Wheat Variety Selection: An Application of Portfolio Theory in Colorado[1]

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Introduction and Background

Each year prior to the growing season, wheat growers are faced with choices when it comes to selecting which wheat varieties to plant. Several Land Grant Universities annually publish results of wheat variety performance trials where both private and public wheat varieties are tested. From these outreach publications, wheat growers can get a reliable sense of the expected performance of the trial varieties for their location. Intuitively, growers select wheat varieties based on previous experiences and the published trial results of the previous year. The correlation between yield performances of the different varieties is largely ignored and a more thorough investigation could lead to increased yield stability.

As expected, any agricultural activity involves risk from diverse sources such as weather variation or disease. Barkley, Peterson, and Shroyer (2010) identified three major strategies to reduce risk in wheat production. The first strategy to reduce risk involves the development of new breeds with agronomic characteristics appropriate to the growing region. The traits of multiple varieties can be combined to create new cultivars that will potentially reduce the variation of yields. The second strategy is to create mixtures or blends of the seed of a few different varieties prior to planting in order to increase the genetic diversity. The third strategy is to create a portfolio by selecting multiple wheat varieties and planting them in different fields.

The number of planted acres of wheat has stayed consistent over the past 10 years in Colorado; therefore, one way to maintain and possibly increase wheat yields is through better risk management strategies. According to Bosley (2010), Colorado growers tend to plant two or three different varieties of wheat in a given year. The selection of varieties is made primarily by a combination of previous experiences, gut feelings, suggestions made by friends, family or seed distributors and an examination of the test plot yields from the previous year.

Through the examination of the year-to-year variance of a given cultivar (variety), and comparing that with the variance and covariance of other cultivars, "portfolios" of wheat varieties can be developed. The portfolios lie graphically on a single line and represent points where variation is minimized for a given level of yield. This line represents the mean-variance

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efficiency frontier. Portfolios can be developed based on the producers' risk preferences, whether it is to maximize yield given a target variance or minimize variance given a target yield. The term portfolio originates from finance and refers to a group of financial instruments such as investments, holdings, and funds that are used to stabilize or reduce exposure to the risks of the financial market. The term is appropriate for wheat variety analysis in the sense that creating a portfolio of wheat varieties helps reduce wheat producers' exposure to yield risk.

There are a several recent studies that have used portfolio theory on grain crops including Nalley et al. (2009) on rice varieties grown in Arkansas; Nalley and Barkley (2010) on wheat varietal selection in Yaqui Valley of Northwestern Mexico; Barkley, Peterson, and Shroyer (2010) in Kansas wheat varietal selection; and Park et al. (2012) on wheat selection for dryland wheat producers in the Texas High Plains. This paper applies existing portfolio theory methods to wheat varietal selection to help Colorado wheat producers make more informed planting decisions. Portfolios are created for northeast and southeast Colorado. The estimated standard deviation is used as a proxy for measuring the "risk" or variation of a given wheat variety portfolio.

Although applying portfolio methods to wheat production has been done in Kansas and Texas, this is the first known study to evaluate wheat varieties in Colorado in this manner. This is important because producers in Colorado generally grow different varieties than producers in those states (USDA/NASS Kansas Field Office 2012; USDA/NASS Texas Field Office, 2012). The timing of this present study is especially important given that it includes several popular varieties recently released by the Colorado State University Wheat Breeding and Genetics Program with different trait characteristics designed to address specific Colorado growing conditions.

Methodology and Data

The model used in this study to estimate the efficiency frontier for Colorado wheat varieties is based on research by Markowitz (1952). In this research, the method of minimizing the expected variation, as measured by standard deviation, subject to a given level of expected (mean) yield, is used. The frontier is estimated by solving a sequence of quadratic programming problems.

It is assumed that a wheat producer has a given number of acres (X) and wishes to produce on the efficiency frontier of mean-variance (MV) by allocating X acres to a combination of varieties. The variable x_i represents the percentage of total acres planted of variety i where i = 1, …, n and $\Sigma_i x_i$ = X or 100% of the producer's land dedicated to wheat production. This frontier is the maximization of the mean yields given a target level of variation or the minimization of variation given a target mean yield. By defining y_i as the mean yield of variety i, the total wheat yield will be the weighted mean yield, equal to: $\Sigma_i x_i y_i$.

The MV efficiency frontier is estimated by minimizing total farm variation (V) for each possible level of mean yields (y_i) as given in equation (1):

(1) $\min V = \Sigma_i \Sigma_j x_i x_j \sigma_{ij}$, for a given level of λ
subject to $x_i \geq 0$ for all i.

The total wheat variety yield variation (V) is defined as:

(2) $V = \Sigma_i \Sigma_j x_i x_j \sigma_{ij}$

where x_i is the percentage of total acres planted to variety *i* and x_j is the percentage of total acres planted to variety *j*, σ_{ij} is the covariance of yields for varieties *i* and *j* and σ_{ij} is the variance when *i* = *j*. Hazell and Norton (1986) explain that the intuition behind equation (2) is that by combining varieties that have negatively related covariates, a more stable yield will likely occur. Also, a variety that may appear to be risky or have a large variance can still be an option when combined with a variety that shares a negative covariate.

The constraint ensures non-negative returns after the quadratic (i.e., it is not possible to plant a negative percentage of wheat variety *i*). The sum of the mean yields for varieties *x* and *y* are set equal to λ, where λ is the target yield for a given portfolio:

(3) $\lambda = \Sigma_i x_i y_i$.

By varying the target yield (λ) over the feasible range, the MV efficiency frontier can be estimated. The same process described above can be performed using a target variation (standard deviation) instead of a target yield. This allows a producer to maximize yield for a given target level of variation.

Data on wheat yields are obtained from the Colorado Wheat Variety Database (Colorado State University Wheat Breeding and Genetics Program). Yields from 2000 – 2011 for dryland trial locations throughout Colorado are used to carry out the analysis. The varieties selected are based on three sets of criteria: 1) the variety is tested in the CSU trials; 2) the variety appears within the National Agricultural Statistics Service (NASS) annual publication "Winter Wheat Varieties" for Colorado for the years 2009, 2010, and 2011; and 3) there are at least three years of comparable mean yields between each variety used to estimate the covariates. A total of 13 wheat varieties met the above criteria and are selected for the analysis. The resulting varietal selection can be seen in Table1.

Table 1. Selected Colorado Wheat Varieties Source, Year of Release, and Percent Planted Acres, 2009-2011

Variety	Source	Year	2009	2010	2011
Above	CSU	2001	3.2%	3.2%	2.8%
Akron/Ankor	CSU	1994/2002	2.8%	2.6%	1.3%
Bill Brown	CSU	2007	0.0%	2.5%	5.1%
Bond CL	CSU	2004	4.8%	4.9%	3.9%
Danby	KSU	2005	1.2%	0.0%	0.0%
Hatcher	CSU	2004	32.9%	26.5%	34.5%
Jagalene	Agripro	2001	8.4%	6.8%	1.6%
Jagger	KSU	1994	4.0%	3.2%	1.9%
Prairie Red	CSU	1998	5.6%	5.6%	1.5%
Prowers 99	CSU	1999	2.0%	1.6%	0.0%
Ripper	CSU	2006	6.8%	12.5%	12.1%
TAM 111	TAMU	2002	8.0%	7.5%	9.5%
Yuma	CSU	1991	2.7%	1.1%	0.0%
Total Wheat Acres Planted			2,630,000	2,478,000	2,345,000

Source: USDA/NASS Colorado Agricultural Statistics Service.

Summary statistics and the coefficients of variation are reported for the Northeast region and Southeast region of Colorado in Table 2 and Table 3, respectively. Because there are distinct differences in production levels between Northeast and Southeast Colorado, this study divides the data to develop separate wheat portfolios that are appropriate for the given region.

Table 2. Selected Variety Summary Statistics: Northeast Colorado Region, 2000-2011

Variety	Mean Annual Yield	Standard Deviation	Coefficient of Variation	Min	Max	Observations
Ripper	50.48	11.84	0.24	4.76	87.65	48
Bill Brown	49.61	11.93	0.24	12.34	84.31	40
Bond CL	49.38	13.33	0.27	10.91	97.26	51
Hatcher	49.09	13.37	0.27	2.17	97.61	56
TAM 111	47.83	15.48	0.32	4.17	101.27	47
Above	47.66	12.52	0.26	5.31	93.06	61
Jagger	46.60	10.85	0.23	13.57	93.17	61
Danby	46.24	14.26	0.31	3.83	83.45	40
Prairie Red	46.02	11.17	0.24	6.02	88.47	61
Jagalene	44.88	12.26	0.27	4.34	90.57	42
Yuma	44.58	12.48	0.28	6.42	93.36	52
Akron/Ankor	41.93	11.78	0.28	3.94	89.39	47
Prowers 99	40.07	10.09	0.25	6.71	83.31	47

Source: USDA/NASS Colorado Agricultural Statistics Service.

In the Northeast region of Colorado, Ripper had the highest average yield at 50.48 bu./ac. followed by Bill Brown (49.61 bu./ac.) and Bond CL (49.38 bu./ac.). Prowers 99 had the lowest yield and the lowest variation (Table 2). In the Southeast region, mean yields are slightly lower than in the Northeast region. Ripper had the highest average yield with 44.86 bu./ac. followed by Bill Brown (44.64 bu./ac.) and Hatcher (44.21 bu./ac.). Similar to the Northeastern region, Prowers99 had the lowest yield (34.04 bu./ac.). However, Akron/Ankor had the lowest variation in the Southeast region (Table 3).

Table 3. Selected Variety Summary Statistics: Southeast Colorado Region, 2000-2011

Variety	Mean Annual Yield	Standard Deviation	Coefficient of Variation	Min	Max	Observations
Ripper	44.86	9.30	0.21	15.03	75.59	26
Bill Brown	44.64	12.12	0.27	14.65	70.50	23
Hatcher	44.21	11.31	0.26	13.42	76.71	29
Bond CL	42.23	9.43	0.22	15.41	68.09	26
Danby	41.77	10.81	0.26	13.13	68.30	23
Above	40.91	8.44	0.21	13.51	62.80	32
TAM 111	40.53	12.67	0.31	11.70	77.38	24
Prairie Red	39.23	9.10	0.23	10.37	59.48	32
Akron/Ankor	37.55	8.41	0.22	15.37	69.18	23
Jagger	37.01	10.18	0.28	9.99	68.80	32
Yuma	36.79	9.27	0.25	16.56	71.27	26
Jagalene	36.43	11.61	0.32	14.18	74.68	20
Prowers 99	34.04	8.90	0.26	12.56	58.11	25

Source: USDA/NASS Colorado Agricultural Statistics Service.

Through the application of portfolio theory to Colorado varietal selection, wheat producers can potentially increase yield and reduce variability by combining wheat varieties that respond differently to growing environments. Through the calculation of means, standard deviations and covariates, it can be estimated as to how each variety's yield responds to different environmental factors relative to each of the other varieties. Ideally, varieties that have a negative covariate would be integrated into the planting plans to reduce risk.

Estimation Procedures and Results

Complete data on wheat variety yield means, standard deviations and covariances are used to estimate wheat portfolios along the efficiency frontier. Standard deviations are estimated across years and pairwise covariates of the selected wheat varieties are estimated. By varying the target yield, while minimizing the standard deviation for the given target yield, the optimal portfolios are established and efficiency frontiers are constructed. A Variance/Covariance matrix for the Northeast and Southeast regions can be found in Tables A1 and A2 of the Appendix, respectively.

2011 Actual Portfolio vs. 2011 Potential Portfolio

The following wheat varieties: Above, Akron/Ankor, Bill Brown, Bond CL, Hatcher, Jagalene, Jagger, Prairie Red, Ripper, and TAM 111 were listed in NASS's "Winter Wheat Varieties – 2011 Crop" and accounted for 75.2% of total acres planted statewide (USDA/NASS Colorado Field Office, 2012). The survey also provides the planted acres percentages for the Northeast and Southeast regions. By proportioning the varieties' percentage planted to equal 100%, it allows the estimation of the variation (V) and mean yield (E) for the actual portfolio in 2011 (2011 Actual Portfolio). The variation is then held constant at the 2011 Actual Portfolio level for each region and quadratic programming is used to maximize the mean yield providing an estimate of the 2011 Potential Portfolio for each region.[6]

Northeast Region Efficiency Frontier Portfolio Results

The standard deviation of the 2011 Actual Portfolio (12.91 bu./ac.) was estimated, and the expected yield was maximized using quadratic programing, allowing for the estimation of the 2011 Potential Portfolio for the Northeast region. The estimated yield difference between the two portfolios was nearly 0.5 bu./ac.

Ripper was the highest yielding variety at 50.5 bu./acre (Table 2) and constitutes the highest point on the efficiency frontier (Figure 1). Prowers 99 was the variety with the lowest variation with a standard deviation of 10.09 bu./ac. (Table 2) and is the left most and lowest point on the efficiency frontier (Figure 1). Using these two points as the extremes, an efficiency frontier was drawn between the two points by varying the target mean yield and then minimizing the portfolio variance for the given varied yield. Several portfolios were developed representing the points along the efficiency frontier between the two extremes (Table 4). The portfolios contain the percentage of each variety to be planted in order to obtain certain levels of yield and variation.

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[6] A statewide analysis was also conducted for Colorado. The statewide analysis results are not reported to here to conserve space and because of the similarities between the statewide and regional analyses (specifically Southeast region). The results for the statewide analysis are available from the authors upon request.

Three portfolios offer the lowest coefficient of variation (CV). A portfolio of 89% Jagger and 11% Ripper (CV = 0.23), a portfolio of 59.1% Jagger and 40.9% Ripper and a portfolio of 29.2% Jagger and 70.8% Ripper. These three portfolios could be suggested to those farmers looking to minimize risk while keeping expected yields relatively high. Choosing the latter portfolio would increase yield by 0.25 bushels per acre when compared to the "Actual Portfolio resulting in a $650,100 increase in production for the Northeast Region.[7] Figure 1 shows the steepness of the efficiency frontier drawn by the portfolios found in Table 4.

Table 4. Portfolio Analysis of Northeast Region Wheat Varieties, 2000-2011

Portfolio	Target Mean Yield (Bu./Acre)	Standard Deviation (Bu./Acre)	Coefficient of Variation
100% Prowers 99	40.07	10.09	0.25
17.8% Jagger 82.2% Prowers 99	41.23	10.27	0.25
35.5% Jagger 64.5% Prowers 99	42.39	10.44	0.25
53.3% Jagger 46.7% Prowers 99	43.55	10.58	0.24
71% Jagger 29% Prowers 99	44.71	10.69	0.24
87.1% Jagger 1.8% Prairie Red 11.1% Prowers 99	45.87	10.79	0.24
89% Jagger 11% Ripper	47.03	10.94	0.23
59.1% Jagger 40.9 Ripper	48.19	11.22	0.23
29.2% Jagger 70.8% Ripper	49.35	11.52	0.23
100%Ripper	50.48	11.84	0.24
2011 Actual Portfolio of Planted Varieties in Northeast Colorado[a]	49.10	12.91	0.26
2011Potential Portfolio[b] 82% Bond CL 17.7% Ripper	49.58	12.91	0.26

[a] The "2011 Actual Portfolio" defined here is based on the percentage planted from the NASS 2011 publication and those varieties found in the CSU Trials, proportioned to equal 100%.
[b] The "2011 Potential Portfolio" is estimated by maximizing the target yield while holding the variance at the 2011 Actual Portfolio variance.

[7] Estimated by multiplying 0.25 with 394,000 acres of wheat planted (NASS) and a wheat price received of $6.60/bu for 2011 (NASS).

By moving left from the 2011 Potential Portfolio for the Northeast region towards a portfolio that lies on the efficiency frontier an estimated 11% reduction in risk, as measured by the standard deviation can be achieved without giving up potential yield. In fact, some of the estimated portfolios on the efficiency frontier would both increase expected yield and reduce the variation when compared with the 2011 Potential Portfolio for the Northeast region.

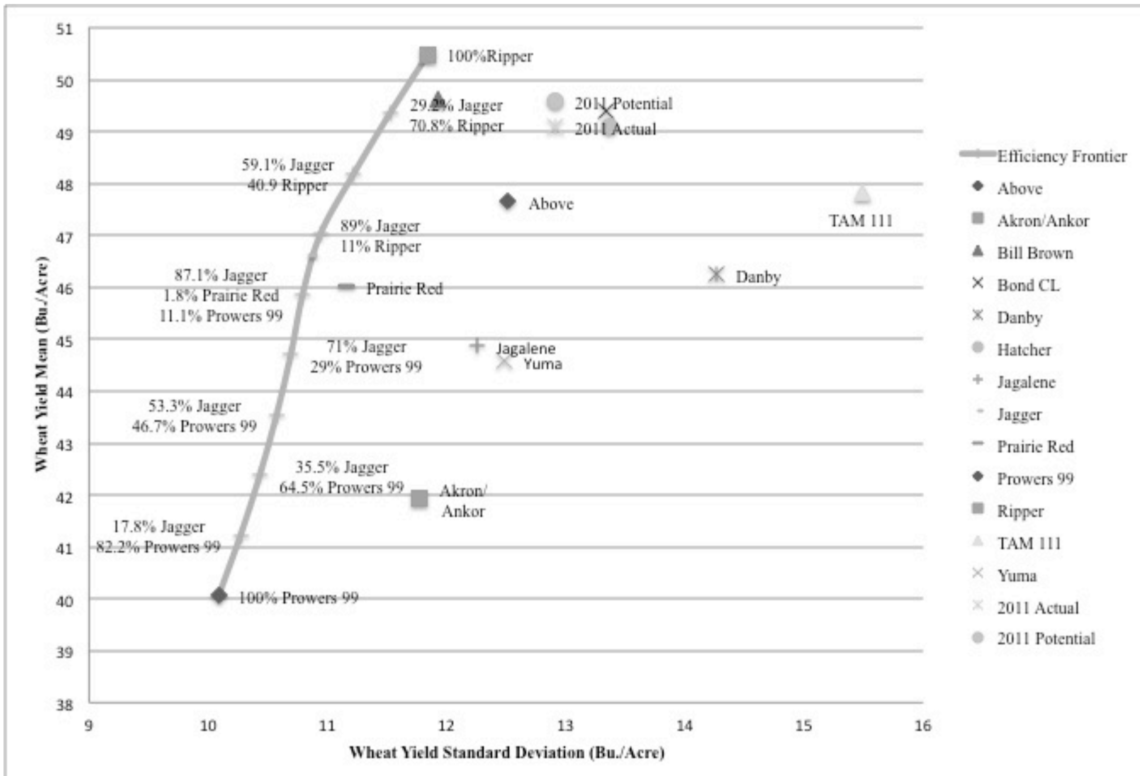

Figure 1. Northeast Colorado Region Wheat Efficiency Frontier, 2011

Southeast Region Efficiency Frontier Portfolio Results

By holding the standard deviation of the Actual Portfolio (11.24 bu./ac.) constant and maximizing the expected yield an estimate of the 2011 Potential Portfolio for the Southeast region can be calculated. The estimated yield difference between the Actual and the Potential portfolio for the Southeast region was nearly one bu./ac. (Table 5).

The Southeast region analysis offers some very interesting results. A single variety did not have the lowest variation, but rather a portfolio produced the lowest variation. This provides empirical evidence towards Hazell and Norton's (1986) discussion that creating a portfolio of varieties that have negatively related covariates can produce a more stable yielding result. A portfolio of 43.4% Akron/Ankor, 23.9% Prairie Red and 32.9% Prowers 99 would result in a minimized standard deviation of 8.08 bu./ac. in the Southeast region (Table 4), whereas the best any one variety could do is a standard deviation of 8.41 bu./ac..

Table 5. Portfolio Analysis of Southeast Region Wheat Varieties, 2000-2011

Portfolio	Target Mean Yield (Bu./Acre)	Standard Deviation (Bu./Acre)	Coefficient of Variation
43.4% Akron/Ankor 23.9% Prairie Red 32.9% Prowers 99	36.80	8.08	0.22
22.5% Above 32.4% Akron/Ankor 18.8 % Prairie Red 26.3% Prowers 99	37.70	8.11	0.22
48.3% Above 18.8% Akron/Ankor 11.2% Prairie Red 21.7% Prowers 99	38.60	8.17	0.21
74.2% Above 5.1% Akron/Ankor 3.5% Prairie Red 17.2% Prowers 99	39.50	8.25	0.21
92.6% Above 7.4% Prowers 99	40.40	8.36	0.21
90.1% Above 9.9% Ripper	41.30	8.55	0.21
67.4% Above 32.6% Ripper	42.20	8.77	0.21
44.6% Above 55.4% Ripper	43.10	8.97	0.21
0.2% Above 32.4% Bond CL 67.4% Ripper	44.00	9.11	0.21
100% Ripper	44.86	9.30	0.21
2011 Actual Portfolio of Planted Varieties in Southeast Colorado[a]	43.84	11.24	0.26
2011 Potential Portfolio[b] 28.1% Bill Brown 71.9% Ripper	44.80	11.24	0.26

[a] The "2011 Actual Portfolio" defined here is based on the percentage planted from the NASS 2011 publication and those varieties found in the CSU Trials, proportioned to equal 100%.
[b] The "2011 Potential Portfolio" is estimated by maximizing the target yield while holding the variance at the 2011 Actual Portfolio variance.

Using the portfolio with the smallest variation and the variety with the highest yield, a frontier was constructed for the Southeast region that resulted in the portfolios found in Table 5 and depicted graphically in Figure 2. Three of the portfolios offer equal coefficients of variation and could be good recommendations to growers. Portfolios made up of 92.6% Above and 7.4% Prowers 99, 90.1% Above and 9.9% Ripper, or 0.2% Above, 32.4% Bond CL, and 67.4% Ripper all have the smallest CV of 0.21 for the Southeast region. The latter portfolio, when compared to the "Actual Portfolio" offers the potential of an additional 0.16 bushels per acre resulting in an additional value of $396,000 to wheat producers in the Southwest Region.[8]

A move from the 2011 Actual Portfolio for the Southeast region to the 2011 Potential Portfolio provides a small 2% increase in expected yield while maintaining the same level of variation. However, a leftward movement from the 2011 Actual Portfolio to an estimated portfolio that lies on the efficiency frontier has the potential of reducing risk by 19% as measured by the standard deviation without reducing yield. Furthermore, there are portfolios on the efficiency frontier that offer slight increases in expected wheat yield along with a significant decrease in variation (see Figure 2).

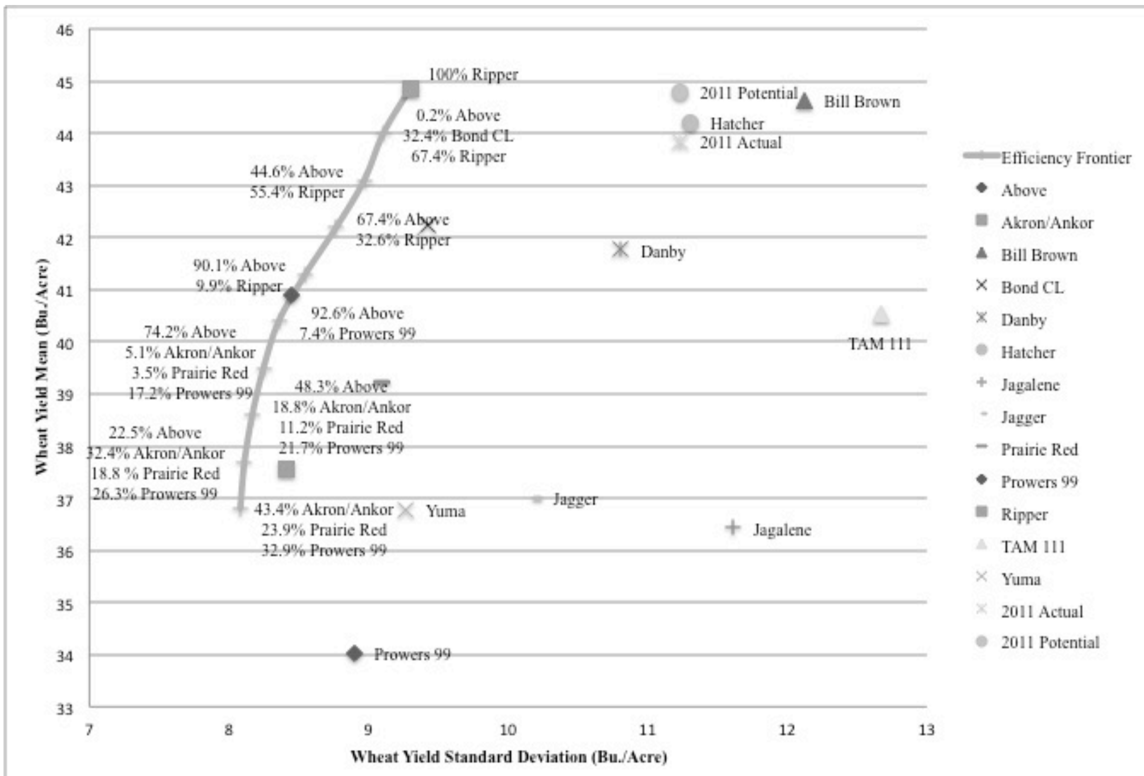

Figure 2. Southeast Colorado Region Wheat Efficiency Frontier, 2011

[8] Estimated by multiplying 0.16 with 375,000 acres of wheat planted (NASS) and a wheat price received of $6.60/bu for 2011 (NASS).

Conclusions and Implications

As an addition to the many tools already available to wheat growers in Colorado, the creation of variety portfolios offers a statistical method to help minimize risk and stabilize yields. This application of portfolio theory to Colorado wheat offers a quantitative look at the relationship among wheat varieties. By analyzing the covariates of wheat varieties, growers can take advantage of the ways in which the varieties react to different growing conditions.

This analysis found that double-digit percentage decreases in risk as measured by the standard deviation can be achieved by Colorado wheat producers without sacrificing potential yield. According to our analysis, this potential reduction in risk is greater in the Southeast quadrant of the state than it is in the Northeast (19% versus 11%). Furthermore, it was found that portfolios exist on the risk-return efficiency frontier in both the Northeast and the Southeast growing regions of Colorado whereby wheat producers have the potential to slightly increase expected yield and significantly decrease yield variation.

All varieties included in this study had at least three years of trial data but many had more than three years. Therefore, a couple of acknowledge limitations of this study are that some varieties may look artificially good or bad depending upon the growing conditions for the years they were included in the trial data and the very latest varieties with less than three years of data are not included in our analysis. However, the results of this analysis seem to fit with anecdotal grower experiences over the last several years. This suggests that this study and the model it contains could provide a powerful tool for helping producers make effective wheat variety planting decisions from a risk management perspective.

References

Barkley, A., H.H. Peterson, and J. Shroyer. 2010. “Wheat Variety Selection to Maximize Returns and Minimize Risk: An Application of Portfolio Theory.” *Journal of Agricultural and Applied Economics* 42(1):39-55.

Bosley, B. 2010. “2010 Colorado Wheat Improvement Work Team Survey of Wheat Growers.” Colorado State University.

Colorado State University Wheat Breeding and Genetics Program. 2012. http://wheat.colostate.edu/CSUWheatBreeding/Database.html. Last accessed August 2012.

Hazell, P.B.R., R.D. Norton. 1986. *Mathematical Programming for Economic Analysis in Agriculture.* New York: MacMillan Publishing Company.

Markowitz, H. 1952. “Portfolio Selection.” *The Journal of Finance* 7(1):77-91.

Nalley, L.L. and A. Barkley. 2010. “Using Portfolio Theory to Enhance Wheat Yield Stability in Low-Income Nations: An Application in the Yaqui Valley of Northwestern Mexico.” *Journal of Agricultural and Resource Economics* 35(2):334-347.

Nalley, L.L., A. Barkley, B. Watkins, and J. Hignight. 2009. “Enhancing Farm Profitability through Portfolio Analysis: the Case of Spatial Rice Variety Selection.” *Journal of Agricultural and Applied Economics* 41(3):641-652.

USDA National Agricultural Statistics Service (NASS). Various Years. “Winter Wheat Seedings by Variety Survey.” USDA/NASS Colorado Field Office.

Park, S.C., J. Cho, S.J. Bevers, S. Amosson, J.C. Rudd. 2012 Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Birmingham, Alabama, 4-7 February.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA/NASS) Colorado Field Office. “Winter Wheat Varieties.” Retrieved from http://www.nass.usda.gov/Statistics_by_State/Colorado/Publications/Special_Interest_Reports/index.asp November 8, 2012.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA/NASS) Kansas Field Office. “Wheat Varieties.” Retrieved from http://www.nass.usda.gov/Statistics_by_State/Kansas/Publications/Crops/Whtvar/index.asp November 8, 2012.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA/NASS) Texas Field Office. “Wheat Variety Results.” Retrieved from http://www.nass.usda.gov/Statistics_by_State/Texas/Publications/Crop_Reports/Wheat/twheat_var.htm November 8, 2012.

Appendix

Table A1. Northeast Variance/Covariance Matrix

	Above	Akron/Ankor	Bill Brown	Bond CL	Danby	Hatcher	Jagalene	Jagger	Prairie Red	Prowers 99	Ripper	TAM 111	Yuma
Above	156.7337	145.3474	181.2197	174.2980	200.2007	170.4131	168.9258	130.2716	139.0155	133.0614	155.7298	155.7298	154.3097
Akron/Ankor	145.3474	138.6889	166.1552	176.0958	200.8963	167.5007	156.3714	125.8534	131.3519	120.7634	169.9424	198.1911	154.3097
Bill Brown	181.2197	166.1552	142.3727	154.8137	166.8779	162.4318	163.1433	136.9370	149.3487	169.4237	147.8465	147.8465	161.1132
Bond CL	174.2980	176.0958	154.8137	177.8010	183.4218	182.3091	164.0084	151.7798	156.0470	163.6424	143.8880	209.6938	189.3869
Danby	200.2007	200.8963	166.8779	183.4218	203.3953	198.5493	192.0854	167.5954	177.6258	195.6767	176.5349	256.0343	193.6006
Hatcher	170.4131	167.5007	162.4318	182.3091	198.5493	178.7384	170.9361	143.8908	151.3601	149.8616	155.6225	155.6225	178.0601
Jagalene	168.9258	156.3714	163.1433	164.0084	192.0854	170.9361	150.2280	144.1234	152.0757	143.6160	157.5391	180.3579	163.5015
Jagger	130.2716	125.8534	136.9370	151.7798	167.5954	143.8908	144.1234	117.6381	115.8604	112.9358	126.9766	184.1481	135.2790
Prairie Red	139.0155	131.3519	149.3487	156.0470	177.6258	151.3601	152.0757	115.8604	124.6576	121.2769	138.9878	191.7038	139.3252
Prowers 99	133.0614	120.7634	169.4237	163.6424	195.6767	149.8616	143.6160	112.9358	121.2769	101.7585	156.9093	178.3648	129.7346
Ripper	155.7298	169.9424	147.8465	143.8880	176.5349	155.6225	157.5391	126.9766	138.9878	156.9093	140.2153	192.5013	170.5154
TAM 111	155.7298	198.1911	147.8465	209.6938	256.0343	155.6225	180.3579	184.1481	191.7038	178.3648	192.5013	239.7455	205.1560
Yuma	154.3097	154.3097	161.1132	189.3869	193.6006	178.0601	163.5015	135.2790	139.3252	129.7346	170.5154	205.1560	155.7875

	Above	Akron/Ankor	Bill Brown	Bond CL	Danby	Hatcher	Jagalene	Jagger	Prairie Red	Prowers 99	Ripper	TAM 111	Yuma
Above	71.3174	67.7452	112.1091	80.2096	103.3449	92.7332	96.5551	79.5357	70.1884	60.3631	80.3758	115.6296	71.2686
Akron/Ankor	67.7452	70.7528	119.4692	79.2067	114.9311	91.6882	100.8925	82.9447	62.8130	59.9136	76.8059	116.3176	72.4105
Bill Brown	112.1091	119.4692	146.9181	123.1223	123.4512	153.3947	142.0586	125.2335	119.3786	143.4522	109.9223	169.0942	142.5819
Bond CL	80.2096	79.2067	123.1223	88.8406	108.2071	107.7546	89.6794	92.5135	85.9545	90.0164	77.8585	115.9512	91.2421
Danby	103.3449	114.9311	123.4512	108.2071	116.7728	135.5307	127.7653	110.8919	111.2004	129.9894	90.4854	155.0817	131.9668
Hatcher	92.7332	91.6882	153.3947	107.7546	135.5307	127.8755	125.2267	108.5331	93.8531	93.8531	97.2137	148.6502	110.1024
Jagalene	96.5551	100.8925	142.0586	89.6794	127.7653	125.2267	134.7978	121.9989	100.6282	82.8992	86.9002	143.2513	108.5611
Jagger	79.5357	82.9447	125.2335	92.5135	110.8919	108.5331	121.9989	103.6899	73.8580	84.4621	95.8871	140.9424	94.2968
Prairie Red	70.1884	62.8130	119.3786	85.9545	111.2004	93.8531	100.6282	73.8580	82.7742	55.8694	76.4002	122.3268	63.9256
Prowers 99	60.3631	59.9136	143.4522	90.0164	129.9894	93.8531	82.8992	84.4621	55.8694	79.2211	73.9364	107.6801	72.3909
Ripper	80.3758	76.8059	109.9223	77.8585	90.4854	97.2137	86.9002	95.8871	76.4002	73.9364	86.4532	108.1636	84.3044
TAM 111	115.6296	116.3176	169.0942	115.9512	155.0817	148.6502	143.2513	140.9424	122.3268	107.6801	108.1636	160.4715	128.8454
Yuma	71.2686	72.4105	142.5819	91.2421	131.9668	110.1024	108.5611	94.2968	63.9256	72.3909	84.3044	128.8454	85.9360