Kernza® varieties of Intermediate wheatgrass for Forage Production in Western Colorado

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Introduction.

The following publication was developed based on data from the "Intermountain Western Alternative Forages Phase I Project". This project was a collaborative effort among a number of organizations and stakeholders to explore the viability of two species, sainfoin (*Onobrychis viciifolia*) and Kernza® varieties of Intermediate wheatgrass (*Thinopyrum intermedium*) (IWG), as alternative forages in different growing regions of western Colorado. These regions represented three different climatic conditions for agricultural production in Colorado.. The regions include the following: 1. Kremmling and Steamboat mountain meadows. 2. The desert valleys from Grand Junction extending south to Olathe and Montrose. 3. The high plateaus surrounding Cortez in SW Colorado. Yield, quality, and water use efficiency were evaluated during this research trial.

Kernza varieties of IWG have been bred for increased grain size. IWG is a cool-season perennial grass used for forage production, as a conservation grass, and for grain production, marketed as Kernza ® perennial grain.

This grass was introduced from Eurasia and can thrive on limited water. As IWG has been bred as Kernza and for grain production, plant size has increased as the energy demands in the plant for large grain have also increased. This results in a variety with dual use: forage and grain production. This crop has been shown to be widely adaptable to a range of climates. The variability in the growing regions throughout western Colorado and the intermountain region makes this crop ideal for the area.

Kernza Varieties Used

Except for TLI C5, all varieties used are synthetics derived from 5-10 parents chosen out of breeding cycles from programs at The Land Institute (TLI) in Salina, KS or the University of Minnesota (UMN). TLI C5 is bulk seed from breeding populations.

TLI C5 or "Cycle 5" is the first commercially available cultivar and was the dominant cultivar tested in western CO.

TLI 701 Good performance in drought conditions.

TLI 703 High # of rhizomes compared to 704. Good performance in drought conditions.

TLI 704 Drought sensitive. Recommended for wet or irrigated conditions,

MN-Clearwater does best under cold, wet spring soils and high precipitation.

Site Selection

Kernza prefers a clean, fine-textured seedbed for good germination that does better in well-drained soils. As a cool season grass, Kernza will thrive in regions where other grasses are grown.

Kernza can grow at elevations ranging from 3,500 to over 9,000 feet. It can tolerate as little as 12 inches of precipitation per year but thrives with more irrigation. The pH of the field can be from 5.5 to 8.4. Fields with high amounts of grass weeds (especially winter annuals and perennials) should have those weed issues addressed prior to planting. Herbicides for Kernza generally target broadleafs.

Establishment

Proper establishment is critical for success. If weed pressure has historically been an issue in your fields, consider addressing weeds before planting. This is especially true of any perennial weeds in the field. Once established, these crops can compete with weeds much better than during the ealy stages of establishment.

Spring or fall is the ideal time to plant Kernza. Fall plantings have lower weed pressure than spring plantings. This is because planting in the fall allows seedlings to establish and compete more effectively

with quick-growing winter annuals in spring. However, successful establishment can be achieved with either spring or fall planting. Plant as close to the last frost date in the spring as possible. For the fall, plant at least 6 weeks before the first frost to allow for proper establishment.

Drawbacks to spring plantings can include greater weed competition and late-season freezes that can kill seedlings. Drawbacks to fall plantings can include early freezes and winter survival of small seedlings.

In the mountain regions, we had success with dormant or frost seeding. This involves planting the seed in the late fall, ideally before the first major snowfall. The seed will sit in the soil throughout the winter as it is too cold for germination. In the spring, the soil will begin to warm, allowing the seeds to germinate.

The advantage of this strategy is allowing the seed to germinate as soon as possible, giving the crop a head start in the spring. Typically, the snow must melt, and the soil must dry enough for equipment to get into the field. A dormant seeding strategy eliminates this waiting and allows the crop to utilize more of the available winter moisture.

Understanding your region, climate, and fields will help determine the best strategy for establishing Kernza. Follow cool-season grass guidelines if none are available for Kernza in your region.

Kernza should be planted at 10 to 12 pounds per acre (20-24 pure live seed per square foot), at a depth of ¼ to ¾ inch, depending on soil texture. For sandier soils, plant deeper; for heavier soils, shallower.

Kernza can also be broadcast-seeded and then dragged or harrowed to incorporate it and ensure good seed-to-soil contact. If using this strategy, increase the seeding rate by 50% to 100% and ensure good soil coverage of the seeds.

Avoid soils prone to high crusting, or be prepared to manage crusting during the establishment phase. Tools like the rotary hoe or a light irrigator can often reduce crusting. Ideally, use a rotary hoe only when necessary, as this can kill some of the seedlings as it breaks the soil crust. This is one of the most challenging aspects of growing Kernza, as the seedlings can struggle to break through a hard soil crust.

Watch for quick-growing annual weeds. A well-timed mowing to knock back weeds before the crop has gotten too tall can be beneficial. If using herbicides for early-season weed control, be sure to follow the label and ensure the Kernza plants are large enough to receive an application. These herbicides will target broadleaf weeds, so different methods will be needed for weedy grasses.

Another approach for controlling weeds is the “stale seedbed” method. This involves irrigating the field at least once prior to planting. Though this can be done multiple times. By irrigating the field, many of the weeds will germinate and begin to grow. These weeds are then terminated with light tillage or herbicide. Do not till too deeply or weed seeds from deeper depths can be brought to the surface. This method reduces the weed seed bank before planting and the weeds that germinate during the first irrigation of your crop.

A combination of weed control methods tends to produce the best results.

Irrigation

Kernza varieties of IWG prefer loamier, well-drained soils with a minimum of 12 inches of water (NRCS). However, the crops will respond to more frequent water applications and, in years with high water availability, should yield well.

Short periods of high water are manageable but extensive periods of standing water can damage crops and reduce production. Kernza may be killed by “wet feet” or high water tables.

The most critical time to irrigate is following harvests or cuttings and during spring as things begin to green up. While these crops have a minimum water requirement during the season, they can also respond positively to additional irrigation during heavy precipitation years or when more irrigation water is available, providing flexibility.

In a furrow or flood system, depending on the heat and timing of the year, irrigation should likely be conducted every 10 to 14 days, if water is available.

With sprinkler and more precise irrigation systems, aim to put down an inch of water every 3 to 5 days, depending on the time of year and available water. Evapotranspiration values are forthcoming and will enable precise water-use tracking and improve irrigation efficiency.

Fertilization

Kernza is a great nitrogen scavenger thanks to its extensive root system. Soil test values of N should be between 70 to 90 lbs/acre (35-45 ppm) of N. It is recommended to take a maintenance approach and replace N each year as it is removed. High levels of nitrogen can cause lodging. Recommended phosphorus levels are at least 42 lbs/acre (21 ppm). Potassium requirements are 240 lbs/acre (120 ppm).

Management

Properly managing for balancing forage productivity with stand longevity is critical. Allowing adequate rest periods between cuttings and irrigating at critical times are important. Kernza needs to be managed differently according to variety, climate, growing/field conditions, soil fertility, and other factors.

Kernza can be managed similarly to many other cool-season grasses when grown for forage. Typically,

the best growth is in the spring, followed by the fall. Kernza will experience a summer slump if temperatures are high, with reduced growth during the hottest periods of summer.

The first cutting typically produces the most biomass. Cutting at early heading is the best way to maximize quality, while cutting at soft dough is the best way to balance yield and quality together.

Kernza needs adequate time to regrow after a cutting. Depending on the growing conditions and water availability, we recommend at least 6 weeks.

Kernza will only produce a seed head once per season; subsequent cuttings will be vegetative growth only. These cuts are typically higher-quality but lower-yielding.

Kernza can be grazed. Care should be taken not to overgraze or intensively graze this crop. Kernza should be given adequate rest time following grazing to replenish root reserves. This grass can be grazed exclusively or grazed in the fall following hay cuttings, or in the spring as things green up. If grazing exclusively, follow the "take half, leave half rule."

Rest time between cutting and entering winter is key to stand longevity and proper management. Plan four to six weeks of rest before the first killing frost.

Weed and Pest Issues

Consider addressing weed issues before planting for the best results. Especially if there is a history of grassy weeds or established perennials in a field. A properly integrated pest management system can aid in better establishment and overall stand health. Herbicides are somewhat limited compared with those used for more widely cultivated species.

For Kernza, if there are common diseases or pests in your area for cool-season grasses, monitor the plants for any issues. As a perennial crop, it takes time to establish properly and build a robust root system. This means that weed management is key during this first season.

Try to control grass weeds in any Kernza fields before planting, especially winter annuals and perennials. During the first stages of establishment, a well-timed mowing can knock back quick-growing weeds while leaving the undercanopy unharmed. This can give Kernza a competitive edge and allow it to grow above the weeds. Utilizing multiple weed control methods will provide the best results.

Herbicide options for Kernza:

If grown only for forage production, any herbicide used on IWG is approved for Kernza varieties. Typically 2,4 D products and MCPA products. There are some Clopyralid options that can be used on cool season grasses as well.

If grown for grain, only Weedar 64 and Curtail M are labeled for use. Make sure to read and follow anything printed on the label when using herbicides. There are restrictions on timing and the amount of applications when using herbicides on Kernza.

Yield and Quality Results (Preliminary)

Our research locations were two research stations with variety trials for Kernza and 5-acre plots of Kernza at six accompanying farms and ranches. TLI C5 was used for the on-farm trials.

Yield- Variety trials (Research Stations)

Variety trials were set up in a randomized complete block design, with three replicates and an alfalfa control. The plots at the Western Colorado Research Center (WCRC) in Fruita, CO were irrigated with both sprinkler and a drip system. At the Southwestern Colorado Research Center (SCRC) in Yellowjacket, CO the plots were irrigated with center pivot sprinkler irrigation. Each field was managed as closely as possible according to the best management practices described above. Any special management will be noted below.

We conducted a one-way analysis of variance (ANOVA) to compare the average yield and quality of Kernza with the alfalfa control. If the ANOVA revealed a significant difference in yield or quality among at least two groups, we used Tukey's post hoc analysis to compare the treatments. $P<0.05$ was considered significant. The analysis was separated by cutting and then combined for the entire season. We did not conduct statistical tests for the on-farm sites as there was no control or replication. On-farm yields and quality are simply reported.

Fruita GVRC	Kernza variety	Alfalfa
	C5	RR
	C6	
	701	
	703	
	704	
	MN Clearwater	
Cortez SWRC	Kernza variety	Alfalfa
	C5	RR
	703	
	704	

Table 1. Varieties tested at each research location. RR= roundup ready.

Fruita Variety Trial-Yield

An ANOVA was used to compare alfalfa yield with all Kernza varieties averaged together. Tukey's test was used to compare each variety individually with the others and with alfalfa. The results are reported below.

Kernza-Fruita

Two harvests of this variety trial occurred, on 06/24/2024 and 09/30/2024. Issues with the irrigation and irrigation system resulted in two cuttings at this site. The alfalfa was cut a third time as it had enough growth towards the end of the season for another harvest.

Fruita Variety Trial	Cut one yield (ton/ac)	Cut two yield (ton/ac)	Season total (ton/ac)
Alfalfa (control)	2.2a	2.6a	6.3a*
C5	1.6ab	0.9b	2.5b
C6	1.4ab	1.1b	2.5b
701	1.1b	1.0b	2.1b
703	1.6ab	0.9b	2.5b
704	1.6ab	0.8b	2.4b
MN clearwater	1.1b	0.6b	1.8b
Average Kernza	1.4b	0.9b	2.3b

Table 2. Yields in tons per acre from the cuttings of the variety trial in Fruita. Numbers with the same letter are significantly similar (P>.05) *=a third cutting of the alfalfa occurred, 1.5 tons per acre.

For the first cutting of the Kernza variety trial at the Fruita site, the alfalfa yield was similar to the Kernza varieties C5, C6, 703, and 704. The varieties 701 and MN clearwater yielded significantly lower than the alfalfa (P<.05). For the second cutting and seasonal total, all the Kernza varieties yielded significantly lower than the alfalfa (P<0.05). Issues with the irrigation system here resulted in only two cuts for the Kernza when three would be expected for a cool season grass in this area.

For cool season grasses (including Kernza), especially in this growing region, the first cut generally yields the most. This is when growing conditions are most ideal for the grasses. Thus, the yields are similar to those of alfalfa during this first cut for some varieties.

As temperatures rise in late June and July in this area, the grasses enter their "summer slump," with reduced growth as temperatures are above the ideal growing range for these grasses. For the second cutting, there was a clear decline in yield for these grasses due to the high-temperature-induced slump.

As the hottest parts of the year move into mid-August and early September, growing conditions are more ideal for cool-season grasses, resulting in a higher yield for this third cutting than for the second.

This variety trial highlights which varieties are most suited for this growing region. Varieties 703, 704, C5, and C6 performed best.

Kernza-Cortez

Two harvests in this trial were conducted throughout the season on 06/11/2024 and 10/01/2024. Issues with the irrigation in the middle of the summer resulted in a delayed second cutting. Following the first cut, these plots received 75% of the typical irrigation for an alfalfa crop in the area.

SWCRC Variety Trial	Cut one yield (ton/ac)	Cut two yield	Season total
Alfalfa (control)	1.8a	1.4a	3.2a
C5	2.0ab	1.4a	3.5a
703	2.6b	1.5a	4.1a
704	1.8a	1.2a	3.1a
Average Kernza	2.2ab	1.4a	3.5a

Table 4. Yield in tons per acre of our Kernza and alfalfa control for two cuttings and the yearly total for our Cortez site in 2024.

There was no significant difference for the first, second, or the yearly total between the alfalfa and average Kernza yield (P<.05). When looking at individual varieties, 703 yielded significantly more than the alfalfa and the 704 variety for the first cutting (P<.05). For the second cutting and season total there was no significant difference between alfalfa and the individual Kernza varieties. This highlights the 703 as the most adaptable variety for this region.

The reduced water application here following the first harvest demonstrates that the Kernza can yield comparably to the alfalfa with and without a full water supply in this region. The Kernza, as a cool season grass, typically yields most in spring and fall, falling victim to the summer slump mentioned above. However, this area is at a higher elevation than our Fruita site and has a lower average temperature, reducing the summer slump effect. Overall, this climate worked well for the Kernza, which could be an option for forage production in this region.

On-farm trial yields

Our on-farm trials presented a unique variety of practical issues and required individualized approaches for each field. We managed these fields in accordance with best management practices and practicality for farmers. Limitations with field

equipment, irrigation, or other factors resulted in limited harvests from these sites.

Location	Harvest Dates
Olathe	05/17/2024 & 08/15/2024
Cortez	06/11/2024 & 10/01/2024

Table 6. Location and dates for the two harvests that occurred at our on-farm trials.

On-Farm Trials Location	Crop	Cut one yield (tons/ac)	Cut two yield	Season total
Cortez	Kernza	2.4	1.6	4.0
Olathe	Kernza	1.2	2.5	3.7

Table 7. Yield in tons per acre of our Kernza for two cuttings and the yearly total at our on-farm sites in 2024.

The on-farm trials were extremely valuable in developing best management practices (BMPs) for these crops on a larger scale than the variety trials conducted at the research stations. They showcased real-world issues and strategies to solve problems. These sites show what a two-cutting season could look like on a farm, though in many of these situations, a third cutting would be justified.

There are a variety of approaches to cultivating Kernza depending on climate, soil types, management factors, and other growing conditions that are unique to each area. Due to the wide spectrum of climatic conditions around Colorado,

The Kernza yields at the Cortez site were comparable to our yields from the variety trials. This area is highly variable in terms of water availability. Some years, it is plentiful, and others, it experiences drought. Throughout the trials, reduced irrigation on Kernza still produced good yields. Kernza responded well to irrigation water but produced a crop under reduced irrigation. This shows its adaptability and makes it useful when water supply is variable.

In Olathe, weeds reduced some of the Kernza yield during the first cutting. These weeds were carefully managed, resulting in a high yield for the second cutting, as the Kernza thrived and established much better. This also resulted in only two cuttings. However, now that the field is established, a third cutting should be possible in the following years.

Quality

The following acronyms are used for quality parameters: Crude protein percentage of dry matter (CP%), neutral detergent fiber percentage of dry matter (NDF %), acid detergent fiber percentage of dry matter (ADF %), relative feed value (RFV), and total digestible nutrients percentage of dry matter (TDN %). Total digestible nutrients are very closely related to ADF, we will focus on TDN during our discussion.

Kernza is a grass. Grasses typically have lower forage quality than legumes like alfalfa due to their physiology and inherent characteristics for each plant family. Therefore, comparing quality can be difficult.

USDA hay quality guidelines, listed below, assign grades for various quality parameters and enable a more balanced assessment of quality.

USDA Hay Quality Designation Guidelines can be found here: https://www.ams.usda.gov/sites/default/files/media/HayQualityGuidelines.pdf

Other ways to compare quality between grasses and legumes include calculated quality parameters. Numbers like total digestible nutrients (TDN) look at the overall energy of a forage and allow a more balanced comparison when looking at grasses vs legumes.

We conducted a one-way ANOVA for both research stations to compare the average quality of our Kernza with the alfalfa control. When the ANOVA revealed a significant difference in yield or quality between Kernza and alfalfa we used Tukey's to compare treatments. $P<0.05$ was considered significant. The analysis was separated by cutting.

Fruita Variety Trial Quality

Cut 1

Fruita Variety Trial Quality Cut 1	CP %	NDF%	ADF %	RFV	TDN %
Alfalfa (Control)	22.1a	37.7a	28.5a	180.3a	66.7a
Average Kernza	13.6b	53.2b	28.6a	116.9b	66.6a

Table 8. Quality of our Kernza and alfalfa control for the first cutting of the variety trial in Fruita 2024. Numbers in a column with the same letter are similar.

The alfalfa was significantly higher in CP than Kernza ($P<0.001$). For Kernza, as a grass, CP above 13% is considered premium quality, the highest category for grasses according to the USDA.

In general, legumes have more crude protein than grasses. Crude protein directly relates to the nitrogen content of a plant. Since legumes have the unique

ability to form relationships with bacteria that fix nitrogen from the air, legumes generally have higher nitrogen contents and, in turn, more crude protein as well.

The NDF of the Kernza was significantly higher than the alfalfa (P<0.001). Grasses generally have higher NDF values compared to legumes, so these results were expected.

The TDN of the Kernza was similar to alfalfa (P=0.9773). This highlights that they are comparable forages from an energy standpoint.

The RFV of the Kernza was significantly lower than alfalfa. As a grass, this is expected due to its high fiber content, especially NDF.

Overall, the Kernza was high quality for a grass compared to the USDA guidelines, and, in terms of energy (TDN), it was comparable to alfalfa.

Cut 2

Fruita Variety Trial Quality Cut 2	CP %	NDF%	ADF %	RFV	TDN %
Alfalfa (Control)	19.1a	44.8a	41.3a	122.3a	56.7a
Average Kernza	16.8a	51.4b	31.4b	116.8a	64.4b

Table 9. Quality of our Kernza and alfalfa control for the second cutting of the variety trial in Fruita 2024.

For the second cutting, due to constraints at the station, these crops were all cut later than ideal.

The Kernza differed significantly from the alfalfa in all quality parameters except RFV (P=0.495). During the first cutting, the Kernza was harvested towards the boot stage. At boot stage, the stems can elongate and reduce quality. During this second cutting, the Kernza was purely vegetative. This resulted in a higher-quality crop during the second cutting but a reduced yield.

The Kernza had lower CP and higher fiber, indicating lower quality. The overall energy measurement (TDN) was significantly higher for the Kernza from this cutting, indicating it remains a comparable forage.

The Kernza would be considered "premium" which is the highest designation for a grass forage.

Cortez Variety Trial Quality

Cut 1

Cortez Variety Trial Quality Cut 1	CP %	NDF%	ADF %	RFV	TDN %
Alfalfa (Control)	21.2a	35.2a	28.3a	178.8a	66.8a
Average Kernza	13.3b	60.4b	34.3b	96.1b	62.2b

Table 11. Quality of Kernza and alfalfa control for the first cutting of the variety trial in Cortez 2024.

During the first cutting, the Kernza differed significantly from the alfalfa for all quality parameters (P<0.05). It performed well compared to other grasses and would be considered “premium.” Most cool-season grasses enter the reproductive phase before the first cutting. This increases the stem to leaf ratio which lowers the quality. However, CP% above 13 is still premium for grass forage and highlights the Kernza still exhibits high quality.

Cut 2

Cortez Variety Trial Quality Cut 2	CP %	NDF%	ADF %	RFV	TDN %
Alfalfa (Control)	19.2a	41.2a	34.2a	144.7a	62.2a
Average Kernza	15.2b	50.7b	35.6a	113.9b	61.2a

Table 12. Quality of our Kernza and alfalfa control for the second cutting of the variety trial in Cortez 2024.

The Kernza was significantly different from the alfalfa for the CP%, NDF%, and RFV. The Kernza was similar to the alfalfa for the ADF% and TDN%. The Kernza was very high in crude protein and TDN. Compared to other grasses this would be “premium quality”.

Quality parameters can be difficult to compare across two different plant families, and even within the same family, due to inherent differences among species. Further complicating matters is the wide range of parameters used to assess forage quality. We only reported the most common quality parameters but many more exist. Some farmers may focus only on protein or energy, while others want the whole picture, including fiber, feed value, and more.

Some of our reported parameters suggest premium-quality hay, while others indicate lower-quality hay. This highlights the complexity in assessing forage quality.

On-farm Trials Quality

On Farm Trials Quality Cut 1	Crop	CP %	NDF%	ADF %	RFV	TDN %
Cortez	Kernza	13.4	59.5	33.4	98.5	65.2
Olathe	Kernza	10.1	54.3	30.4	111	65.2

Table 13. Quality of our Kernza and alfalfa control for the first cutting of the on-farm trials 2024.

The Kernza demonstrated good to premium quality during the first cutting at our Cortez site. This site tested as premium forage based on the crude protein percentage. It also reported a high TDN highlighting a high-quality forage.

Our Olathe sample was lower in CP %, reporting in the "good" category according to the USDA guidelines. This site tested high in TDN % highlighting its high energy value. Overall Kernza performs well in terms of quality when compared to other cool-season grasses for our on-farm trials.

Cut 2

On Farm Trials Quality Cut 2	Crop	Crude Protein %	Neutral detergent fiber %	Acid detergent fiber %	Relative feed value	Total Digestible Nutrients %
Cortez	Kernza	15.1	46.4	30.4	131	65.2
Olathe	Kernza	8.4	62.7	43.8	81.1	54.8

Table 14. Quality of our Kernza and alfalfa control for the second cutting of the on-farm trials 2024.

The second cutting of the on-farm trials had varied results. The Cortez site reported high CP values for the second cutting, similar to the first. The TDN and energy values were also very high for this cutting.

The Olathe field saw a decline in quality compared to the first cutting. This would rank as "fair" quality hay under USDA guidelines.

Forage quality can be variable and depends on multiple factors, including soil fertility, growing conditions, management, and water availability. This study demonstrates that Kernza can produce high-quality forage compared to other cool-season grasses.

Conclusion

Our initial research indicates that these crops can be successfully cultivated throughout western Colorado. Yields and quality were variable, highlighting that there are still many unknowns about management that could optimize yield and quality.

Projects like this help bridge the gap between research and commercial farming, reducing risk for producers interested in alternatives. Baseline management practices for cultivating these in three distinct growing regions in the Intermountain West of Colorado will guide others searching for alternative forages. More work is needed to continue expanding these crops and refining best management practices.

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