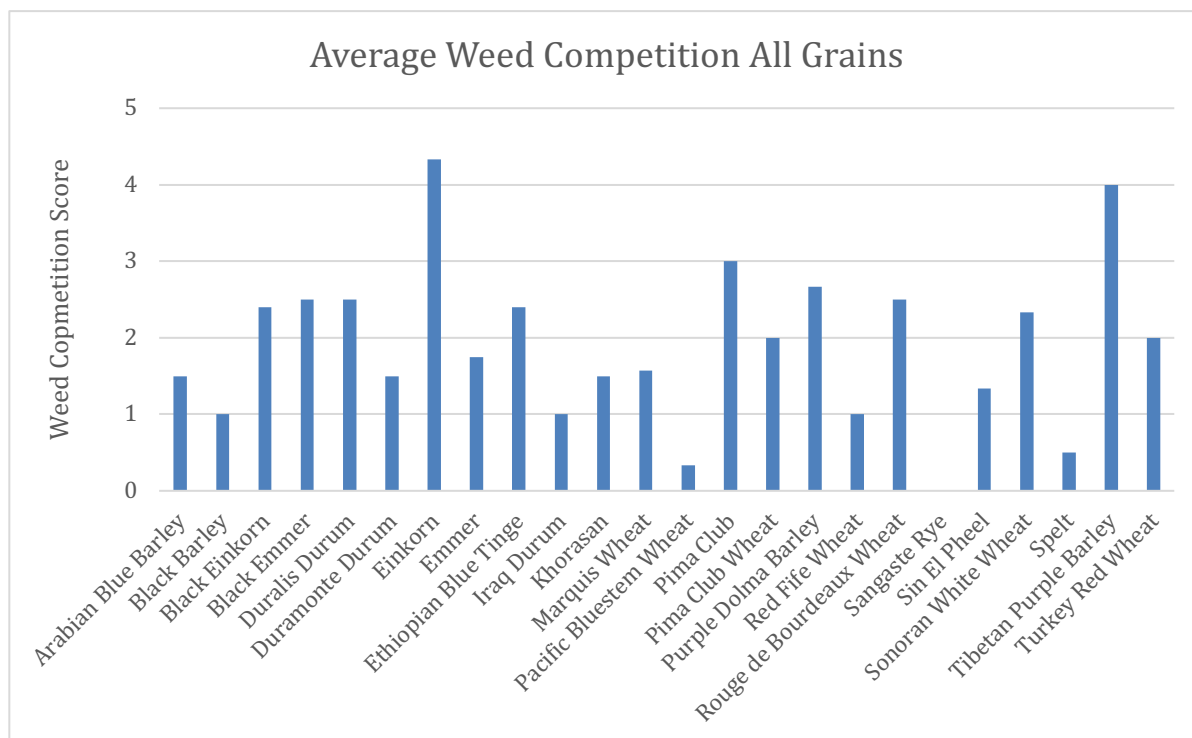
*LWF and Zephyros show same trend for Tibetan Purple with a higher yield when grown in winter, and an opposite trend for Marquis with a higher yield in spring for LWF and higher yield in winter for Zephyros. *Need more data to understand if these observations are causal.*

Weed Competition

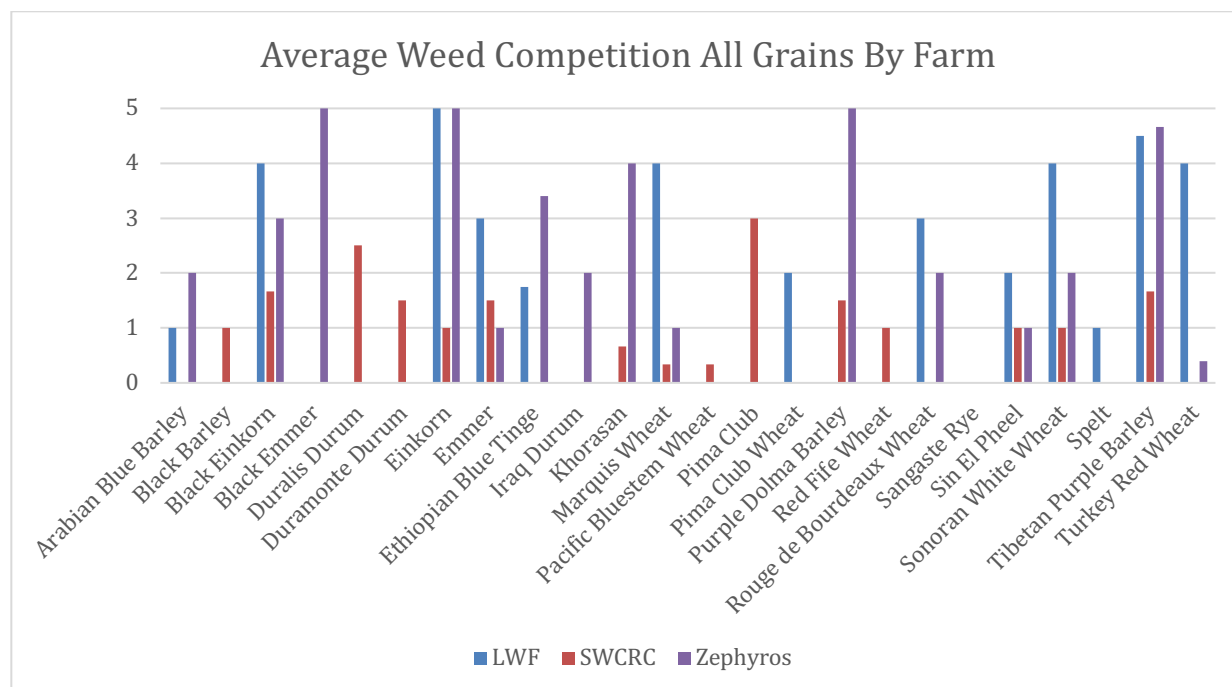
2021 was considered by many farmers and growers as one of the worst years for weeds in their experiences and memories, which was attributed to high early season temperatures followed by heavy mid-summer rains. As such, weed suppression was a key data set in the field research, and is becoming an ever-more valuable trait. Overall, varieties planted in the fall had a “head start” in the spring to outpace the weeds, and spring varieties with the most vigor and height also performed better than shorter and less vigorous varieties. However, another key observation by trialists and research farmers alike was that grains were not growing as tall this year overall. Allelopathy warrants more attention, and may have lendled to the greater performance of the Sangaste rye. Weeds outpaced many of the grain varieties in the research trials, particularly those spring planted that were slow to germinate like the einkorn and emmers, and the shorter varieties of barleys, to the degree that the grains couldn’t be harvested. Further, we are hearing from more farmers a greater interest in winter grains, specifically because of their greater chance at outcompeting weeds, thus the data on facultative and winter tolerant varieties.

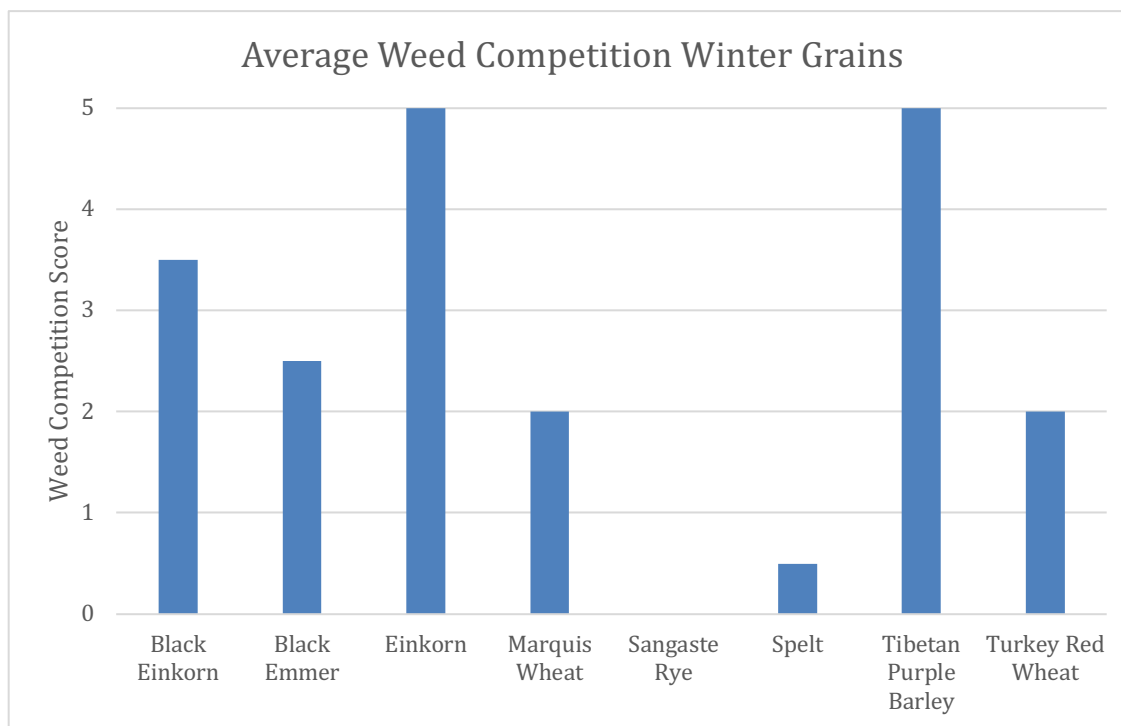
Grains that did not sustain the weed impacts included Einkorn, which was very slow to germinate and grow, enabling fast-growing spring weeds to outpace the plants and in some cases overtake the plots entirely, and Tibetan Purple Barley that grew shorter with heavy heads. Weeds outgrew this variety, particularly spring planted, and pulled the heavy heads down, decreasing optimal performance for harvest, which would be especially challenging for mechanical harvest.

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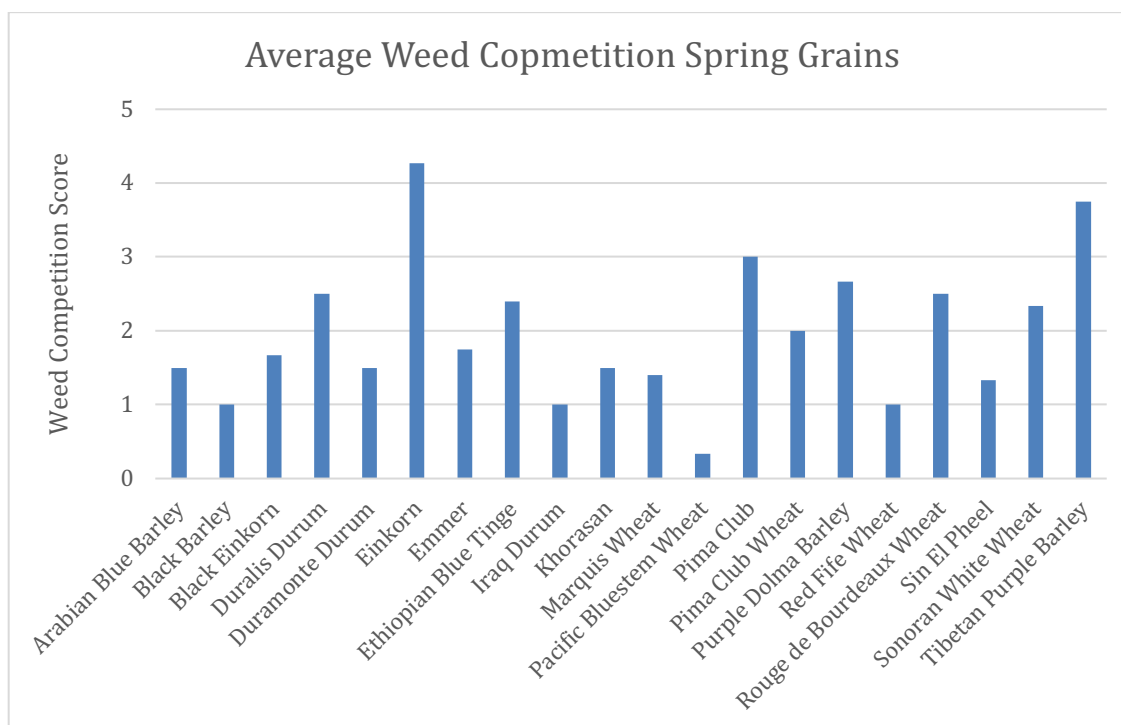


The higher the weed competition score, the worse the weeds. 5=crop failure from weeds. Sangaste rye had no weed competition at all farms.

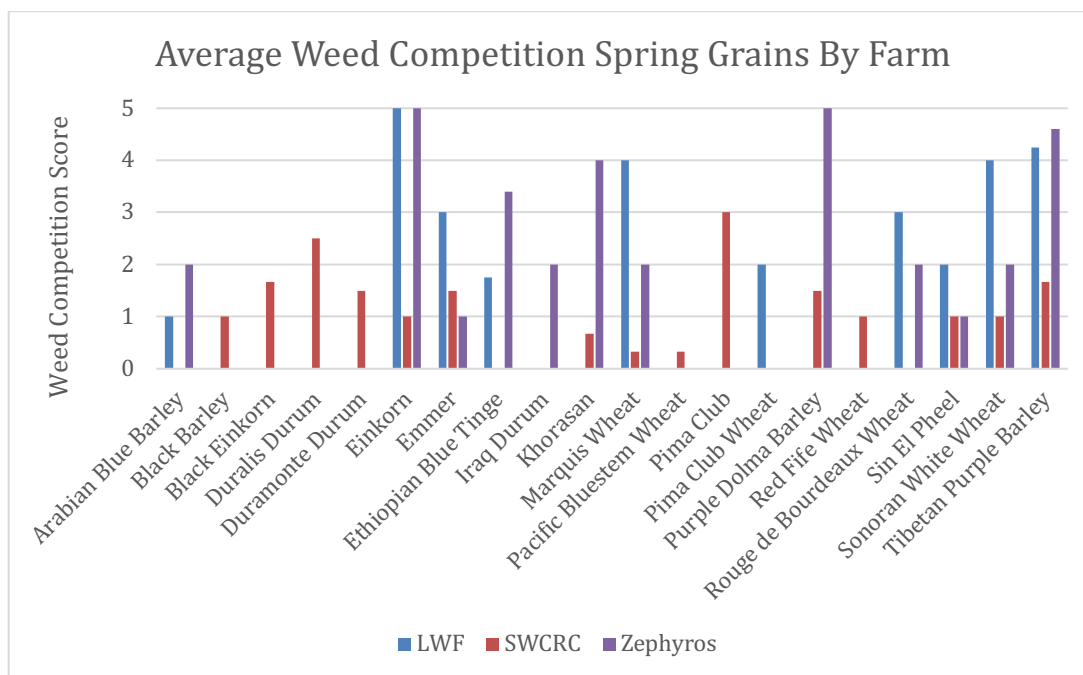
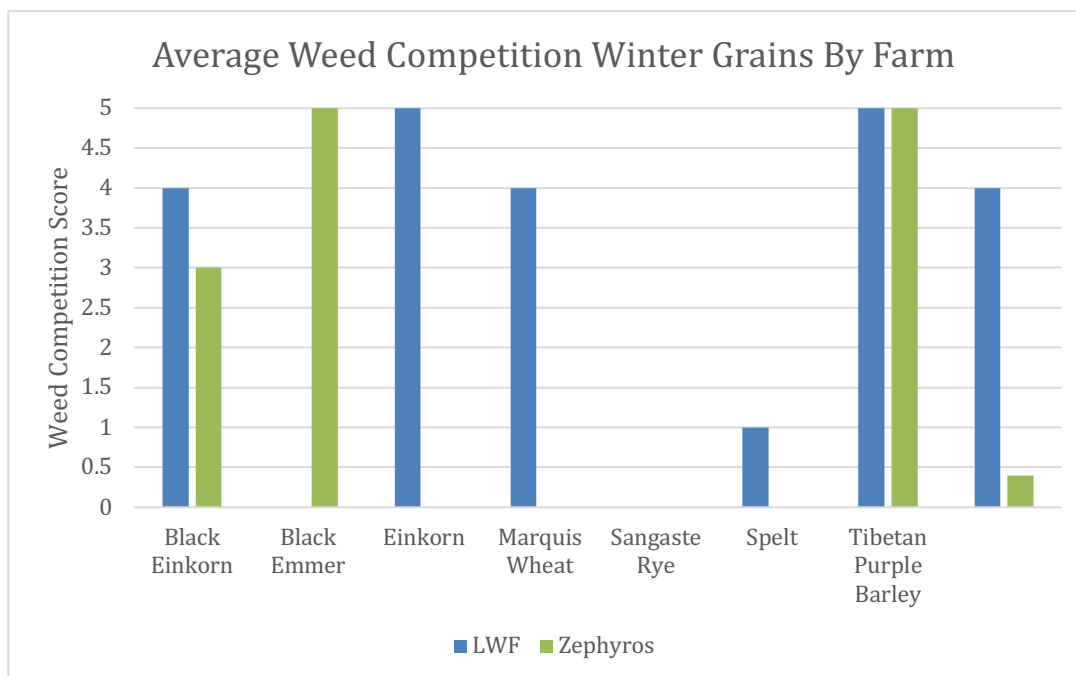


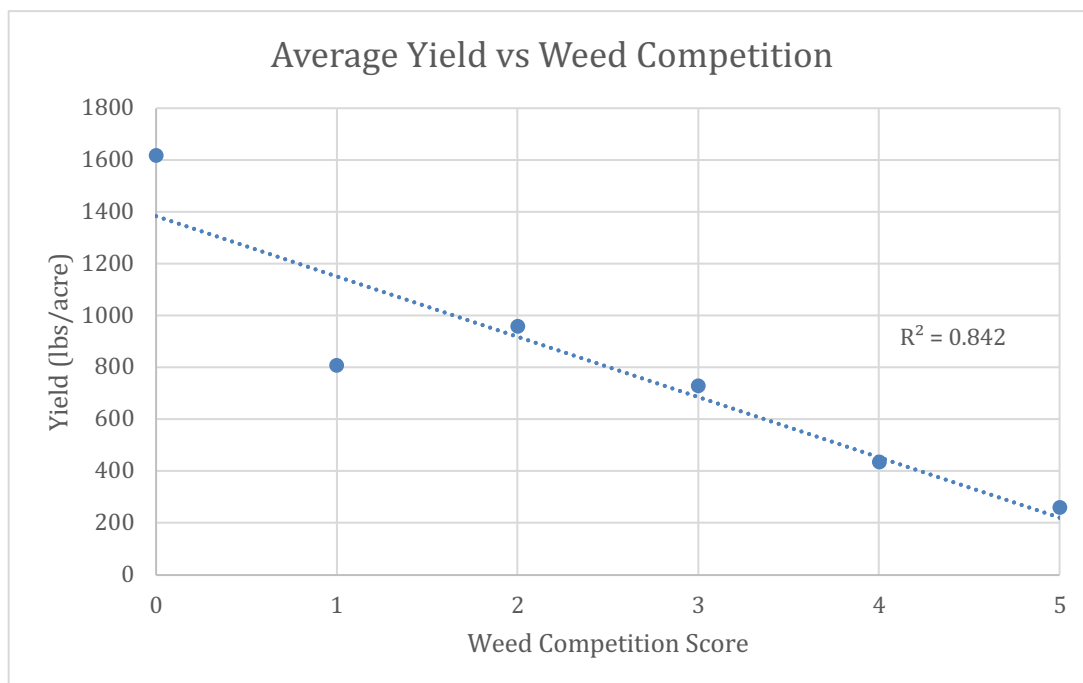


Winter grown Einkorn and Tibetan Purple Barley had highest weed competition.

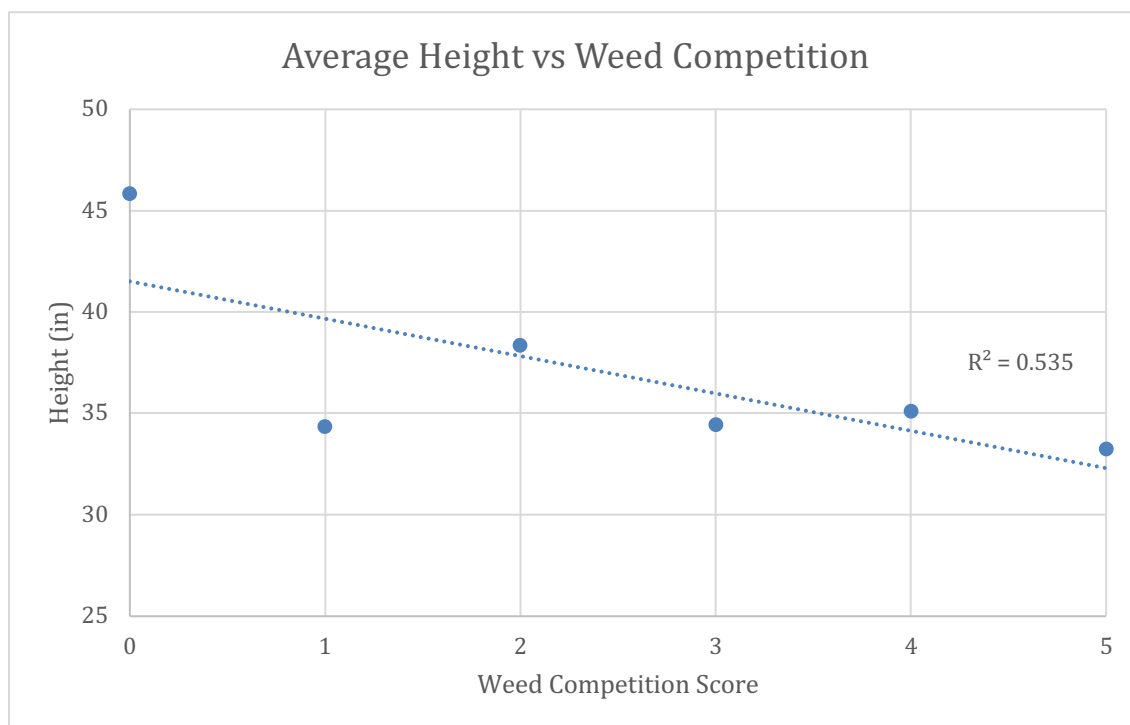


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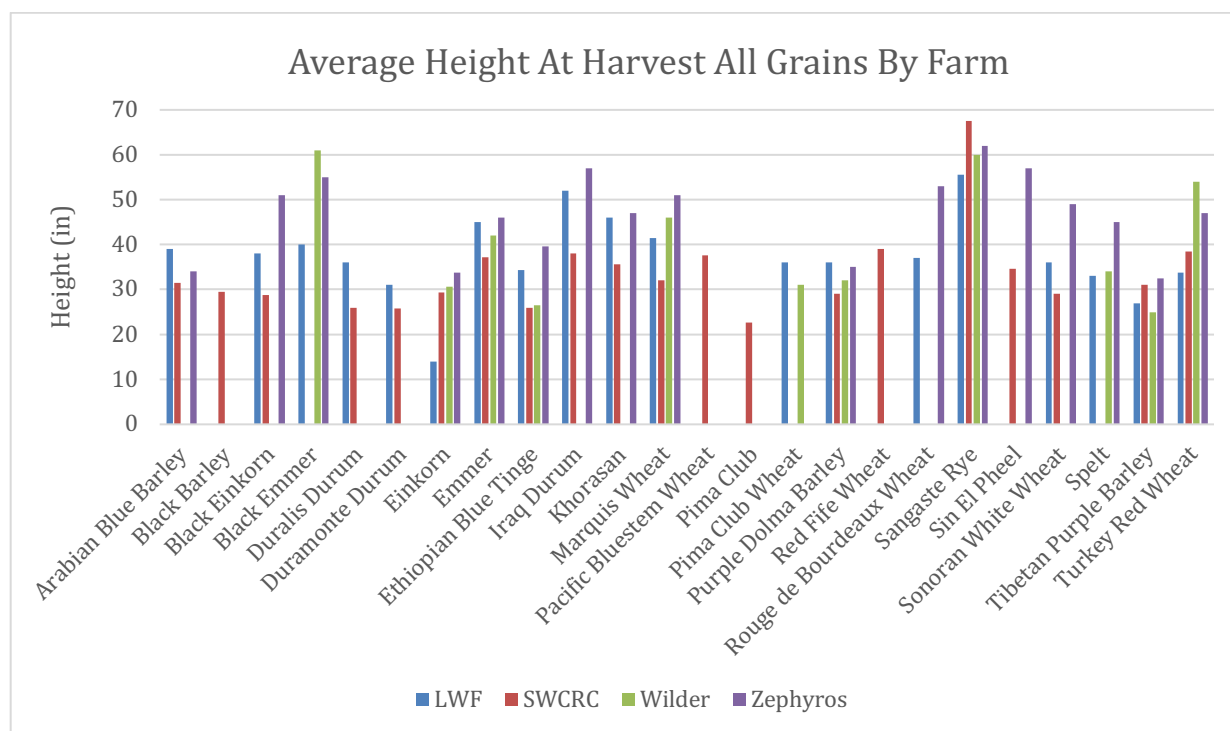
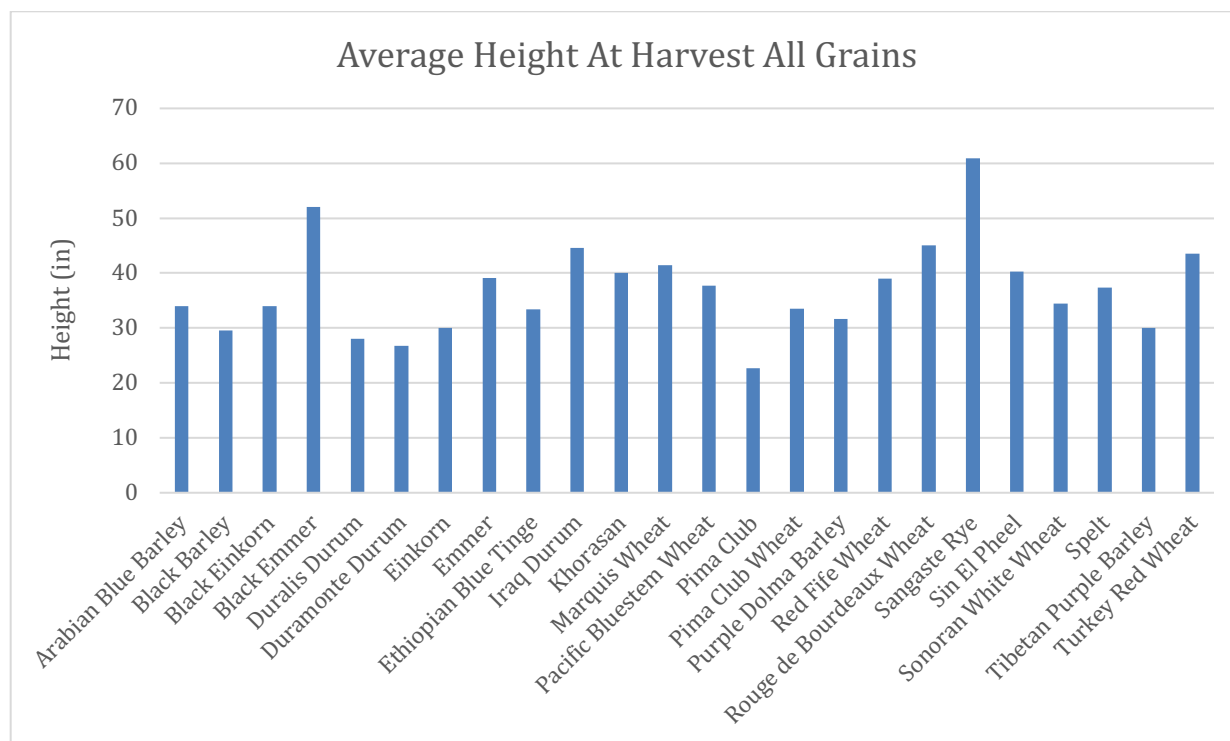
Average yield strongly correlated with weed competition; 5=crop failure from weeds.



Moderate correlation between height and weed competition; tallest grains have no weed competition (further data needed to assess causation).

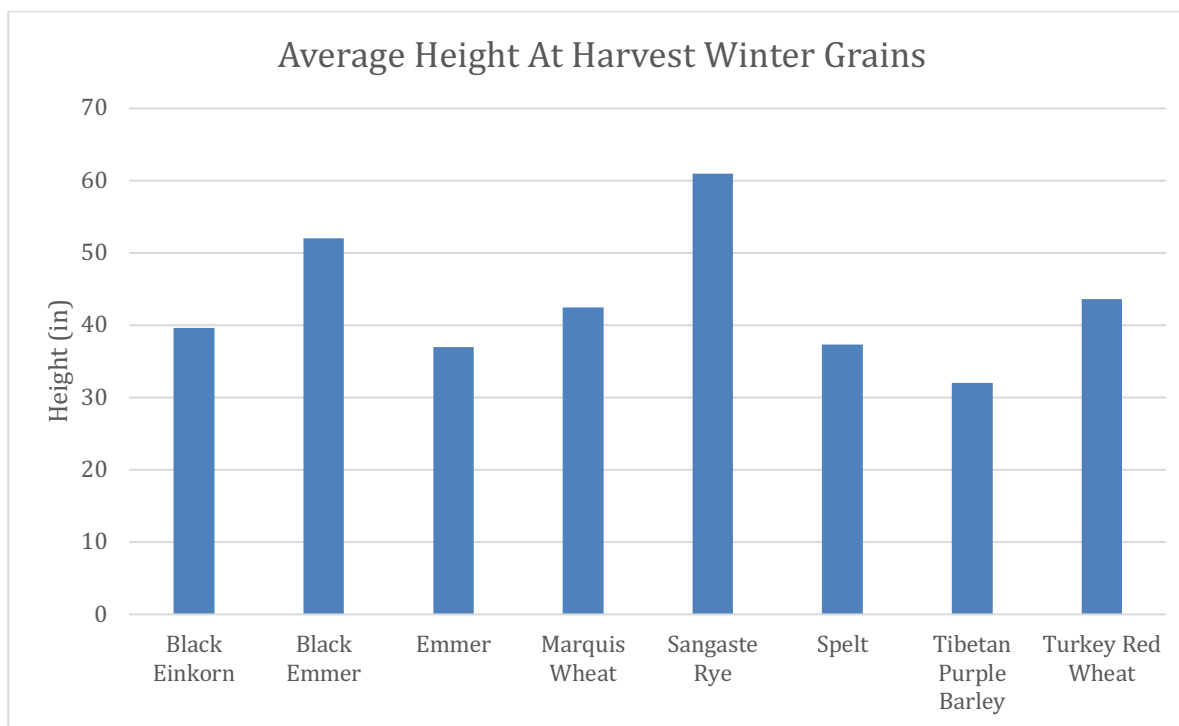
Height and Lodging

Height is a key consideration for mechanical cultivation, harvest, and potential lodging, though was not necessarily a factor in lodging during this project.

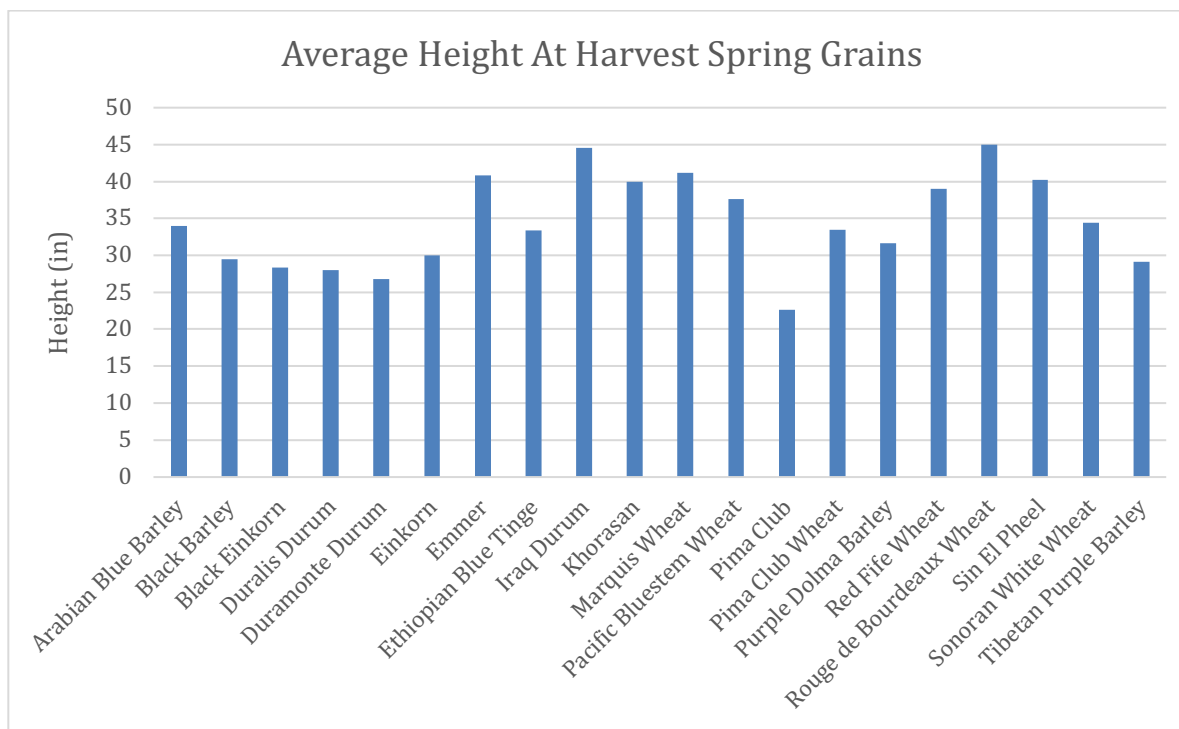


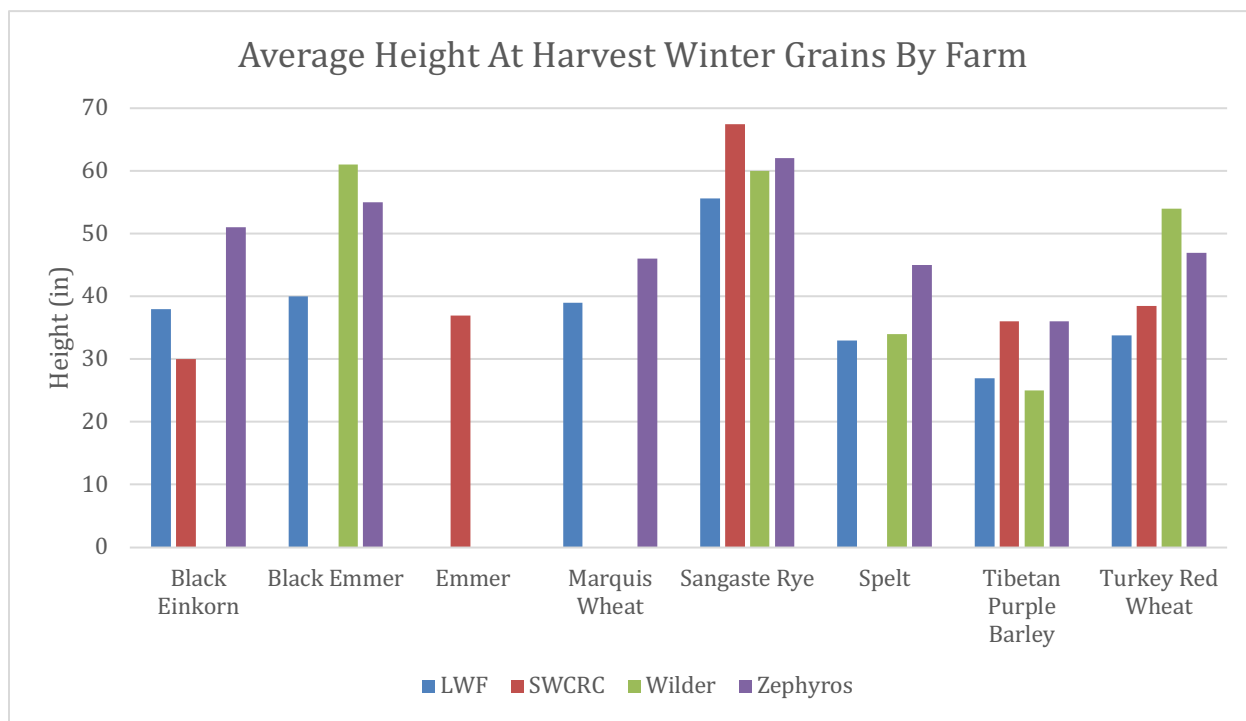
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Height between farms statistically different ($p=0.0015$). Zephyros statistically taller than LWF ($p=0.004$) and SWCRC ($p=0.0001$). Need more data to understand including irrigation times and amounts, soil health and composition, crop rotations and farm practices, etc.

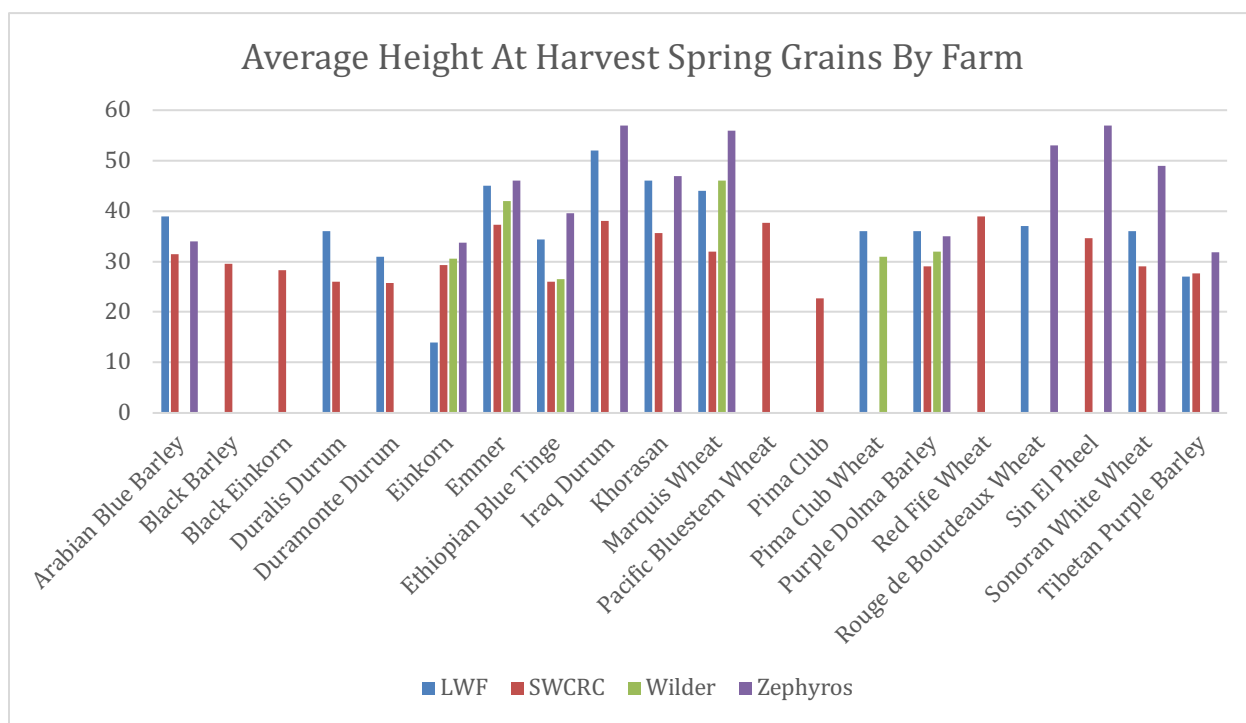


Sangaste rye on average is over 60 inches tall, with a max height reported of 70 inches.

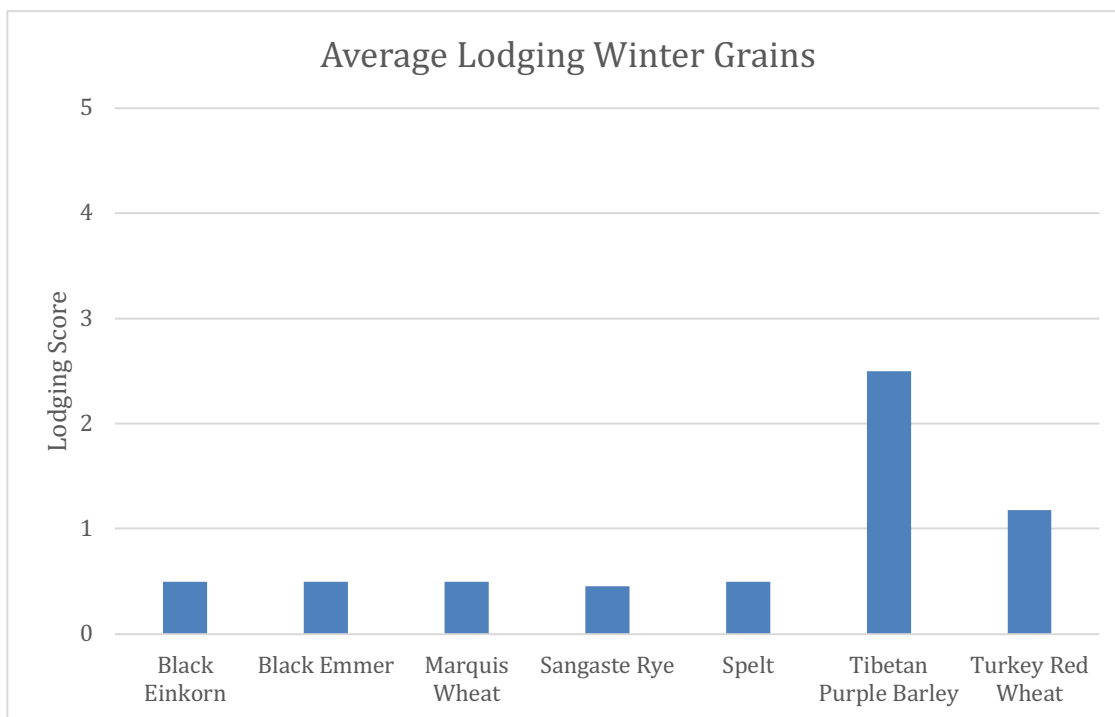




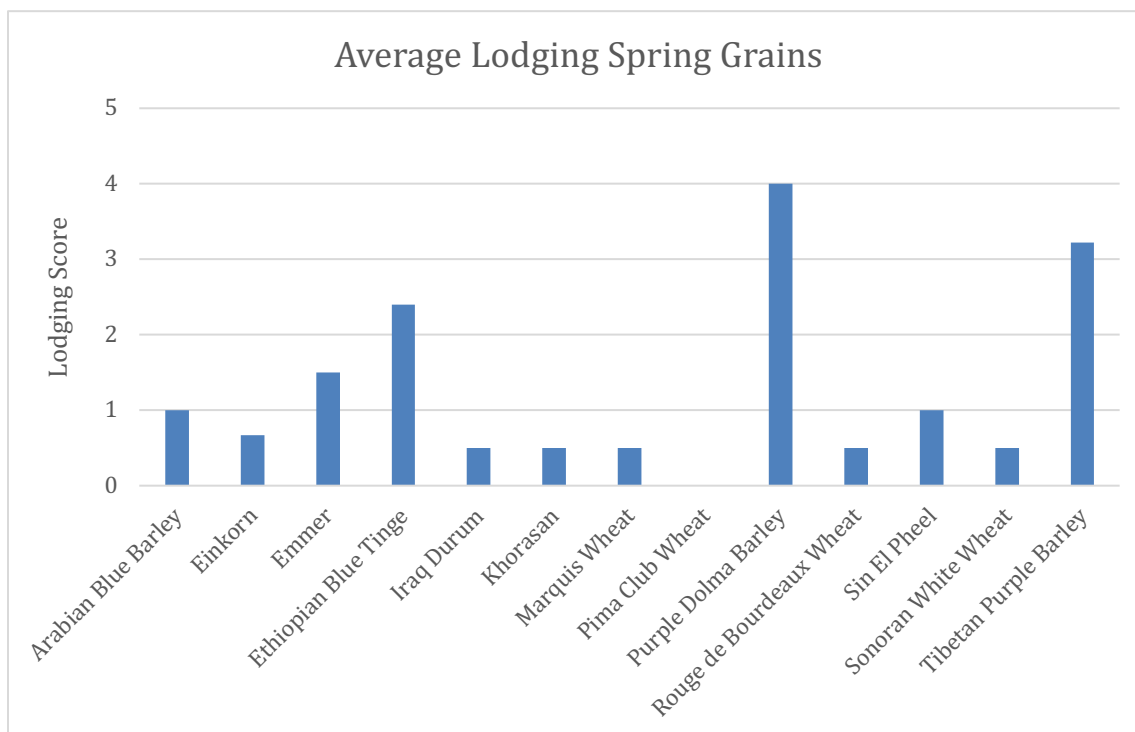
Sangaste rye tallest variety at all farms with no lodging issues.



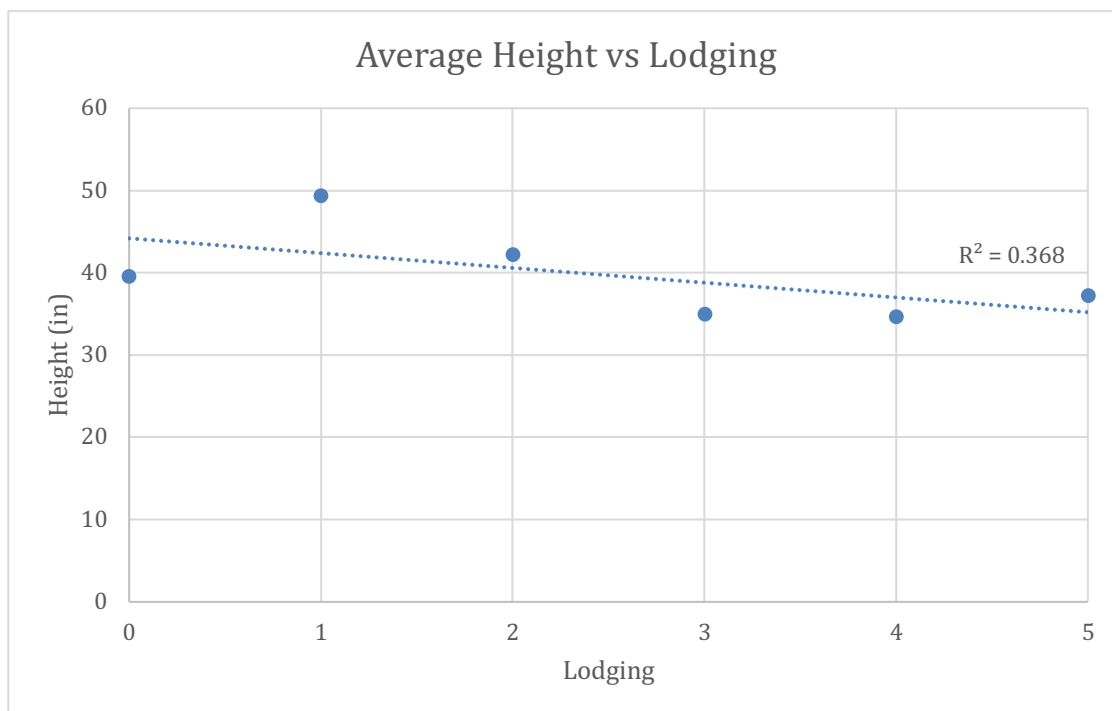
Height was not the primary factor in lodging at Zephyros where the tallest grain, Sangaste rye, remained upright after a storm devastated the field on June 25th, within weeks of harvest. Many of the grains lodged including top performers at other sites.



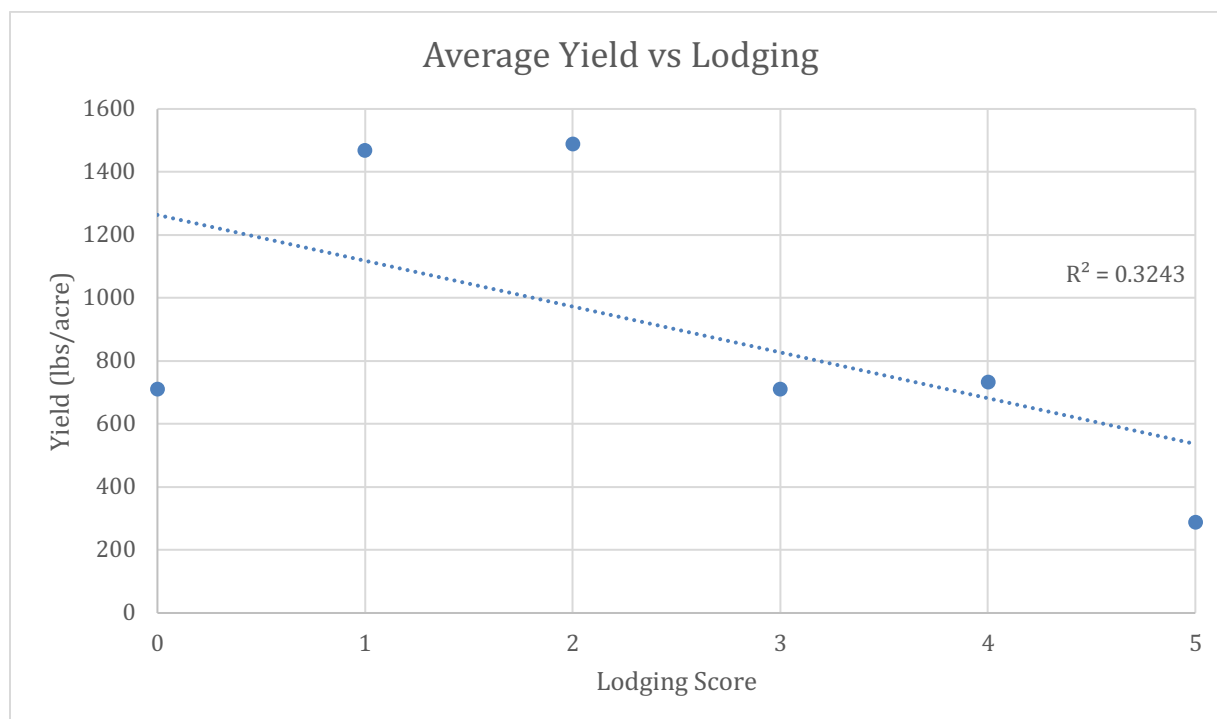
Winter grains appear to have less lodging than spring grains.



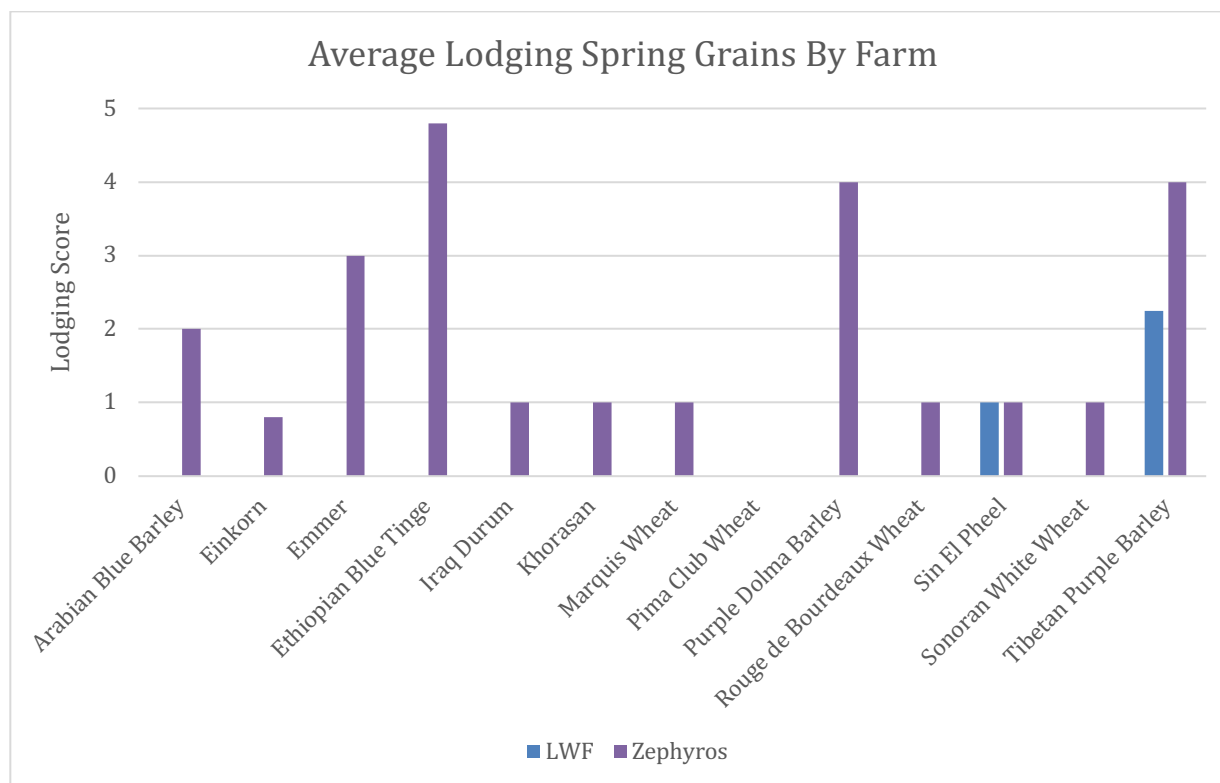
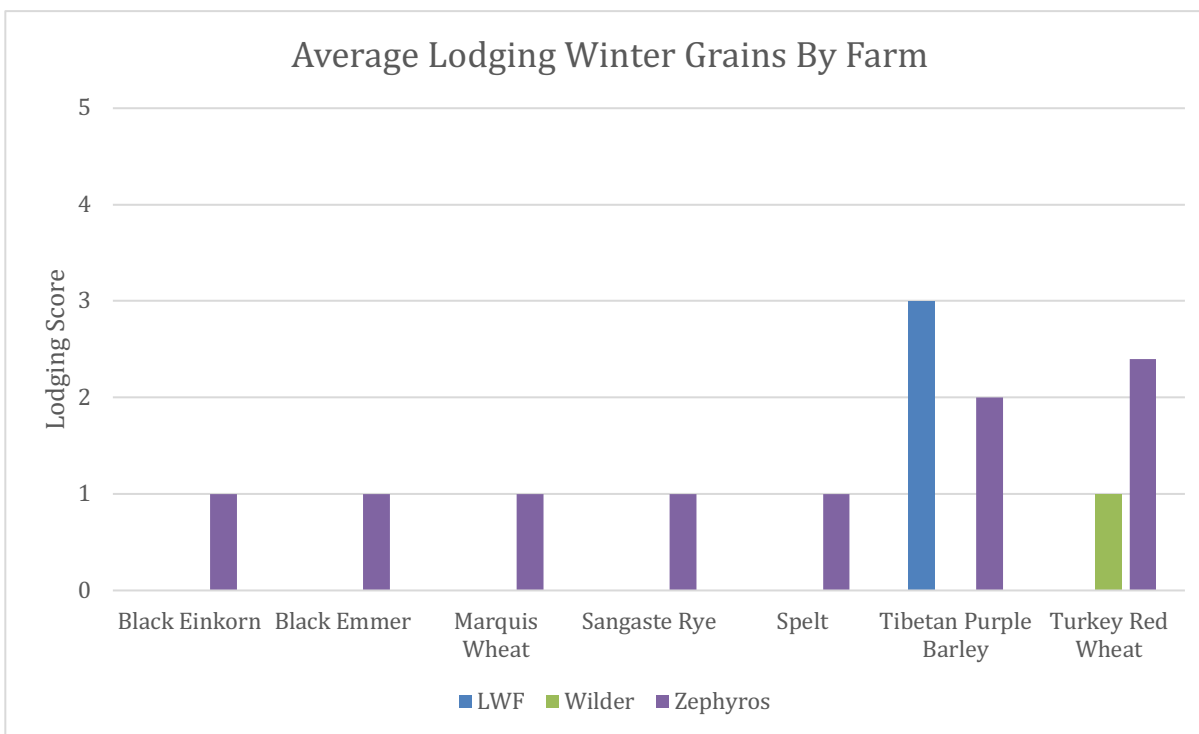
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Average yield and average height weakly correlated with lodging.

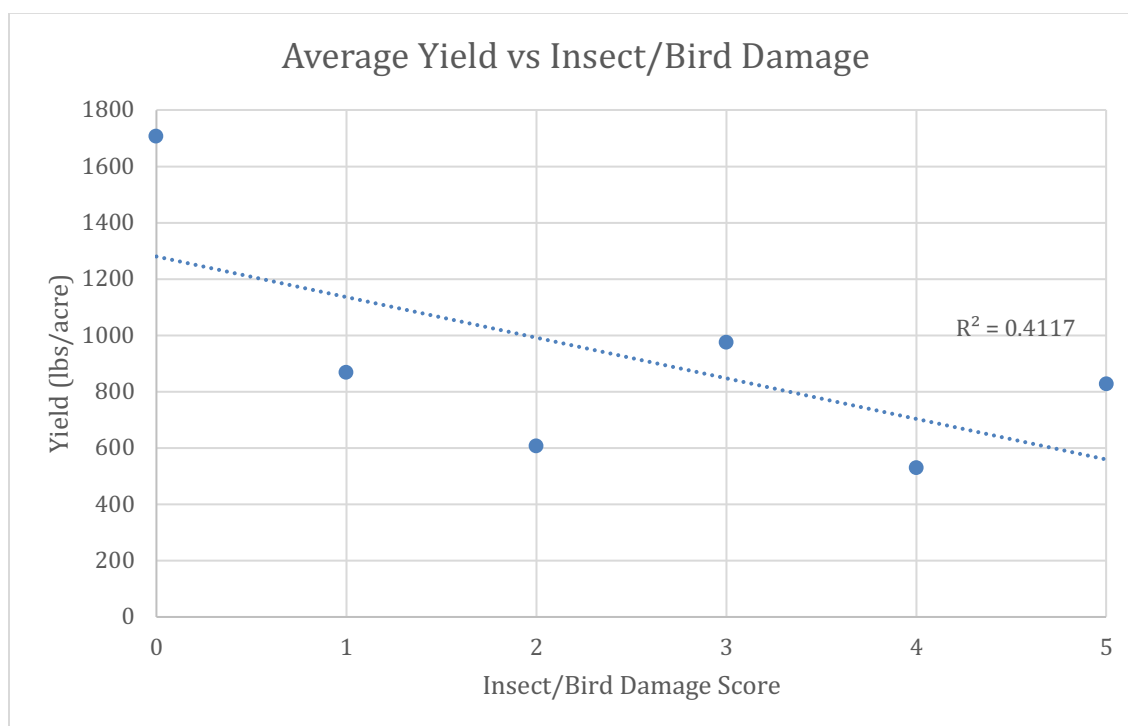


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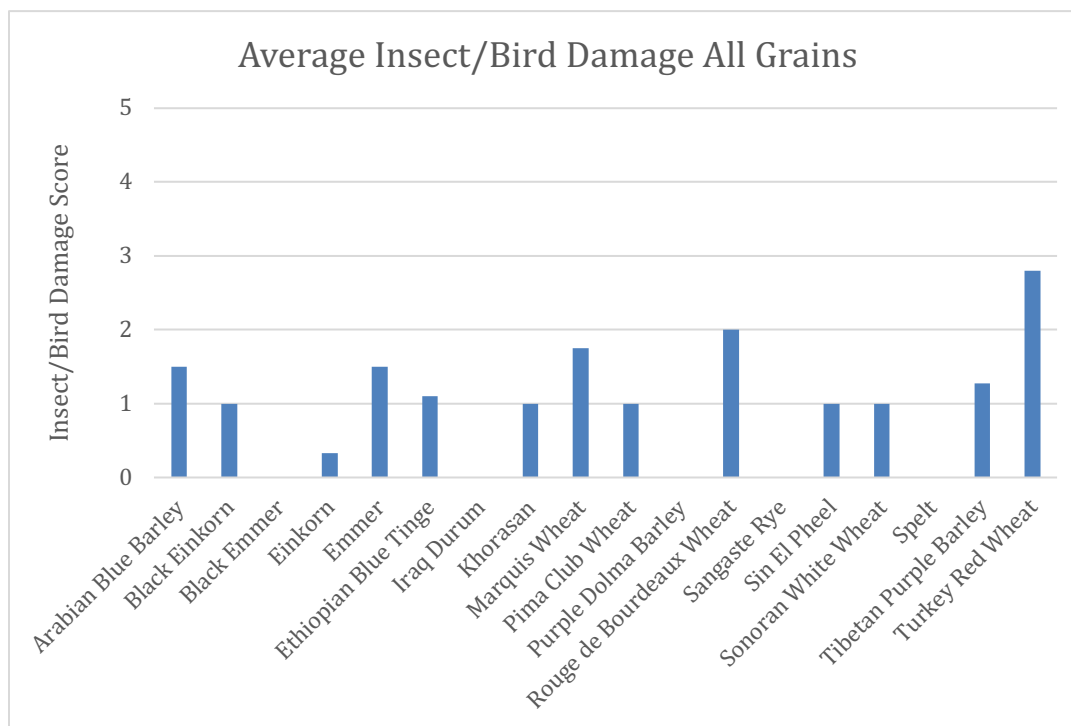


Pest Pressures

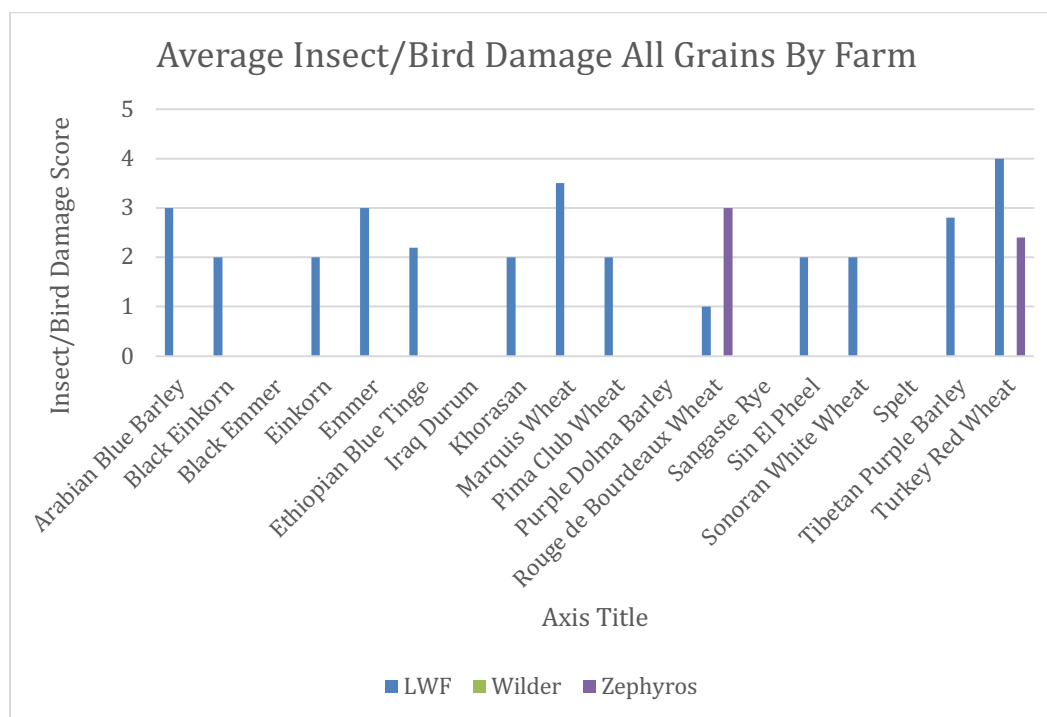
Pest pressures of greatest interest in both the grassroots and research trials are from birds, grasshoppers, squirrels and rabbits. Pest pressures were minimal at the Zephyros Farm in Paonia, Colorado and at King's Crown Farm in Idaho, however grasshoppers have been an increasingly destructive factor at Laughing Wolf Farm in Mancos, Colorado to the point of crop failures. Farmers in that area are moving or changing crop foci because of the grasshopper devastation to crops. Southwest Colorado Research Center had impacts from squirrels, however that has not been tracked in this data. No correlation between height and insect/bird damage was evident in the data. The average yield weakly correlated with insect/bird damage.

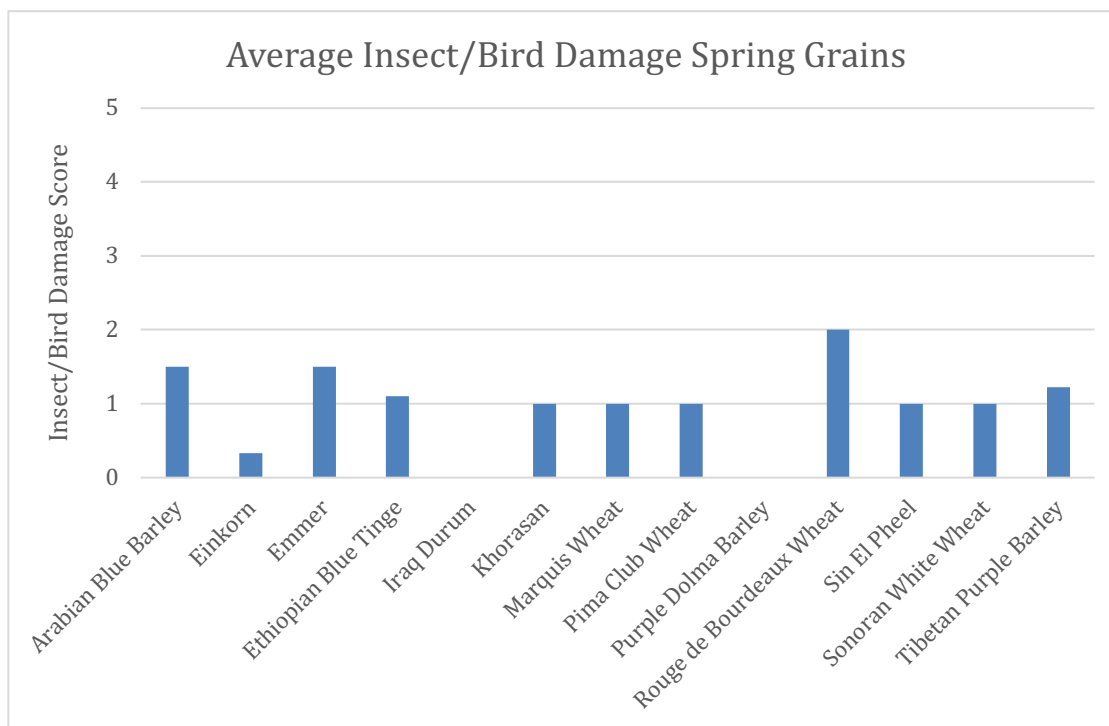


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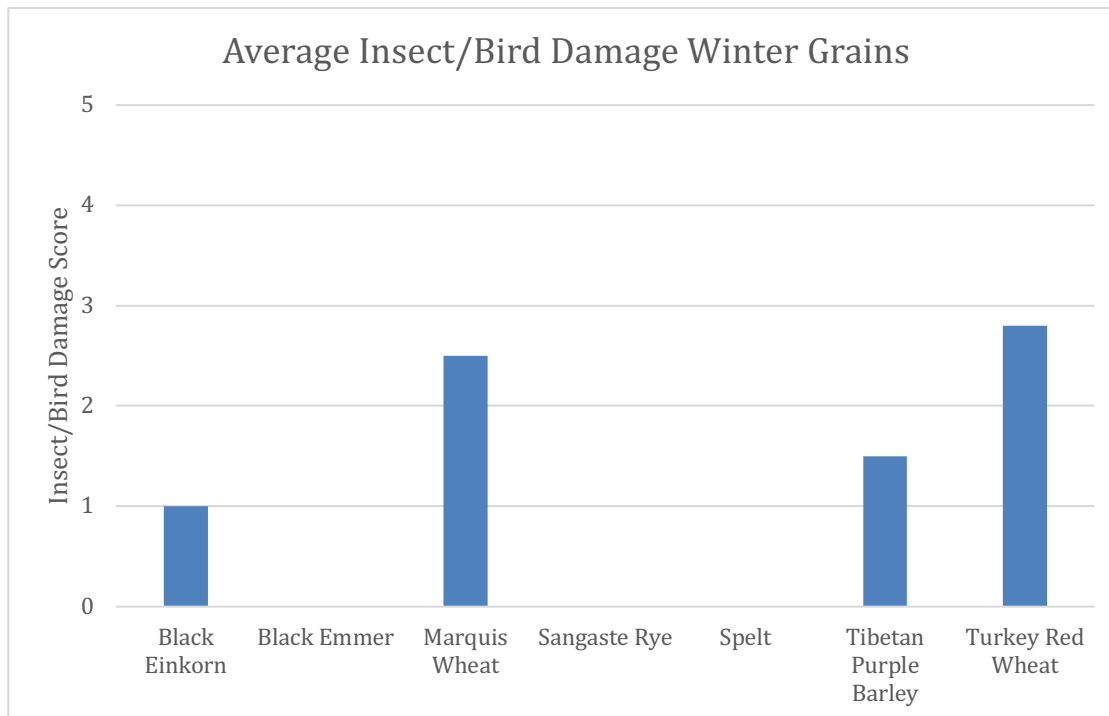


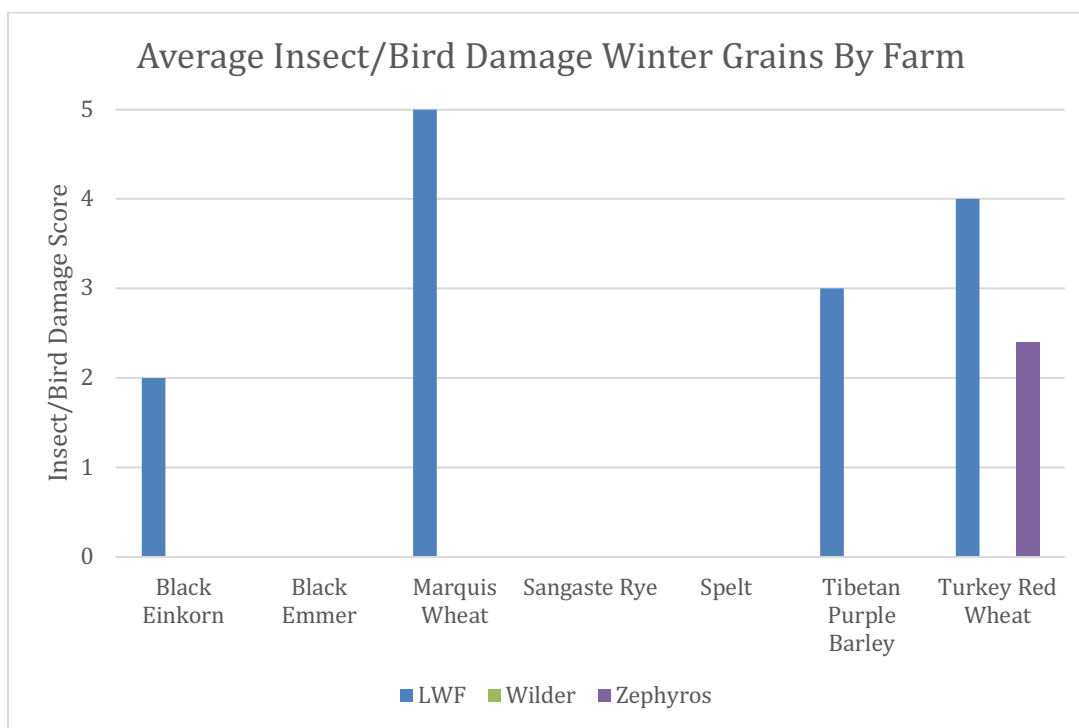
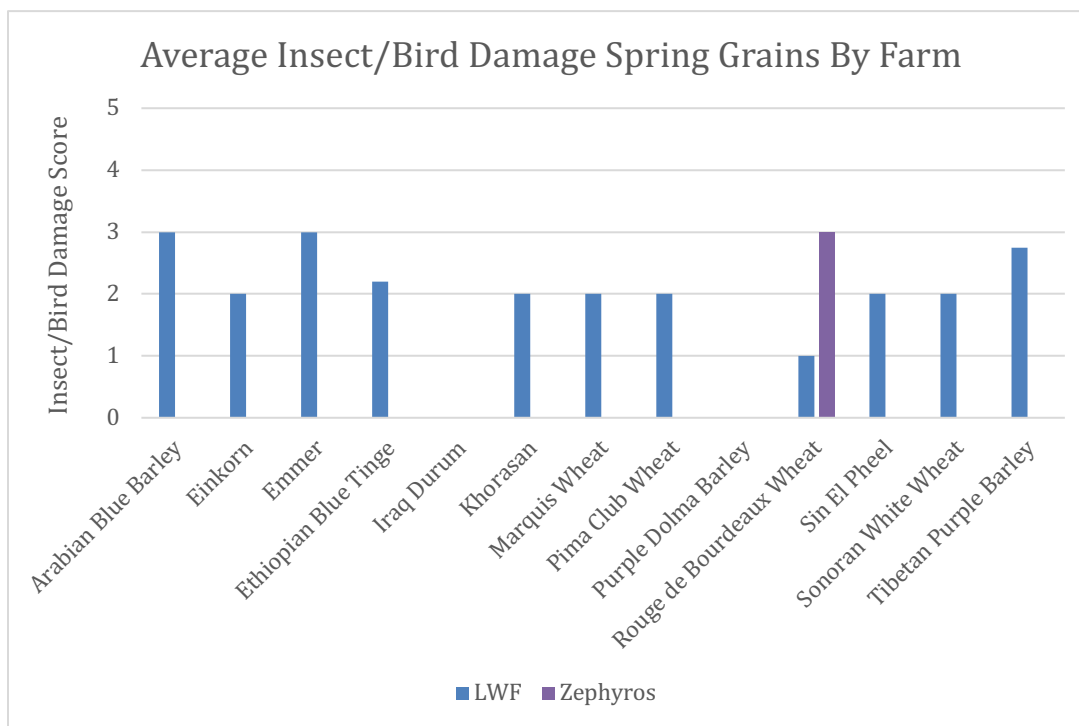
Further studies are needed on pest impacts re: awned vs. awnless varieties.





Marquis and Turkey Red winter grains had highest average insect/bird damage; Turkey Red has awns and Marquis is predominantly awnless. Both are hard red wheats.





Disease

With the drier climate and primarily ground level irrigation practices with the grains, disease pressures in Colorado have thus far been non-existent. In Idaho, overhead watering was employed and the durum varieties including Iraq Durum, Sin El Pheel, Khorasan, and Ethiopian

Blue-Tinged¹ exhibited signs of mold and shriveled grains. These varieties were not harvested at the Idaho site.

Climate Conditions

More data is warranted on climate conditions including temperature ranges and precipitation (both rainfall and snowpack). For fall planted grains that have the recommended plant growth of 3-5 inches prior to dormancy, cold temperatures can induce “winter kill,” particularly if the plants are exposed rather than under a layer of snow that provides insulation and protection. Temperature data during flowering time (May through July, depending on the variety) is valuable for assessing if pollination is compromised in higher or lower temperatures. “Blank heads” are grain heads that do not produce grain, which can be a result of freeze damage during a very specific time of grain formation. More studies on climate and temperature impacts are warranted.

Challenges

The farmers involved in the project were also market farmers with little time available for data tracking and cultivating the grains. Trial plots were located in fields away from the primary focus of their work. The project was designed to be integrated into polycropping market farming practices, and the participating farmers were encouraged to grow and cultivate the grains as they would in their usual systems. However, the grains were lower on the priority list for the daily tasks. One farmer shared that it was hard to prioritize harvesting the grain when they needed to harvest the tomatoes at that same time, which are one of their primary cash crops. In short, participating farmers indicated that the trial plots were neglected. Weed competition and impacts were significant, and some varieties were completely overtaken by the weeds, as illustrated in the data analysis. The lodging at Zephyros Farm in Paonia, Colorado was a significant issue that was devastating to the trials and the morale. While weeds and lodging were challenging, this was helpful information as the varieties that handled the impacts best are likely the better candidates for commercial organic growing. Following is a reflection on the project from Zephyros Farm:

As a small-scale market farm, with little extra resources to dedicate to trials, it became apparent that executing such a trial to the best of our ability is more than we have resources for at the moment. We were hugely lucky to borrow a small combine from our local research station. This was an enormous help as we were harvesting the grains at the height of our Farmer’s Market season, which is full of every task imaginable on the farm. The combine saved us many hours of threshing. We still harvested the heads by hand, but were able to hand feed the combine. For a farm that is not set up to harvest/clean grain, and has lots of other moving parts at that time of year I think we did as well as we could have!

Summary

In summary, best candidates for weed competition were related to taller heights. Highest yields were related to lower weed competition and were winter-planted varieties:

¹ At the time of the final writing of this report, we have been alerted that Ethiopian Blue-Tinged is not technically an emmer, rather the taxonomy suggests it is tetraploid and free threshing, hence a durum (*Triticum turgidum* ssp. durum). We are in the process of updating our data and information accordingly.

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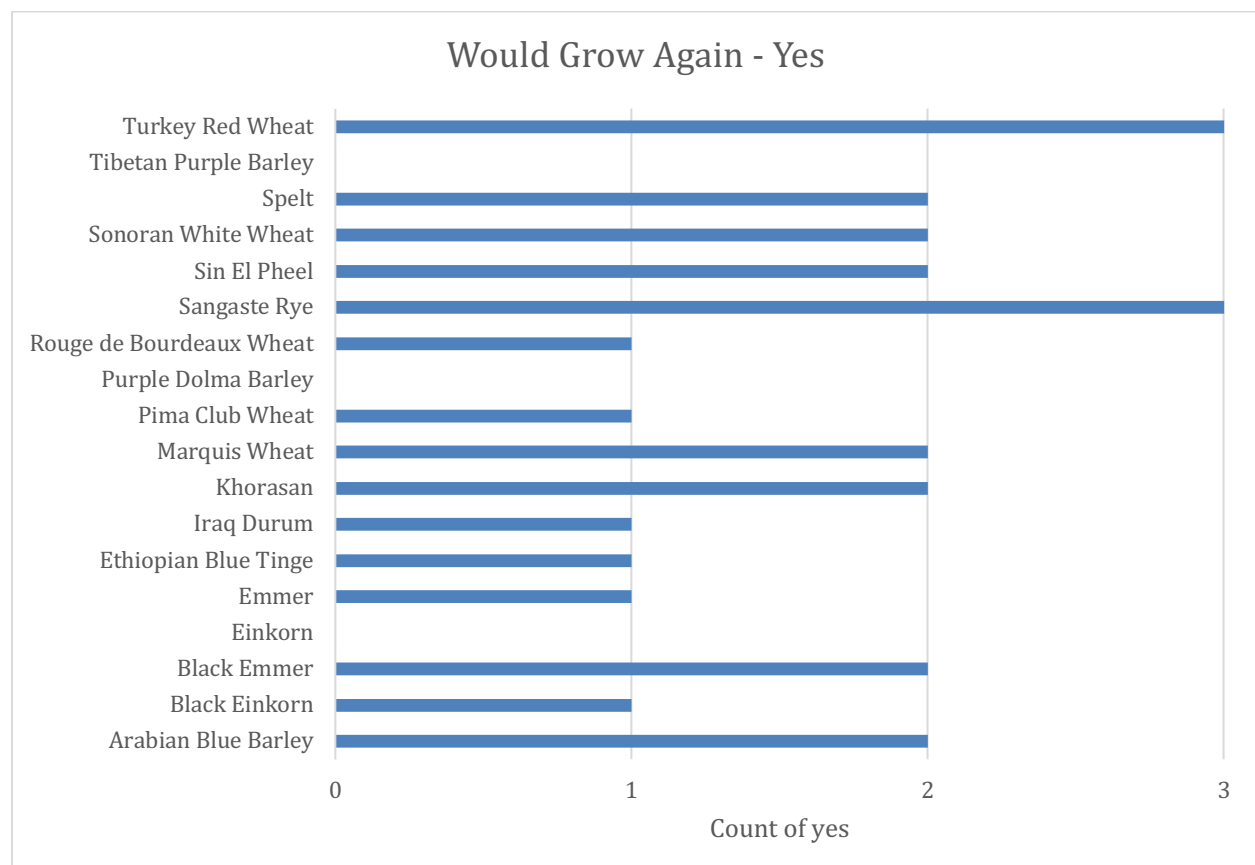
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1. Sangaste rye: Quick growth with top height range of 52-69 inches, along with potential allelopathic traits make this variety a top performer. Fairly easy to clean; favored by sourdough bakers who are looking for local rye sources.
2. Black emmer: Tall and vigorous with a height range of 40-44 inches in Colorado to 61 inches in Idaho, with thick stalks and abundant tillers that help shade out weeds. This is a hulled variety that requires dehulling equipment for processing, which is costly.
3. Spelt: Favored for lower gluten content and flavor, and with high yields, spelt is popular in the field and in the kitchen, though also requires dehulling equipment for processing.
4. Turkey Red: This hard red winter wheat adapts well in situ and has a long-standing reputation for flavor as well as field and kitchen performance.

Varying results:

1. Turkey Red Winter Wheat was a top performer in Idaho and also performed well at Zephyros Farm, though a poor performer in Southwest Colorado with birds and grasshoppers impacting the crop early.
2. Both Einkorn varieties performed well in Idaho despite late germination and maturation, though did not perform well in Colorado because of weed and pest competition with the later growth.

The following chart shows the feedback from farmers regarding varieties that they would grow again, however results are slightly skewed since one farm only provided partial answers for top 2 (Turkey Red Wheat and Sangaste).



While einkorn has increasing market popularity, the yields are lower and the weed competition is significant which impacts the organic marketability unless mechanical cultivation practices are employed. Spelt was the most productive of the ancient hulled varieties, though requires dehulling equipment, as does the Black Emmer that also produced and performed well.

Supplemental Research

SeedLinked Trials: 21 participants received samples of the following varieties of grains and were invited to share data and photos via a field app. In the wheat categories, participants received a randomized selection of three varieties, and in the barley category, participants received each variety to trial.

Heritage Wheat:

1. Jamu (new trial variety)
2. Marquis Wheat
3. Pima Club Wheat
4. Red Fife Wheat
5. Sonoran White Wheat

Ancient Wheat:

1. Einkorn
2. Emmer
3. Ethiopian Blue-Tinged
4. Iraq Durum
5. Khorasan
6. Sin El Pheel

Hulless Barley:

1. Arabian Blue
2. Excelsior
3. Purple Dolma
4. Tibetan Purple

While we did reach our target goal of 20 participants in the SeedLinked trials, few participants reported results, and no photos were uploaded to the platform. The data that was shared did reflect the overall results in the farmer trials. Generally, data collection in participatory trials is difficult to achieve without a dedicated staff position to conduct individual outreach.

c. Potential Impact

The impacts of this study on organic farming and the related market value of heritage and ancient grains are substantive and ongoing. Top performers have been identified in relation to locations based on yield, ability to compete with weeds and pests, and with observations on potential mildew/diseases. In general, the arid West offers a favorable climate for growing heritage grains. The field research conducted in this project, and partnered with the lab analyses on grain quality and baking performance, as funded through additional grants during this project and collated with this field research in the forthcoming *Heritage Grain Guidebook*, will offer a comprehensive portrait of the potential of each of the “Top 20” varieties from field to plate. Further, the goal of growing 20 pounds of each variety of grains for foundational stock was achieved. Further scaling up of these grains to support the reintroduction of these varieties to local and regional markets is still needed. We are currently conducting seeding rate analyses at 10, 40, and 80 lbs./acre on several of the varieties including Durum, Emmer, Khorasan, Marquis and Sonoran White, to assess best practices and best planting rates for commercial endeavors.

(2) **Financials** (see attached spreadsheet)

As mentioned, we are rolling this project into a larger *Heritage Grain Guidebook* project that will be available in the Fall of 2022 with additional data analysis from our research partners from Colorado State University, and further supported by Western SARE and UNFI. The *Heritage Grain Guidebook* will include baking analyses from pup loaf tests and data on protein, gluten content, falling number, and stalk nitrogen analyses for the Top 20 varieties in this research. We will include maps of sites where varieties have been grown, and profiles of participating farmers and grain varieties. Handbook compilation, graphic design and printing costs are ongoing, though OFRF funding has been used in full. The final version will be sent to OFRF once complete and OFRF will be credited in the handbook for your support of this dynamic project.

(3) Photos

Complete files of height data are available for the three participating farms and available on request. Attached here are samples from the participating farms, including the Southwest Colorado Research Center, and the field days at each farm.

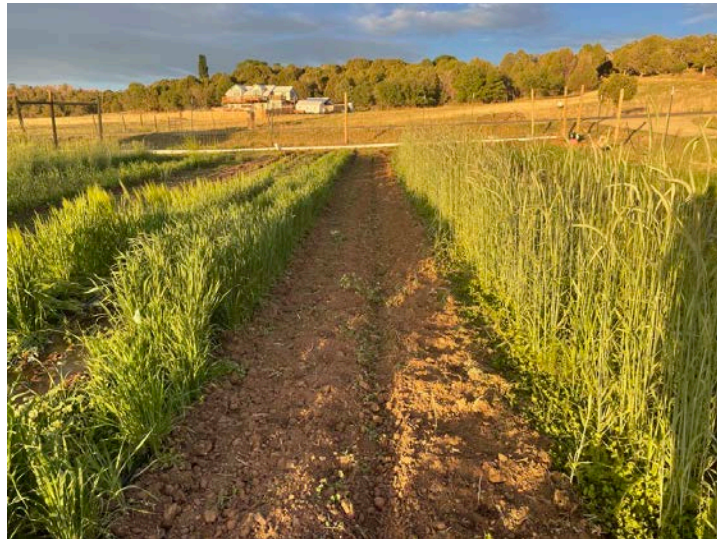


Figure 1: Winter grains at Laughing Wolf Farm (LWF); Mancos, CO June 9, 2021



Figure 2: LWF height measurements; June 29, 2021



Figure 3: Southwest Colorado Research Center (SWCRC); Yellowjacket, CO June 24, 2021



Figure 4: SWCRC Winter Trial Plots; June 24, 2021



Figure 5: Sin El Pheel; LWF July 26, 2021



Figure 6: Black einkorn; LWF, July 26, 2021



Figure 7: SWCRC Trials; July 26, 2021



Figure 8: SWCRC Grain Day; July 27, 2021



Figure 9: Zephyros Farm Winter Trials; Paonia, CO May 4, 2021



Figure 10: Zephyros Farm winter trials; June 23, 2021



Figure 11: Pedal threshing demo at Zephyros Farm Grain Day in Paonia, CO August 4, 2021



Figure 12: Mountain Oven Heritage Grain Baking Presentation at Zephyros Farm Field Day in Paonia, CO; August 4, 201

Rocky Mountain Seed Alliance
20 to 20 in 2020



Figure 13: Grain Day at Laughing Wolf Farm in Mancos, CO; August 12, 2021



Figure 14: Grain Day at King's Crown Farm; Glenn's Ferry, ID Sept. 9, 2021



Figure 15: King's Crown Farm; Glenn's Ferry, ID Sept. 9, 2021



Figure 16: King's Crown Grain Trials; Glenn's Ferry, ID Sept. 9, 2021