IMPROVING THE PERFORMANCE OF WINTER WHEAT PLANTED AFTER GRAIN SORGHUM IN NO-TILL SYSTEMS

by

JOSHUA D. JENNINGS

B.S., Kansas State University, 2004

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agronomy
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Abstract

Previous research has revealed that winter wheat (*Triticum aestivum* L.) yields are often reduced following grain sorghum [*Sorghum bicolor* (L.) Moench] compared to wheat after other summer crops. The objectives of the study were to: (a) evaluate grain sorghum residue management strategies to improve the performance of a following winter wheat crop in no-till systems; (b) determine grain sorghum hybrid characteristics that facilitate planting wheat following grain sorghum, and identify winter wheat cultivars that are suitable for planting after grain sorghum; (c) evaluate effect of environment, sampling time, and grain sorghum hybrid plant pigmentation on phenolic acid concentration in sorghum residues. Experiments were conducted in environments suitable for planting winter wheat following a summer crop. Treatments for objective one were: glyphosate (pre-harvest application, post-harvest, none), residue (removed, chopped, left standing), and nitrogen (34 kg ha^{-1} applied to residue, none). Treatments for objective two and three were grain sorghum hybrids representing three maturities (early, medium, medium-late) and two plant pigmentations (red, tan), wheat cultivars occupying significant planted acreage and having favorable performance within the region. Wheat yields increased in two environments by 217 and 630 kg ha^{-1} when glyphosate was applied to the sorghum pre-harvest. Residue chopping or removal either had no effect or a negative effect on wheat yields compared to residue left standing. Nitrogen applied to the sorghum residue increased wheat yields in only one environment. Grain sorghum hybrid characteristics did not influence winter wheat yields in any environment, but winter wheat cultivar did influence grain yields of the winter wheat in three of the four environments. Breakdown of phenolic acids depended on environment. Results for these studies indicate that wheat yield after a grain sorghum crop can be maximized by planting a red-pigmented sorghum hybrid of an early or medium maturity, desiccating the sorghum crop with pre-harvest glyphosate if it can be applied to the sorghum roughly 45 to 50 days before a frost, and with a wheat cultivar that is well suited to no-till planting.

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This research would not have been possible without the financial support provided by the Kansas Grain Sorghum Commission.

Dedication

To my wife, without her dedication, encouragement, and patience, none of this would have been possible.

To my sons, they never complained when time they deserved was not always shared.

To my father, mother, brother and sister, they have been in my heart through this journey.

Chapter 1 - Harvest and Residue Management of Grain Sorghum to Facilitate Wheat Planted after Grain Sorghum in No-till Systems

Introduction

Winter wheat (*Triticum aestivum* L.) is the number one planted crop in Kansas, and grain sorghum [*Sorghum bicolor* (L.) Moench] is fourth in planted area (NASS, 2015a). Based on data from 2011, Kansas ranks first in production nationally for both wheat and grain sorghum (NASS, 2015b). However, since the Federal Agriculture Improvement and Reform Act of 1996, planted areas of winter wheat and grain sorghum have declined 20.3% and 40.6% respectively (NASS, 2015a). Within that same time period, planted areas of corn (*Zea mays* L.) and soybean [*Glycine max*. (L.) Merr.] have increased 62% and 95.1%, respectively, in Kansas (NASS, 2015a). Trends in this data show the reduction in planted winter wheat areas could be partially attributed to increased planted areas of summer crops, such as corn and soybeans. Reduction in planted areas of grain sorghum may be due to the increased difficulty of managing a following winter wheat crop. In South Central Kansas, Claassen (2007) reported that wheat yields following grain sorghum were 671 kg ha^{-1} and 590 kg ha^{-1} less than wheat yields following soybean or corn, respectively. Grain sorghum harvest can be later compared to other summer crops, such as corn (Assefa et al., 2014), and although overall water use may be less compared to corn (Hattendorf et al., 1988), grain sorghum that is harvested later than corn may use more soil water later in the growing season (Assefa et al., 2014; Norwood and Currie, 1997) limiting the amount of available soil water for the following wheat crop. Management of winter wheat following summer crops can be challenging compared to wheat planted after a fallow period, but intensifying a crop rotation can improve the overall economics of a crop production system (Schlegel et al., 1999), and management strategies should be identified to facilitate a more intense crop rotation.

Planting dates of winter wheat often are delayed following summer crops. Optimum planting dates for winter wheat range from early September to the end of October (KSU, 1996). In Kansas, average corn harvest dates range from the beginning of September to the end of October, but grain sorghum typically is harvested in late September to the end of November (Assefa et al., 2014). Later harvest dates of grain sorghum may result in wheat planting dates being later following grain sorghum compared to other summer crops. In Wisconsin, reduction in wheat yields following corn and soybean was partially due to delayed planting dates in the fall (Lund et al., 1993). Research in Louisiana reported an average reduction of 717 kg ha^{-1} in wheat yields when wheat was planted late (Shah et al., 1994). Later planted wheat had fewer tillers developed in the fall, reduced the overall number of productive tillers. Research at Kansas State University showed that winter wheat planted in early November had 203 fewer productive fall tillers m^{-2} than wheat planted in early October (Thiry et al., 2002). Staggenborg et al. (2003) found that when following grain sorghum or soybeans, seeding rates of winter wheat required at least an additional 35 kg ha^{-1} above what was recommended for planting a continuous winter wheat crop. Increased planting rates following summer field crops may compensate for reduced tiller development in the fall.

Chemical desiccation of summer field crops could potentially result in an earlier harvest, thus facilitating a timelier planting of a following wheat crop. Grain sorghum harvest was 5 to 7 days earlier when glyphosate at 2.24 kg ha^{-1} and paraquat at 1.12 kg ha^{-1} were applied to the crop at 30% grain moisture (Gigax and Burnside, 1976). Diquat applied to sunflowers (*Helianthus annus* L.), prior to harvest, moved up harvest dates by 0 to 26 days, depending on timing of desiccation (Gubbels and Dedio, 1985). Although responses of summer crops to chemical desiccation have been well documented, there has been little research on the effects of desiccation on following crops. Grain sorghum can potentially use more soil water later in the growing season compared to corn (Norwood and Currie, 1997). Terminating the grain sorghum crop earlier in the fall could limit late season water use by the sorghum crop.

Conservation tillage practices such as reduced tillage and no-till can also improve soil water conservation. South Central Kansas research showed that residue cover in no-till systems was 47 to 68% greater compared to residue cover in conventionally-tilled systems (Claassen, 2007). Research in Southwest Kansas reported that following a 10 to 11 month fallow period available soil moisture in a 1.8 m soil profile at wheat planting was greater following corn (24.1 cm) and grain sorghum (24.9 cm) compared to soybean (22.4 cm) and sunflower (19.8 cm) (Norwood, 2000). Increased soil moisture at wheat planting following corn and grain sorghum could be due to increased surface residue (Norwood, 2000). Claassen (2007) reported that residue cover was 20% greater following corn and 19% greater following grain sorghum compared to following soybean, respectively. Results from a five-year study in Southwest

Kansas showed soil water content at corn and grain sorghum planting and water use efficiency (WUE) of both corn and grain sorghum was improved following no-till management compared to conventional-till management (Norwood and Currie, 1997). Soil water conservation could be one reason that surveys conducted by the Conservation Technology Information Center (CTIC) reported a 19% increase in no-till managed land from 1989 to 2008 (CTIC, 2015).

Crop residues also may impede the performance of following crops. Grain sorghum is one of many agricultural crops that have been identified to have phytotoxic effects on other crops (Narwal, 2004). Water extracts of corn, sorghum, oat, and wheat residues have been shown to inhibit growth of wheat seedlings (Guenzi et al., 1967). Roth et al. (2000) speculated that phytotoxic compounds leached out of the sorghum residue on the soil surface could have caused greater wheat yield reductions observed following no-till sorghum versus conventionally-tilled sorghum. Some researchers blame reductions in wheat yields following grain sorghum on nitrogen immobilization rather than phytotoxic compounds (Sanford and Hairston, 1983; Staggenborg et al., 2003). Wheat grown after a soybean crop had, 1.3 to 1.9 times greater nitrogen uptake compared to wheat that followed sorghum (Sanford and Hairston, 1983). Results from research conducted in Northeast Kansas found maximum wheat yields following grain sorghum required an additional 21.3 kg nitrogen (N) ha^{-1} compared to wheat that followed a soybean crop (Staggenborg et al., 2003). Kelley and Sweeney (2005), found that placing nitrogen fertilizer under the surface residue can increase winter wheat yields by as much as 0.5 Mg ha^{-1} compared to surface applied nitrogen in no-till and reduced till systems.

Grain sorghum is an important warm season crop in Kansas that is well adapted to arid environments, and has a place in Kansas cropping systems. A five-year study in Southwest Kansas by Norwood and Currie (1997) found WUE of grain sorghum was greater than corn when available soil water at planting was 3.2 to 7.0 inches compared to other years in the study when soil water content ranged from 6.7 inches to 12.6 inches. Within the same study, soil water content at corn and sorghum planting averaged 9.85 inches in no-till managed systems compared to 8.5 inches in conventionally-tilled systems. Increased available soil water provided by conservation tillage practices would facilitate a more intensive crop rotation. As conservation tillage practices, such as no-till, continue to increase (CTIC, 2015), it is important to identify management systems that will facilitate including both grain sorghum and winter wheat in crop rotations without negatively effecting grain yields. The objective of this study was to identify combinations of grain sorghum harvest and residue management techniques that are effective for improving the performance of the following winter wheat crop in no-till cropping systems.

Material and Methods

Experiments were conducted at six field locations over two growing seasons, 2011 to 2012 and 2012 to 2013, encompassing the grain sorghum – wheat cropping sequence at each location. Locations were selected that have environments suitable for planting winter wheat following grain sorghum (Table 1.1).

Grain sorghum was planted in 76-cm row spacing at all locations in both years. A four row planter (AGCO Corporation; Duluth, Georgia) was used at all locations except at Manhattan during the 2012 to 2013 growing season when a two row planter with John Deere (Deere & Company; Moline, Illinois) row units was used to plant the grain sorghum. Management practices of grain sorghum were based on Kansas State University recommendations for optimal grain production at each location (KSU, 1996; KSU, 1998). Prior to planting grain sorghum, glyphosate (N-[phosphonomethyl] glycine, in the form of its potassium salt); (Roundup WeatherMAX; Monsanto Company; St. Louis, Missouri) was used to control established weeds. Acetochlor (2-chloro-N-ethoxymethy-N-[2-ethyl-6-methylphenyl] acetamide plus atrazine 9 (2-chloro-4-[ethylamino]-6-[isopropylamino]-s-triazine); (Degree Xtra; Monsanto Company; St. Louis Missouri) was used as a pre-emergence residual herbicide to control early season weed establishment. Early-maturing grain sorghum hybrids were selected to facilitate post-harvest wheat planting at each location (Table 1.2). Inter-row cultivation was used to control weeds that escaped the residual herbicide application at the Ottawa location. The center two rows of the grain sorghum crop were harvested using a commercial combine (Model EIII, AGCO Corporation; Duluth, Georgia) modified to harvest and weigh grain from two-row plots, except at Hutchinson in 2012. Above normal summer temperatures and late fall rains resulted in the sorghum crop not being harvested at Hutchinson in 2012. Enough biomass was produced by the sorghum crop to continue the study, and sorghum was mowed to simulate combine harvest at Hutchinson in 2012 (Table 1.2). Grain yields were adjusted to 125 g kg^{-1} grain moisture (Stone and Schlegel, 2006).

Winter wheat was planted in 19-cm row spacing except at Hutchinson where it was seeded in 25.5 cm row spacing. Management practices of winter wheat were based on Kansas

State University recommendations for optimal grain production following grain sorghum at each location (KSU, 1996; KSU, 1997). Winter wheat grain yields were obtained by harvesting the center of the plots with a commercial combine (model EIII; AGCO Corporation, Duluth, GA) modified to harvest and weigh grain using a 1.75-m header. Grain yields of winter wheat were adjusted to 125 g kg^{-1} grain moisture. Winter wheat cultivars, planting dates, and harvest dates are presented in Table 1.2.

Experimental design at each location was a randomized complete block with four replications. Treatment structure was a 3 x 3 x 2 factorial combination of treatments that were applied either to the grain sorghum crop or the sorghum residue following sorghum harvest. Treatment factors were: glyphosate (pre-harvest, postharvest, untreated), residue (chopped, removed, untreated), and nitrogen (applied, untreated). Plot size was 3 m wide and 9 m long, except at Manhattan in 2011 to 2012 where plot size was 3 m wide and 15.25 m long. Dates of treatment applications are presented in Table 1.3.

Glyphosate treatments were made to the center 1.8 m of each plot using a CO_2 pressurized backpack sprayer with a six-nozzle spray boom (R & D Sprayers; Opelousas, LA). Pre-harvest glyphosate treatments were applied to the grain sorghum crop before harvest when grain moisture was 250 g kg^{-1} or less to minimize grain yield losses (Gigax and Burnside, 1976), and at least 7 days before harvest to meet label restrictions (Monsanto, 2009). The full rate of 2.12 kg ae ha^{-1} recommended for pre-harvest desiccation of grain sorghum was used and was applied in a spray volume of 140 L ha^{-1} (Monsanto, 2009). Postharvest applications of glyphosate were sprayed on the standing residue following grain sorghum harvest (Table 1.3) at the same quantities and rates used in the pre-harvest glyphosate treatments.

Residue treatments were imposed on the plots at least 6 days after the postharvest glyphosate treatment (Table 1.3). A 1.5 m wide flail mower (model CP60; Rhino; Gibson City, IL) was used to chop and shred the grain sorghum residue within treated plots. In 2011, a plot forage harvester (Carter Manufacturing Company, Inc.; Brookston, IN) was used to remove the above ground grain sorghum biomass. In 2012, a walk-behind sickle bar mower (model 718 harvester series; BCS America; Portland OR) was used to mow down standing grain sorghum residue, and then the sorghum residue was removed entirely from the treated plots by raking. Grain sorghum residue was left standing in untreated plots.

The nitrogen treatment was imposed by applying liquid UAN [28-0-0 (N-P-K)] down the center of the treated plot using the same CO_2 pressurized backpack sprayer and spray boom as was used with the glyphosate treatments. Nitrogen was applied at 34 kg ha^{-1} to the treated plots after residue treatments had been imposed (Table 1.3).

Percent cover of grain sorghum residue was quantified once during the winter at each location after winter wheat was planted, but before green up of winter wheat. Percent residue cover was estimated using the line transect method (KSU, 1989). A 15.25 m long tape measure was placed in each plot in a zig-zag pattern and the number of instances where residue intersected the tape at 15 cm intervals was counted. Two counts were made within each plot. Percent residue cover was determined by dividing the number of intersections by the total number of 15 cm intervals and multiplying by 100.

Two, 1 m length rows were randomly selected within each plot to evaluate the growth and development as well as yield components of the winter wheat crop throughout the season. Winter wheat emergence, plant density, fall and spring tiller numbers, and height were recorded to quantify the growth and development of the winter wheat crop. Yield components of winter wheat recorded were spikes m^{-2}, kernels spike $^{-1}$, and kernel size.

Emergence of winter wheat was evaluated at Manhattan in 2011. Stand counts were taken daily until emergence ceased. Emergence promptness index (EPI)

$$EPI = \sum_{i=1}^{15} (\frac{n}{i})$$

was calculated to quantify how quickly winter wheat emerged where n = number of emerged seedlings and i = days after planting (Roth et al., 2000). Population counts were taken between Feekes 1.0 and 2.0 growth stages (emergence to beginning tillering), and fall tiller counts were taken during the Feekes 2.0 to 3.0 growth stages (beginning tillering to tillers formed). Because later planting and cool fall temperatures delayed emergence, fall tiller numbers were not recorded for the Manhattan and Hutchinson locations during the 2012 to 2013 growing season. Total number of tillers was counted again in early spring when the wheat was at the Feekes 2.0 to 4.0 growth stages (beginning tillering through beginning of erect growth). Plant height was measured at approximately Feekes 10.5.4 growth stage (early grain fill). To obtain plant height values for each plot, plants were measured from the soil surface to the tip of the spike at three random spots within each plot and averaged. Just prior to wheat grain harvest, all plants within the two 1 m rows were removed for analysis of yield components. Spikes were counted to determine spikes m^{-2}, and then 50 spikes were randomly selected and threshed using a wheat head thresher (Precision Machine Co. Inc.; Lincoln NE). Kernels were collected and counted using a seed counter (model 801 COUNT-A-PAK; Seedburo Equipment Co.; Des Plaines, IL) and then weighed to determine kernel weight (g 1000 $seed^{-1}$) and to calculate kernels spike $^{-1}$. If the two 1 m rows contained fewer than 50 spikes, all spikes within those two 1 m rows were used to determine kernels $spike^{-1}$ and kernel weight.

Analysis of variance (ANOVA) was performed to evaluate treatment main effect differences and their interactions using PROC GLIMMIX in SAS 9.2 (SAS, 2009) statistical analysis software with environment, glyphosate treatment, residue treatment, and nitrogen treatment as fixed effects and replication as a random effect. Grain sorghum and winter wheat response variables were analyzed across environments to determine if environment influenced response to the treatments.

Results

Weather

During the 2011 grain sorghum growing season (May/June to September/October) precipitation was less than normal in all months at Manhattan and Ottawa and in May, September, and October at Belleville (Figure 1.1). Precipitation amounts for June, July, and August were above normal at Belleville, but during the winter wheat growing season (October 2011 to June 2012) precipitation was less than normal in most months. This was also true for the Manhattan and Ottawa locations during the 2011 to 2012 growing season, except that during early season development of winter wheat (November and December) and spring green up (February and March), precipitation quantities were above normal. Precipitation amounts for the 2012 to 2013 growing season at all locations were below normal in most months for both grain sorghum and winter wheat crops (Figure 1.1).

Maximum temperatures during both growing seasons (2011 through 2013) and at all locations were above normal in most months (Figure 1.2). Exceptions were in 2013 when maximum temperatures during winter and early spring (January through April) were often below normal. Minimum temperatures tended to be below normal for most of the 2012 to 2013 growing season in Belleville and Hutchinson. Manhattan, 2012, maximum temperatures were slightly below normal during grain sorghum harvest and wheat planting (September and October) (Figure 1.2). Minimum temperatures also were below normal or only slightly above normal at all six environments during this same time period (Figure 1.3). Fall freeze dates in 2011 were later than normal at all three locations compared to 2012 when all fall freeze dates occurred earlier than normal (Tables 1.1 and 1.3).

Grain Sorghum

Of the three treatment factors, pre-harvest glyphosate application was the only one imposed before grain sorghum harvest and therefore the only one that potentially could influence grain sorghum yield. There was no interaction of sorghum response to pre-harvest glyphosate application with environment (environment x glyphosate for all response variables Pr > F, > 0.4 for all response variables), so the treatment means for grain sorghum were averaged over all locations and both growing seasons. Pre-harvest applications of glyphosate did not significantly influence grain yield or test weight ($\alpha = 0.05$). Grain sorghum yield was 6212 kg ha^{-1} and test weight was 776 kg m^{-3} averaged across all environments. Grain moisture was 2 g kg^{-1} less following the glyphosate treatment, but this difference would likely not affect harvest management practices. Gigax and Burnside (1976) found that grain sorghum harvest was 2 days earlier when applications of pre-harvest glyphosate where made to grain sorghum at 250 g kg^{-1} grain moisture compared to grain sorghum that was untreated, and applications of pre-harvest glyphosate to the sorghum crop at 300 g kg^{-1} grain moisture resulted in sorghum harvest being 5 to 7 days earlier than untreated grain sorghum. Yield reductions in grain sorghum following chemical desiccation treatments were associated with number of lodged sorghum plants in those studies (Gigax and Burnside, 1976). No plant lodging was noted in this study following pre-harvest glyphosate treatments in any of the six environments.

Analysis of variance for percent sorghum residue cover revealed significant environment x treatment interactions. Environment x residue x nitrogen (Pr > F = 0.0437), environment x residue (Pr > F = <0.0001), and environment x glyphosate (Pr > F = 0.0018) were significant. Therefore, residue cover responses to treatment factors were analyzed separately for each environment.

In Belleville, 2011 to 2012, there was a glyphosate x residue interaction (Pr > F = 0.0092) for residue cover. Examination of the interaction showed that pre-harvest glyphosate applications coupled with untreated and chopped residue treatments reduced sorghum residue cover by 10.9 and 7.3%, respectively, compared to untreated and chopped residue treatments that had no glyphosate application (Figure 1.4). When residue was removed from the soil surface, glyphosate applications did not impact residue cover.

Percent sorghum residue cover responded to at least one treatment main effect at every location (Table 1.4). Pre-harvest glyphosate reduced percent residue cover compared to postharvest and untreated glyphosate treatments at Ottawa and Belleville in the 2011 to 2012 growing season, and a similar trend was evident at most other locations. Field observations indicated that grain sorghum plants treated with pre-harvest glyphosate in 2011 resulted in plants showing visible injury symptoms, such as dry and brittle leaves, well before the killing frost. Pre-harvest glyphosate treatments were applied 22 to 50 days before the first fall freeze in 2011 compared to just 0 to 17 days before the first fall freeze in 2012 (Table 1.3). This additional time in 2011 allowed pre-harvest glyphosate treatments to be more effective in terminating the grain sorghum plant. The more brittle residue of the grain sorghum treated with pre-harvest glyphosate could have been removed or destroyed more easily by wind or planting equipment than residue that was not treated with pre-harvest glyphosate. As expected, percent sorghum residue cover was always greatest where sorghum residue was untreated, and percent sorghum residue cover was always least following treatments where residue was removed (Table 1.4). Additional application of nitrogen did not impact percent sorghum residue cover in any of the six environments.

Winter Wheat

Treatment x environment interactions occurred for all response variables except plant height and kernel size (Table 1.5). Analysis showed no significant treatment main effect or interaction for plant height or kernel weight, so data are not presented for those two variables. Analysis was performed by environment for all other wheat variables. Winter wheat growth and development, yield components, and grain yields were influenced by glyphosate, residue, and nitrogen treatments, as well as various treatment interactions. When treatment interactions did not occur, wheat responses are discussed as main effects for each location in each growing season.

Grain Yield

Wheat yields were influenced by glyphosate, residue and nitrogen treatments at all six environments (Table 1.6). Glyphosate treatments increased wheat yields at Manhattan and Ottawa in 2012 compared to postharvest and untreated glyphosate treatments. Glyphosate treatments did not influence wheat yields in 2013 in any environment. Grain sorghum planting dates at Manhattan and Ottawa in 2012 were earlier than all other environments, resulting in an earlier harvest (Table 1.2). This allowed pre-harvest glyphosate treatments to be applied 45 to 50 days before the first frost at Manhattan and Ottawa in 2012, respectively (Table 1.3). First frost dates were 12 to 13 days earlier in 2013 than in 2012 at all locations (Table 1.3). Untreated sorghum residue resulted in wheat yields that were superior or equal to yields of the other residue treatments in all six environments (Table 1.6). When sorghum residue was removed from the soil surface, wheat yields were reduced compared to wheat yields following untreated sorghum residue at Belleville in 2012, and at all three locations in 2013. Chopped sorghum residue reduced wheat yields compared to untreated residue at all locations except Ottawa in 2012 and Manhattan in 2013. Wheat yields were greater following chopped residue compared to residue that was removed at Belleville in 2012 and Hutchinson in 2013. Additional applications of nitrogen fertilizer to the sorghum residue increased the following winter wheat grain yields by 272 kg ha^{-1} at Ottawa in 2012, but did not affect grain yields at any of the other five environments (Table 1.6).

Growth and Development

Residue removal reduced EPI compared to untreated residue at the Manhattan location in 2011. Emergence promptness index values were 46.2 when residue was removed compared to 54.6 when residue was chopped and 54.0 when residue was untreated. Glyphosate and nitrogen treatments did not influence emergence rates of winter wheat. A precipitation event after wheat planting, and slightly above normal temperatures (Figure 1.2), resulted in soil crusting where residue was not present on the soil surface, inhibiting wheat seedling emergence.

Treatments affected plant density in three of the six environments (Table 1.7). Pre-harvest glyphosate increased plant density in Ottawa (2011) compared to the untreated glyphosate treatment. Plant density was greatest following either untreated residue or chopped residue at Belleville in both years and at Ottawa in 2011 (Table 1.7). Plant density was not impacted by nitrogen treatments at any of the six environments.

No fall tillers were formed at Manhattan or Hutchinson in 2012 (Table 1.8) due to delays in emergence caused by dry conditions and cool fall temperatures. Pre-harvest and postharvest glyphosate treatments increased fall tiller numbers at Ottawa in 2011. In 2011, fall tiller numbers at Manhattan were greatest following untreated residue, and at Ottawa chopped residue increased fall tillers compared to untreated residue (Table 1.8). Removing residue at Belleville in 2012 reduced fall till numbers compared to when residue was chopped or untreated. Nitrogen did not influence fall tiller numbers at any environment.

Spring tiller numbers were influenced by an interaction of residue and nitrogen treatments ($Pr > F = 0.0441$) at Ottawa in 2012 (Figure 1.5). When no additional nitrogen was applied, chopping sorghum residue reduced spring tiller numbers. There was no significant difference between other residue and nitrogen treatment combinations. In 2013, spring tiller numbers were greater at Belleville following glyphosate treatments compared to no-glyphosate application (Table 1.9). Spring tillers were less when residue was removed in 2012 at Belleville, and at all three locations in 2013. Chopping sorghum residue decreased spring tillers at Belleville in 2013 compared to residue that was untreated. When nitrogen was applied to the sorghum residue, spring tiller numbers were greater only at Belleville in 2012 (Table 1.9).

Yield Components

In 2013, there was a glyphosate x residue interaction at Belleville ($Pr > F = 0.0497$), and a glyphosate x nitrogen interaction at Manhattan ($Pr > F = 0.0077$) for spike density (Figure 1.6a and b). At Belleville, when sorghum residue was chopped, the addition of pre-harvest glyphosate increased spikes m^{-2} by 122 compared to residue that was chopped without glyphosate applied (Figure 1.6a). Removing residue reduced spike density for all glyphosate treatments. At Manhattan, glyphosate treatments coupled with nitrogen applications reduced spike density, but had the opposite effect without nitrogen application (Figure 1.6b). When glyphosate was applied in addition to nitrogen, spike density declined by 72 spikes m^{-2}, but increased by 95 spikes m^{-2} when sorghum was treated with glyphosate and no nitrogen. At Manhattan in 2012, spike density numbers of winter wheat were increased following grain sorghum treated with pre-harvest glyphosate compared to untreated grain sorghum (Table 1.10). Spike density was reduced when residue was removed from the soil surface at Belleville in 2012. In 2013, chopping sorghum residue and removing sorghum residue decreased spike density at Hutchinson. Nitrogen treatments did not influence spike density in 2012 or 2013 (Table 1.10).

Response of kernels spike^{-1} to residue treatments differed depending on glyphosate and nitrogen treatments at Belleville in 2013 (Figure 1.6c and d). Removing residue reduced kernels spike^{-1} with postharvest glyphosate application, but untreated residue resulted in fewer kernels spike^{-1} when no glyphosate was applied (Figure 1.6c). Residue treatment had no effect with pre-harvest glyphosate application. With no nitrogen application, kernels spike^{-1} were less if no residue treatments were imposed compared to chopping or removing residue. Pre-harvest glyphosate treatments increased number of kernels spike^{-1} at Manhattan in 2012 (Table 1.11). Removing the sorghum residue increased kernel numbers spike^{-1} compared to sorghum residue that was either chopped or untreated at Manhattan in 2012, but at Belleville during the same year, kernels numbers spike^{-1} increased following sorghum residue that was either chopped or untreated. Nitrogen treatments did not influence number of kernels per spike in 2012 or 2013.

Discussion

Wheat response to glyphosate treatments primarily occurred during the 2011 to 2012 growing season at Manhattan and Ottawa. In 2011, pre-harvest glyphosate treatments were applied 22, 45, and 50 days before the first freeze at Belleville, Manhattan, and Ottawa, respectively (Table 1.3). Until grain sorghum is terminated by freezing temperatures it continues using water (Stone et. al., 2002). Desiccation of the grain sorghum crop using glyphosate prior to the first freeze at Manhattan and Ottawa in 2011 likely prevented the grain sorghum from using additional soil water and nutrients. Evidence of this can be seen in the growth and development, yield components, and grain yields of winter wheat at both locations. Precipitation was below normal for most of the grain sorghum growing season at both Manhattan and Ottawa, reducing soil water content in late summer and early fall. In Ottawa, approximately 39 mm of precipitation was received 18 to 19 days following glyphosate treatments, 21 days before wheat was planted, and 29 days before the first freeze (data not shown). No other significant precipitation events occurred at Ottawa until November. Increased plant density and fall tiller numbers in wheat following grain sorghum treated with pre-harvest glyphosate compared to wheat following untreated grain sorghum was likely due to more available soil water early in the growing season. In more arid environments of Western Kansas, Stone and Schlegel (2006) found that for every 1 cm of additional water at emergence wheat yields increased 98 kg ha^{-1}. Glyphosate effects were not detected at Manhattan in 2011 due to precipitation events that occurred 4-8 days after wheat planting, thus, stimulating wheat seedling growth. Below normal precipitation in April and May at Manhattan in 2012 (Figure 1.1) resulted in spike density and kernels spike^{-1} being increased following grain sorghum treated with glyphosate pre-harvest. Owing to 91 mm of precipitation at Feekes 5 (leaves becoming strongly erect), yield components of wheat were not improved at Ottawa in 2012. Precipitation amounts were above normal during the grain sorghum growing season at Belleville in 2011 (Figure 1.1), but conditions remained dry for the remainder of the study. Average daily temperature and relative humidity for the seven days following pre-harvest glyphosate treatments in 2011 were 9.25 °C and 4.75 °C warmer and 10.9% and 15.5% greater at Ottawa and Manhattan, respectively, compared to Belleville. Adkins et al. (1998) reported when soil moisture conditions were favorable, the efficacy of glyphosate was improved with warmer temperatures and increased relative humidity.

During the second growing season, glyphosate treatments were made at the time of the first freeze at Manhattan and Hutchinson, limiting the effect of glyphosate on the grain sorghum. At Belleville in 2012, glyphosate treatments were made 17 days before the first freeze, but other than spring tiller development, treatments had no effect on the following wheat crop.

Pre-harvest glyphosate treatments may have prevented or inhibited allelopathic compounds from interacting with the wheat. Phenolic acids are phytochemical compounds that are often associated with allelopathy (Ben-Hammouda, et al., 1995; Taiz and Zeiger, 2010). Glyphosate disrupts the shikimate pathway, which is the primary pathway where many phenolic compounds are synthesized (Taiz and Zeiger, 2010). Early termination of the sorghum crop would allow more time for phytotoxic chemicals to be leached out of the residue and broken down. Past investigations have found that allelochemicals can remain toxic for 8 to 22 weeks depending on crop species (Guenzi et. al., 1967), and environmental conditions such as precipitation may influence the toxic effects of crop residues (Cochran et. al., 1977).

Precipitation amounts in both growing seasons often were below normal (Figure 1.1). Increased surface residue in no-till systems (Claassen, 2007) can help reduce water losses by preventing runoff and evaporation (Norwood, 1994). Visual observations were made in the field where residue left undisturbed caught more snowfall during the winter. Norwood (2000) found that crop residues from soybeans and sunflowers were not as valuable as corn or grain sorghum for conserving soil moisture. Claassen (2007) reported 20% and 19% greater residue cover following corn and grain sorghum, respectively, compared to soybeans. The overall improvement of wheat performance following untreated sorghum residue was likely due to its ability to catch more snowfall compared to treatments where residue was chopped or removed. Chopped residue increases the surface area of the residue that is in contact with the soil surface increasing the potential for residue breakdown. Immobilization of nitrogen is increased when residue is chopped and spread over the soil surface compared to residue that is tilled into the soil (Schomberg et al., 1994). Research by Rice and Smith (1984) found that 7 to 10% more of the fertilizer applied was immobilized after 35 days in no-till systems compared to conventional tilled systems. Purvis (1990) concluded that inhibition of wheat seedling growth was not due to immobilization of nitrogen by crop residues, but by phytochemicals released from residues hindering the crops ability to use nitrogen. Research conducted by Booker et al. (1992) found that 200 µM of ferulic acid hindered nitrate uptake by cucumber seedlings.

Nitrogen treatments did not improve early growth and development of winter wheat in any environment (population and/or fall tillers), but some positive responses were observed in the spring at Ottawa (2012) and Belleville (2013), with overall grain yields being improved at Ottawa (2012). Ottawa grain sorghum yields were 3156 to 5987 kg ha^{-1} less than other environments (data not shown). Due to lower grain yields, nitrogen content of the sorghum residue could have been greater compared to other locations. Additional nitrogen applied to the residue in the fall, coupled with increased nitrogen content in the sorghum residue would likely increase mineralization of nitrogen. Wagger et al. (1985) found that sorghum residues incorporated into silt loam soils with nitrogen fertilizer had approximately 14% more nitrogen mineralized compared to residues with no nitrogen fertilizer.

Conclusion

Below normal precipitation across all environments made conditions drier than normal for both growing seasons in this study. In these conditions the performance of winter wheat planted after grain sorghum can be improved by sorghum harvest and residue management techniques. Terminating grain sorghum prior to harvest using glyphosate required that glyphosate applications be made 45 to 50 days before the first freeze to maximize winter wheat grain yields. Undisturbed sorghum residue did not negatively affect winter wheat performance in any environment compared to residue that had been chopped or removed. Improvements in wheat performance following undisturbed sorghum residue could be attributed to the ability of the standing sorghum stalks to catch and hold more snowfall during the winter months. Winter wheat planted after grain sorghum that had lower grain yields (3093 kg ha^{-1}) positively responded to additional nitrogen applied to the sorghum residue in the fall.

Figures and Tables

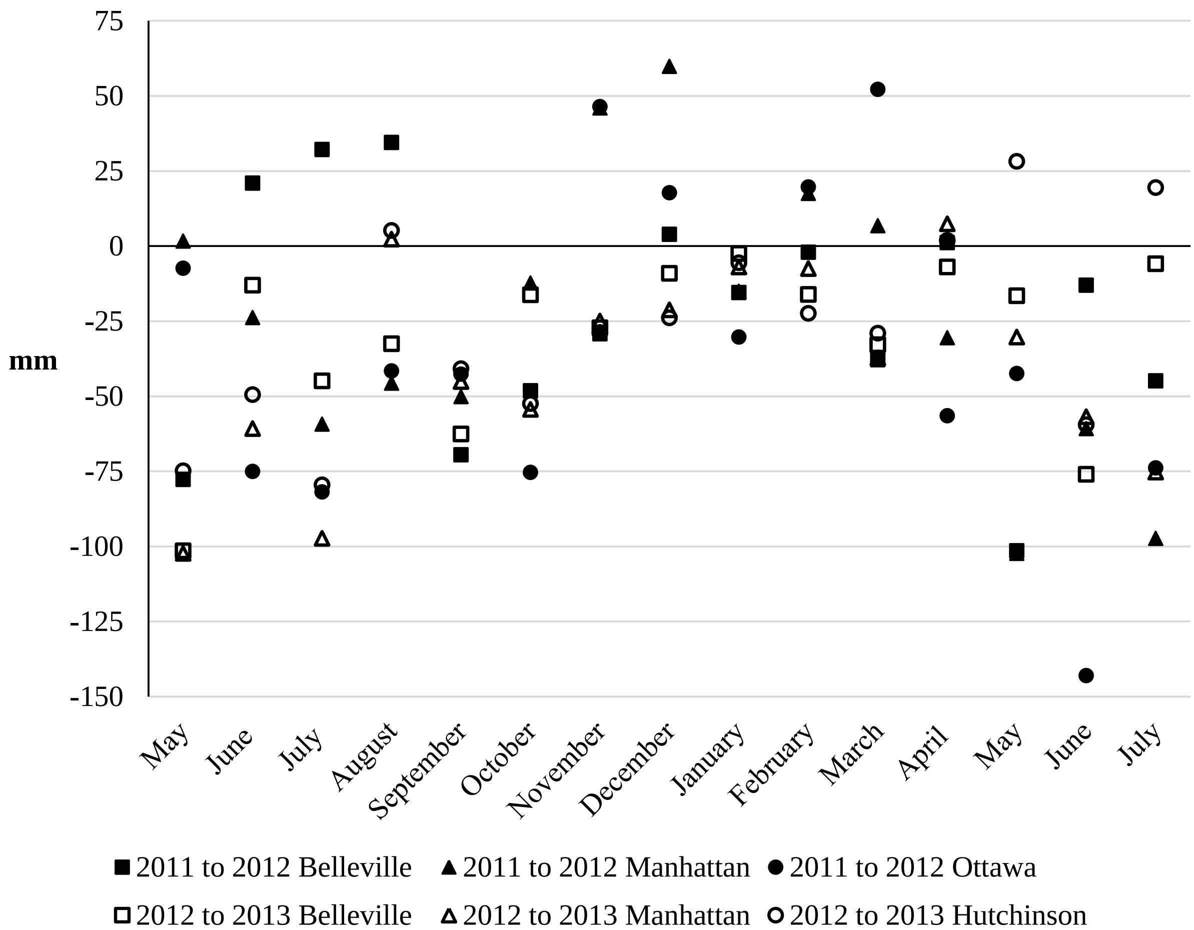

Figure 1.1 Monthly precipitation departure from normal for six environments in Kansas from May 2011 to July 2013.

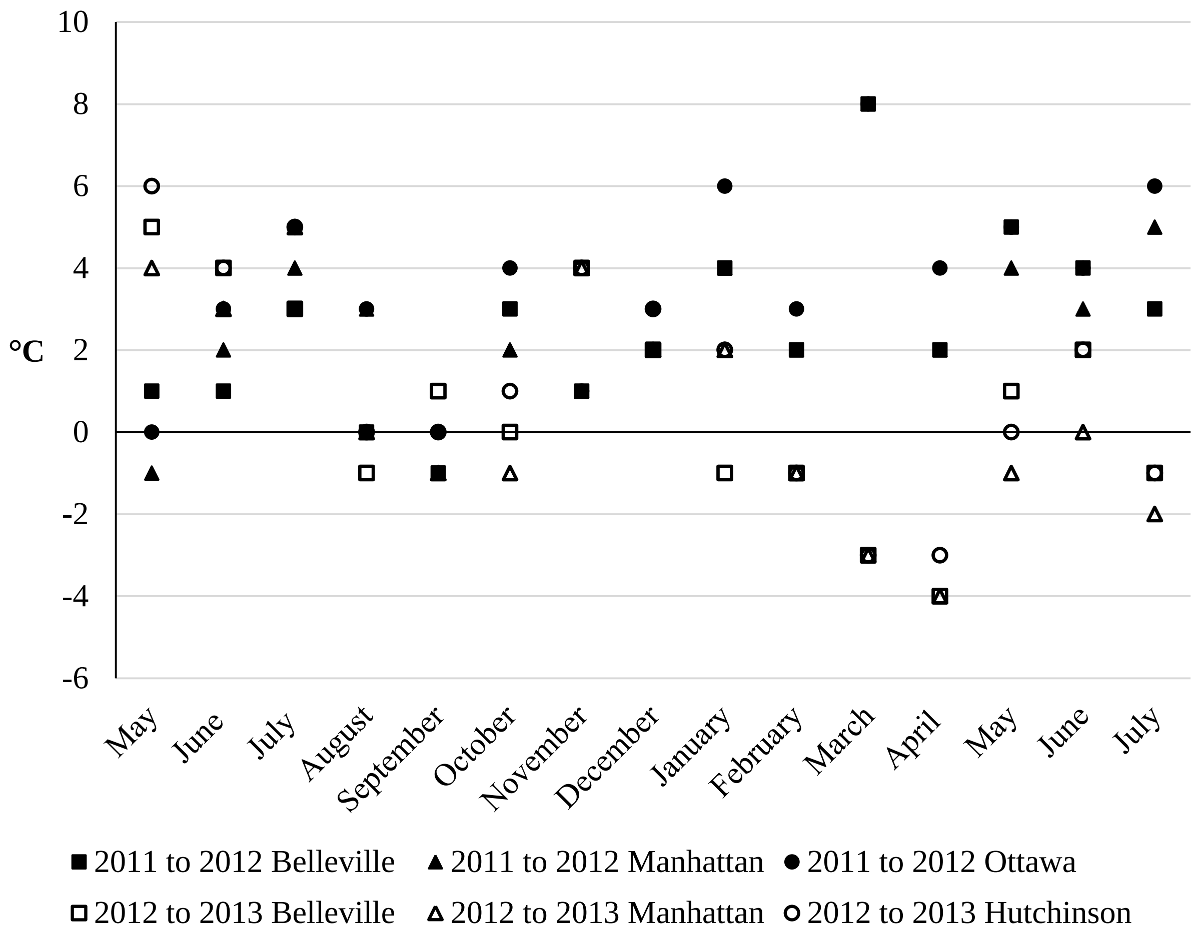

Figure 1.2 Monthly maximum temperature difference from normal for six environments in Kansas from May 2011 to July 2013.

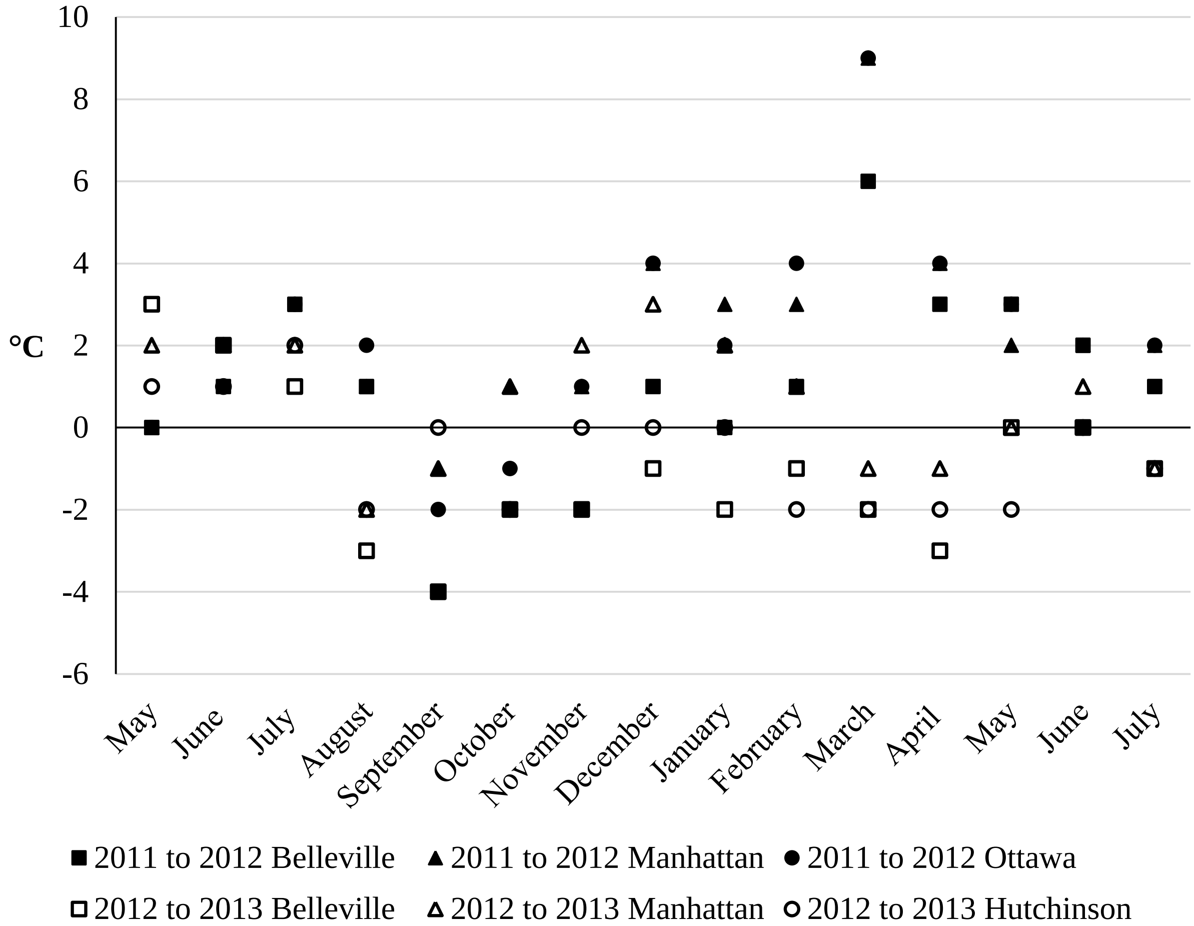

Figure 1.3 Monthly minimum temperature difference from normal for six environments in Kansas from May 2011 to July 2013.

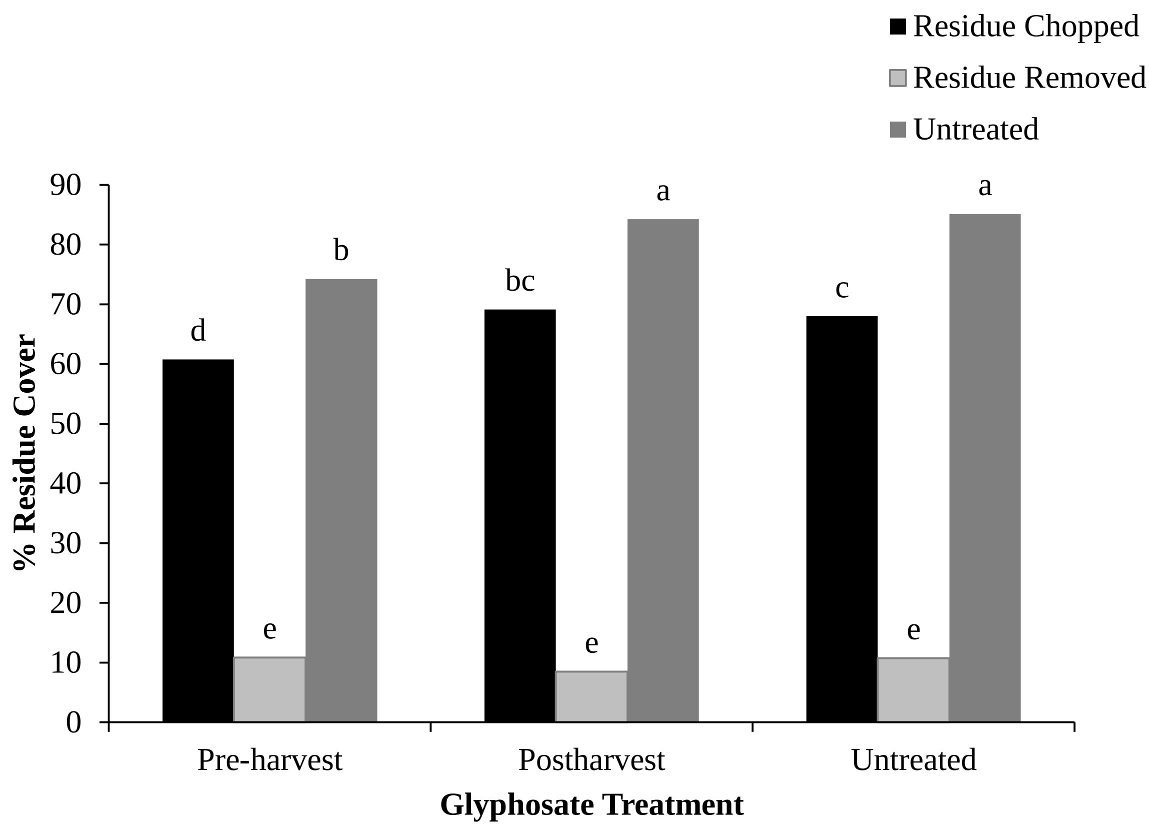

Figure 1.4 Response of sorghum residue cover to glyphosate and residue treatments at Belleville in 2011 to 2012.

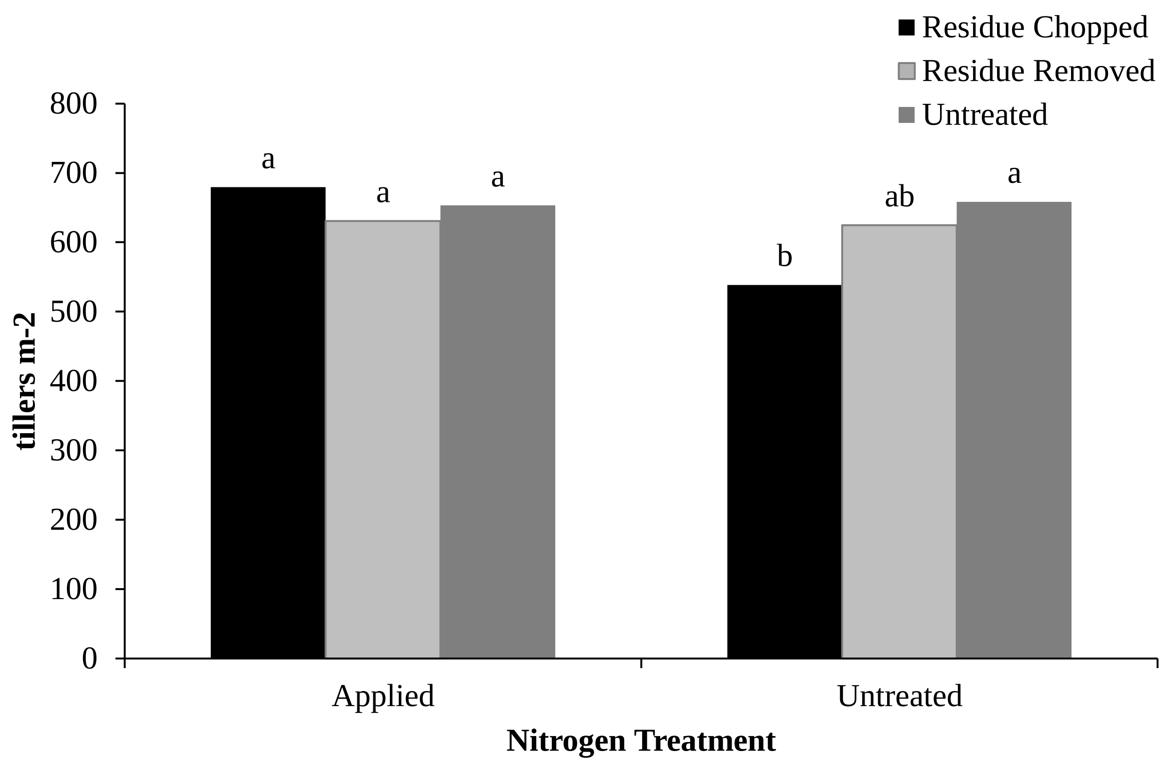

Figure 1.5 Response of spring tillers to nitrogen and residue treatments at Ottawa in 2011.

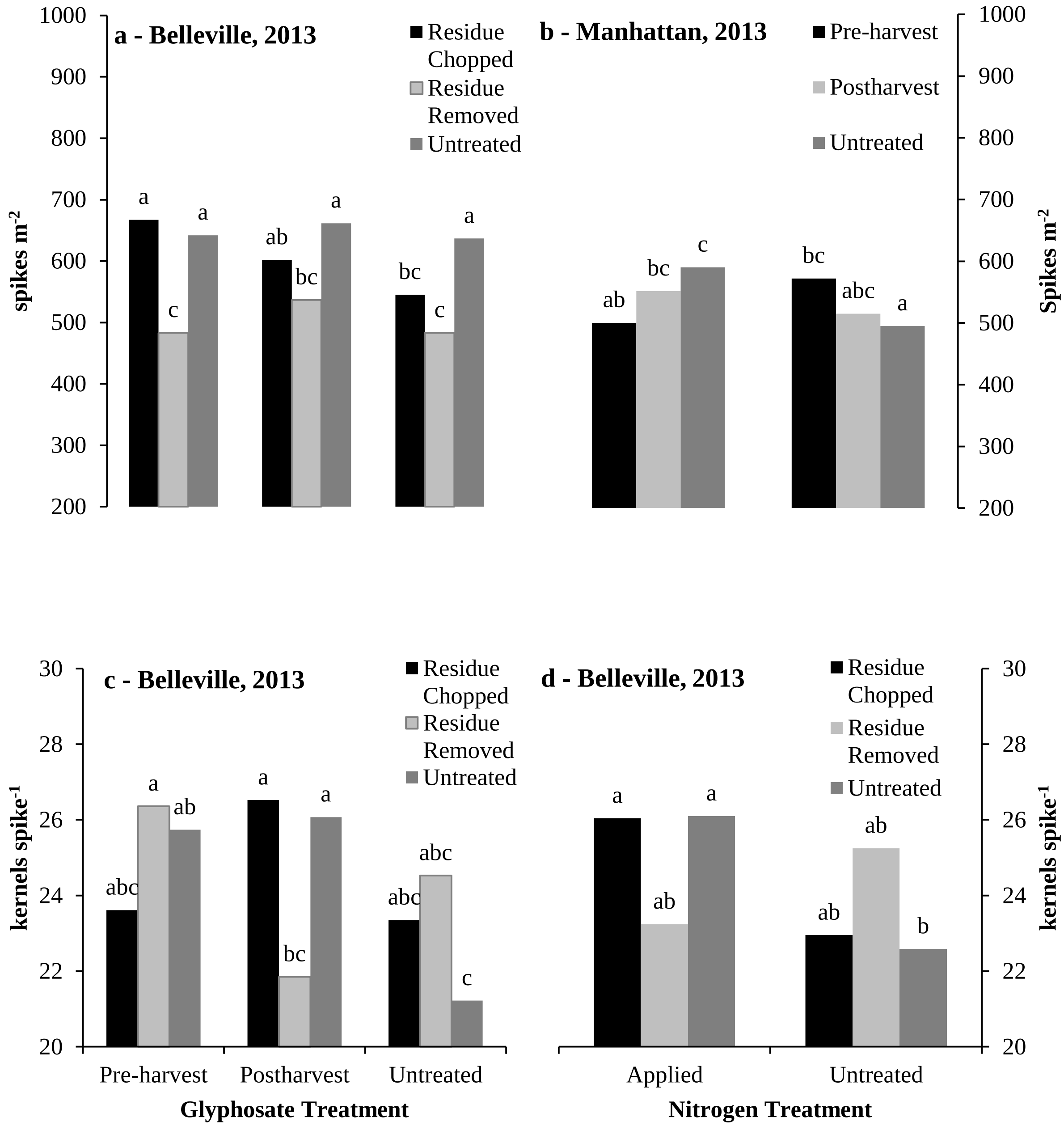

Figure 1.6 Response of a) spike density to nitrogen and glyphosate treatments at Belleville, 2013 b) spike density to glyphosate and residue treatments at Manhattan, 2013 c) kernels spike^{-1} to glyphosate and residue treatments at Belleville, 2013 d) kernels spike^{-1} to nitrogen and residue treatments at Belleville, 2013. Bars within each environment followed by the same letter are not significantly different (α = 0.05).

Table 1.1 Environmental descriptions for six field locations used to evaluate harvest and residue management practices of grain sorghum to facilitate planting wheat following grain sorghum in no-till systems in Kansas.

Location	Coordinates	Soil Series	Soil Classification	Normal Freeze Dates		Frost Free Days	Precipitation
				Spring	Fall		cm
2011 to 2012							
Belleville	39.816053, -97.674892	Crete silt loam	Fine, smectitic, mesic Pachic Udertic Argiustolls	21-Apr	4-Oct	176	77.7
Manhattan	39.112264, -96.612778	Chase silty clay loam	Fine, smectitic, mesic Aquertic Argiudolls	18-Apr	15-Oct	179	90.5
Ottawa	38.540022, -95.242522	Woodson silt loam	Fine, smectitic, thermic Abruptic Argiaquolls	15-Apr	17-Oct	185	102.0
2012 to 2013							
Belleville	39.815275, -97.674842	Crete silt loam	Fine, smectitic, mesic Pachic Udertic Argiustolls	21-Apr	4-Oct	176	77.7
Hutchinson	37.956125, -98.1218	Taver loam	Fine, smectitic, mesic Udertic Argiustolls	19-Apr	17-Oct	183	77.8
Manhattan	39.122158, -96.638072	Reading silt loam	Fine-silty, mixed, superactive, mesic Pachic Argiudolls	18-Apr	15-Oct	179	90.5

Table 1.2 Grain sorghum hybrid, wheat cultivar, and planting and harvest dates for six environments in Kansas.

	Grain Sorghum			Winter Wheat		
Location	Hybrid	Planting date	Harvest date	Cultivar	Planting date	Harvest date
2011 to 2012						
Belleville	DKS 28-06	13-Jun	6-Oct	Everest	13-Oct	18-Jun
Manhattan	DKS 36-06	16-May	13-Sep	Everest	4-Oct	7-Jun
Ottawa	DKS 36-06	9-May	8-Sep	Everest	11-Oct	6-Jun
2012 to 2013						
Belleville	DKS 28-06	29-May	27-Sep	Everest	9-Oct	5-Jul
Manhattan	DKS 36-06	6-Jun	15-Oct	Everest	24-Oct	2-Jul
Hutchinson	DKS 36-06	4-Jun	16-Oct	Everest	25-Oct	2-Jul

Table 1.3 Glyphosate, residue, and nitrogen treatment application dates and first freeze dates for six environments in Kansas.

		Treatment				
		Glyphosate		Residue		
Location	First Freeze	Pre-harvest	Postharvest	Chopped	Removal	Nitrogen
2011						
Belleville	18-Oct	26-Sep	7-Oct	13-Oct	13-Oct	14-Oct
Manhattan	18-Oct	2-Sep	15-Sep	21-Sep	21-Sep	22-Sep
Ottawa	19-Oct	30-Aug	8-Sep	15-Sep	15-Sep	15-Sep
2012						
Belleville	6-Oct	19-Sep	2-Oct	9-Oct	9-Oct	9-Oct
Manhattan	6-Oct	5-Oct	17-Oct	24-Oct	24-Oct	24-Oct
Hutchinson	6-Oct	7-Oct	16-Oct	25-Oct	25-Oct	25-Oct

Table 1.4 Percent grain sorghum residue cover response to glyphosate, residue, and nitrogen treatments.

		Environment											
		2011 to 2012						2012 to 2013					
Treatment		Manhattan		Belleville		Ottawa		Manhattan		Belleville		Hutchinson	
		(%)											
Glyphosate	Pre-harvest	25.2	a†	–		30.3	b	49.1	a	66.9	a	34.8	a
	Postharvest	29.3	a	–		31.2	a	51.0	a	67.8	a	35.4	a
	Untreated	31.7	a	–		37.9	a	51.1	a	66.7	a	32.1	a
Residue	Chopped	28.6	b	–		41.4	a	70.4	a	92.3	b	47.7	a
	Removed	20.0	c	–		16.0	b	10.2	b	14.2	c	5.9	b
	Untreated	37.5	a	–		41.9	a	70.7	a	94.8	a	48.3	a
Nitrogen	Applied	27.6	a	53.4	a	31.9	a	50.3	a	67.4	a	35.0	a
	Untreated	29.9	a	51.4	a	34.3	a	50.6	a	66.8	a	32.9	a

† Column means within each treatment followed by the same letter are not significantly different (α = 0.05).

Table 1.5 Main effects and interaction effects of glyphosate, residue, and nitrogen treatments on winter wheat response variables across all six environments.

Source of Variation	Grain yield	Plant density	Fall tillers	Spring tillers	Plant height	Spike density	Kernels per spike	Kernel size
	Pr > F							
Env†	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
G	<0.0001	0.0138	0.0019	0.6418	0.1372	0.0145	0.2257	0.9041
R	<0.0001	<0.0001	0.3216	<0.0001	0.2866	<0.0001	0.1290	0.5925
N	0.0968	0.5470	0.0482	0.0068	0.6783	0.1855	0.1498	0.4781
G x R	0.6171	0.1423	0.8978	0.9266	0.6230	0.7502	0.2965	0.1921
G x N	0.6001	0.6152	0.4771	0.7340	0.4993	0.1080	0.8358	0.9293
R x N	0.3057	0.5520	0.6300	0.8633	0.3934	0.5703	0.1380	0.4355
G x R x N	0.6935	0.4859	0.4418	0.5841	0.3991	0.4682	0.7376	0.2787
Env x G	<0.0001	0.4236	0.0832	0.4396	0.3557	0.1970	0.2257	0.1810
Env x R	<0.0001	<0.0001	0.0005	0.0016	0.0705	<0.0001	0.0002	0.1024
Env x N	0.0123	0.9681	0.5422	0.5429	0.5271	0.4294	0.1498	0.6652
Env x G x R	0.9587	0.7987	0.5144	0.9111	0.4073	0.0412	0.2471	0.6672
Env x G x N	0.2458	0.4630	0.4009	0.4373	0.2268	0.0312	0.9303	0.5310
Env x R x N	0.9508	0.8028	0.9524	0.6452	0.4847	0.9552	0.1253	0.9395
Env x G x R x N	0.0884	0.0437	0.8389	0.9597	0.4699	0.9870	0.0276	0.1733

† Env = Environment, G = Glyphosate, R = Residue, N = Nitrogen.

Table 1.6 Winter wheat grain yield response to glyphosate, residue, and nitrogen treatments.

Treatment		Environment											
		2012						2013					
		Manhattan		Belleville		Ottawa		Manhattan		Belleville		Hutchinson	
		kg ha^{-1}											
Glyphosate	Pre-harvest	3060	a†	2767	a	3515	a	3395	a	2613	a	2435	a
	Postharvest	2401	b	2546	a	3367	b	3426	a	2582	a	2545	a
	Untreated	2433	b	2600	a	3288	b	3515	a	2535	a	2526	a
Residue	Chopped	2322	b	2780	b	3406	a	3458	ab	2522	b	2475	b
	Removed	2862	a	2060	c	3373	a	3327	b	2397	b	2234	c
	Untreated	2710	a	3073	a	3392	a	3552	a	2810	a	2797	a
Nitrogen	Applied	2664	a	2697	a	3526	a	3396	a	2572	a	2483	a
	Untreated	2598	a	2578	a	3254	b	3495	a	2581	a	2520	a

† Column means within each treatment followed by the same letter are not significantly different (α = 0.05).

Table 1.7 Response of winter wheat plant density to glyphosate, residue, and nitrogen treatments.

Treatment		Environment					
		2011			2012		
		Manhattan	Belleville	Ottawa	Manhattan	Belleville	Hutchinson
		plants m^{-2}					
Glyphosate	Pre-harvest	185 a†	173 a	197 a	200 a	314 a	235 a
	Postharvest	188 a	175 a	183 ab	193 a	291 a	227 a
	Untreated	189 a	166 a	173 b	196 a	281 a	229 a
Residue	Chopped	187 a	176 a	196 a	210 a	310 a	234 a
	Removed	188 a	151 b	181 ab	188 a	253 b	218 a
	Untreated	186 a	188 a	172 b	190 a	323 a	238 a
Nitrogen	Applied	187 a	173 a	183 a	199 a	295 a	233 a
	Untreated	187 a	170 a	185 a	193 a	296 a	227 a

† Column means within each treatment followed by the same letter are not significantly different (α = 0.05).

Table 1.8 Response of winter wheat fall tiller numbers to glyphosate, residue and nitrogen treatments.

		Environment					
		2011			2012		
Treatment		Manhattan	Belleville	Ottawa	Manhattan	Belleville	Hutchinson
		tillers m^{-2}					
Glyphosate	Pre-harvest	593 a†	273 a	491 a	–	533 a	–
	Postharvest	575 a	262 a	481 a	–	501 a	–
	Untreated	558 a	267 a	402 b	–	502 a	–
Residue	Chopped	558 b	257 a	481 a	–	543 a	–
	Removed	565 b	277 a	469 ab	–	464 b	–
	Untreated	603 a	267 a	423 b	–	529 a	–
Nitrogen	Applied	563 a	269 a	446 a	–	498 a	–
	Untreated	588 a	265 a	470 a	–	526 a	–

† Column means within each treatment followed by the same letter are not significantly different (α = 0.05).

Table 1.9 Response of winter wheat spring tiller development to glyphosate, residue, and nitrogen treatments

Treatment		Environment											
		2012						2013					
		Manhattan		Belleville		Ottawa		Manhattan		Belleville		Hutchinson	
		tillers m^{-2}											
Glyphosate	Pre-harvest	446	a†	553	a	623	a	844	a	339	ab	720	a
	Postharvest	411	a	532	a	609	a	857	a	373	a	670	a
	Untreated	404	a	571	a	661	a	870	a	308	b	707	a
Residue	Chopped	426	a	628	a	–	‡	906	a	357	b	707	a
	Removed	405	a	438	b	–		788	b	244	c	639	b
	Untreated	429	a	590	a	–		877	a	420	a	751	a
Nitrogen	Applied	430	a	588	a	–		853	a	356	a	716	a
	Untreated	410	a	516	b	–		860	a	325	a	682	a

† Column means within each treatment followed by the same letter are not significantly different (α = 0.05).

‡ Treatment interaction for residue and nitrogen is presented in Figure 1.4.

Table 1.10 Response of winter wheat spike density to glyphosate, residue, and nitrogen treatments.

Treatment		Environment											
		2012						2013					
		Manhattan		Belleville		Ottawa		Manhattan		Belleville		Hutchinson	
		spikes m^{-2}											
Glyphosate	Pre-harvest	439	a†	507	a	635	a	–	‡	–	§	631	a
	Postharvest	417	ab	474	a	630	a	–		–		548	a
	Untreated	389	b	462	a	606	a	–		–		586	a
Residue	Chopped	400	a	489	a	643	a	570	a	–		564	b
	Removed	420	a	440	b	620	a	498	b	–		544	b
	Untreated	425	a	514	a	608	a	544	ab	–		657	a
Nitrogen	Applied	418	a	493	a	642	a	–		574	a	600	a
	Untreated	411	a	469	a	605	a	–		595	a	577	a

† Column means within each treatment followed by the same letter are not significantly different (α = 0.05).

‡ Treatment interaction for glyphosate and nitrogen is presented in Figure 1.5.

§ Treatment interaction for glyphosate and residue is presented in Figure 1.5.

Table 1.11 Response winter wheat kernels spike^{-1} to glyphosate, residue, and nitrogen treatments.

		Environment											
		2012						2013					
Treatment		Manhattan		Belleville		Ottawa		Manhattan		Belleville		Hutchinson	
		kernels spike^{-1}											
Glyphosate	Pre-harvest	25.3	a†	28.2	a	18.2	a	26.9	a	–	‡	23.6	a
	Postharvest	20.7	c	27.7	a	17.6	a	25.8	a	–		25.8	a
	Untreated	23.2	b	28.6	a	17.6	a	25.9	a	–		26.3	a
Residue	Chopped	21.3	b	29.1	a	17.2	a	26.8	a	–		25.0	a
	Removed	24.8	a	24.8	b	17.9	a	26.3	a	–		24.5	a
	Untreated	23.0	b	30.7	a	18.2	a	25.7	a	–		26.2	a
Nitrogen	Applied	23.0	a	28.3	a	18.1	a	26.1	a	–		25.8	a
	Untreated	23.1	a	28.1	a	17.4	a	26.3	a	–		24.6	a

† Column means within each treatment followed by the same letter are not significantly different ($\alpha = 0.05$).

‡ Treatment interactions for glyphosate – residue and residue – nitrogen are presented in Figure 1.5.

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Chapter 2 - Grain Sorghum Hybrid and Wheat Cultivar Traits for Planting Wheat after Grain Sorghum in No-Till Systems

Introduction

In a crop rotation, the performance of a crop can be influenced substantially by the preceding crop grown in a rotation. Claassen (2007) reported that winter wheat yields were reduced by 720 and 632 kg ha^{-1} following grain sorghum compared to when preceding crops were soybean and corn, respectively. Rieger et al. (2008) reported a 10% increase in winter wheat grain yields when the previous crop was oilseed rape compared to when corn was the previous. Research conducted over 6 years in Southwest Kansas found when winter wheat followed a 10 to 11 month fallow period, average winter wheat grain yields were reduced when preceding crops were soybeans or sunflowers compared to winter wheat grain yields that followed corn or grain sorghum (Norwood, 2000). Winter wheat in rotation with grain sorghum or winter canola averaged roughly 50% greater grain yields compared to when winter wheat was continually grown or in rotation with a spring canola crop (Unger, 2001). In Eastern Colorado, Nielsen et al. (1999) reported that grain yields of winter wheat and proso millet (*Panicum miliaceum* L.) often were reduced when sunflowers were introduced into the crop rotation. When implementing crop rotations, crop diversification is important for overall performance. Tanaka et al. (2007) found when the same crop was planted back-to-back, grain yields in the second year were often reduced. Increasing the time interval between when a crop is grown along with introducing different crop types within a crop rotation improved overall grain production of a cropping system (Anderson et al., 1999).

Planting winter wheat following a summer row crop can be difficult to manage. Because grain harvest for summer crops often occurs during the same time period for winter wheat planting, planting dates of the winter wheat can be delayed. In Kansas this is especially true for winter wheat that follows grain sorghum. Typically grain harvest is later for grain sorghum compared to other summer row crops such as corn (Assefa et al., 2014). Grain harvest of summer row crops may extend even later into the fall if later-maturing hybrids are used. Planting winter wheat later than recommended may reduce overall grain yields (Lund et al., 1993). When winter wheat was planted 5 to 7 weeks later than the normal planting date, Shah et al. (1994) reported average grain yield reductions of approximately 26% for the winter wheat crop. Research from Southwest Kansas found that when fall planting of winter wheat was delayed until November or December, an additional 16 to 74 days, respectively, may be needed for the winter wheat crop to emerge (Witt, 1996). Witt (1996) reported an average yield decline of 16.7% per month for every month through April 1 that wheat was planted later than October 1. Later planting dates associated with wheat planted after a summer row crop is just one factor that may reduce wheat yield in these situations.

Crop performance within a crop rotation also may be influenced by water requirements of preceding crops. Nielsen et al. (1999) found that for every inch reduction in available soil water at planting, yields of winter wheat were reduced by 199.9 kg ha^{-1} and proso millet by 331.1 kg ha^{-1}. Based on analysis of past research in Western Kansas, Stone and Schlegel (2006) concluded that there was a positive relationship between grain yield and available soil water at emergence for both grain sorghum and winter wheat crops. An experiment conducted over two years at a sites in Western Kansas and Northeast Kansas found average seasonal water use for corn, grain sorghum, pearl millet, pinto bean (*Phaseolus* vulgaris), soybean and sunflower was 565, 484, 489, 424, 541, and 545 mm, respectively (Hattendorf et al., 1988). Norwood (1999) reported water use for corn averaged over four growing seasons was 34 and 39 mm greater than for grain sorghum in conventional tillage and no tillage managed systems, respectively. Hattendorf et al. (1988) found that ET ratios (measured ET/reference ET) for corn, sunflowers, and pinto beans were less near physiological maturity compared to ET ratios of grain sorghum, pearl millet, and soybean at that growth stage. Based on typical later planting dates for grain sorghum, Assefa et al. (2014) hypothesized that grain sorghum water use occurs later in the growing season compared to corn. The depth at which soil water is reduced can also depend on crop type. In Western Kansas, Stone et al. (2002) reported that average reduction in soil water was 0.6 m deeper for sunflower compared to grain sorghum. Length of the crops growing season of a crop may influence seasonal water use more than a crops rooting depth (Merrill et al., 2007). Researchers in Southwest Kansas found that average daily water use did not differ between later and earlier maturing corn hybrids, but total seasonal water usage was greatest for the longer maturing hybrid (Trooien et al., 1999). Similar results were observed in experiments conducted in the Texas Panhandle where earlier-maturing grain sorghum had improved water use efficiency compared to later-maturing grain sorghum under limited irrigation (Allen and Musick, 1993). Crop characteristics and crop management both can influence soil water use.

Conserving soil moisture can be improved in reduced tillage or no-till managed systems by minimizing water losses due to runoff and evaporation and increasing soil water infiltration (Norwood, 1994). Norwood (1994) found available soil water tended to be greater at deeper soil depths in no tillage systems compared to conventional-tilled systems. Research conducted in Western Kansas reported in a wheat-fallow crop rotation, the average amount of available soil water was 28.6% greater in reduced-tilled systems compared to conventionally-tilled systems (Norwood et al., 1990). Similar results were observed in a wheat-sorghum-fallow crop rotation where available soil water content at wheat planting was 28.2% greater in no-tilled systems compared to conventional-tilled systems (Norwood et al., 1990). Water use efficiency of crops also can be improved by no-tilled managed systems. Stone and Schlegel (2006) showed that responses of winter wheat grain yields to available soil water at emergence and in-season precipitation were 52 kg ha^{-1} cm^{-1} greater in no-till systems than in conventionally-tilled systems.

Allelopathic or phytotoxic potential of certain crops can negatively influence the performance of a crop rotation. Literature reviews have found that multiple agricultural crops have been identified to have phytotoxic effects on other crops (Narwal, 2004). Water soluble compounds leached from crop residues can negatively influence the growth and yield potential of crops planted into the residue. Water extracts of corn, sorghum, oat, and wheat residues have been shown to impede the growth of wheat seedlings (Guenzi et al., 1967). Results from research conducted in Kansas speculated that reductions in winter wheat grain yields following no-tilled grain sorghum compared to conventionally-tilled grain sorghum may be due to allelopathic effects of the grain sorghum residue left on the soil surface in the no-till system (Roth et al., 2000). Phenolic acids are secondary plant metabolites that often are associated with allelopathy in agricultural systems (Guenzi and McCalla, 1966; Ben-Hammouda et al., 1995). Allelopathic effects vary with crop species, genotype, environment, and phenolic acid type, concentration, and combination of phenolic acids. The response of wheat seedlings to crop residues was dependent on crop species, time exposed to crop residues, and environment (Guenzi et al., 1967). Guenzi and McCalla (1966) found phenolic acid concentrations vary across crop types, and phytotoxic effects were dependent upon concentration and type of phenolic acid. In experiments conducted by Ben-Hammouda et al., (1995) concentrations of phenolic acids varied across sorghum hybrids and plant parts. Similar results were reported by Cheema et al. (2007), who found that concentrations of multiple known phytotoxins varied across nine different sorghum hybrids. Grain sorghum hybrids differing in plant color may also differ in phytotoxicity. A study by Dykes et al. (2005) evaluating 13 sorghum genotypes found that levels of phenolic compounds in sorghum grain was greatest in genotypes with purple or red pigments compared to tan pigmented genotypes.

Cropping system intensification has the ability to improve the economic performance of a production system (Schlegel et al., 1999). It is important to identify best management practices when implementing a more intensified crop rotation. The objectives of this study were to: identify grain sorghum hybrid characteristics that facilitate planting winter wheat after grain sorghum; classify wheat cultivars that are suitable for planting after grain sorghum in no-till systems; and determine if the influence of grain sorghum hybrid characteristics and wheat cultivars are modified by production environment.

Material and Methods

Experiments were conducted at four field locations over two growing seasons from 2012 to 2014 (Table 2.1). Grain sorghum in the first growing season was planted and harvested in 2012, and in 2013 for the second growing season. Winter wheat was planted following sorghum harvest in both years, and winter wheat was harvested in 2013 for the first growing season and in 2014 for the second growing season. Locations were selected that have sufficient precipitation and season length to facilitate planting winter wheat following grain sorghum harvest.

Experimental design was a randomized complete block with four replications and a split-block, two-way factorial treatment structure. Treatments included six summer crop hybrids consisting of five sorghum hybrids and one corn hybrid (Table 2.2). Grain sorghum hybrids included three maturities (early-medium, medium, and medium-late) and two plant pigmentations (red, tan). The corn hybrid was selected based on past performance at the locations (Table 2.2). Six wheat cultivars were planted in the fall following grain sorghum harvest. Wheat cultivars were selected based on past performance and planted acreage across the study region (Table 2.2). Summer crop hybrids and winter wheat cultivars used in the study were the same across all environments over both growing seasons. Plot size for each summer crop hybrid was 12 m wide and 18 m long, and plot size for the winter wheat was 3 m wide and

72 m long resulting in plot size for wheat and previous summer crop hybrid combination being 3 m wide and 12 m long.

Grain sorghum and corn were planted in 76-cm row spacing at all locations in both years (Table 2.3). A four row planter (AGCO Corporation; Duluth, Georgia) was used at the Hutchinson locations both years, and a two row planter with John Deere (Deere & Company; Moline, Illinois) row units was used both years at the Manhattan locations. Management practices for grain sorghum were based on Kansas State University recommendations for optimal grain production at each location (KSU, 1996; KSU, 1998). Prior to planting grain sorghum and corn, glyphosate (N-[phosphonomethyl] glycine, in the form of its potassium salt); (Roundup WeatherMAX; Monsanto Company; St. Louis, Missouri) was used to control established weeds. S-Metolachlor (Acetamide, 2-chloro-N-[2-ethyl-6-methylphenly]-N-[2-methoxy-1-methylethyl]-,S) plus atrazine (2-chloro-4-[ethylamino]-6-[isopropylamino]-s-triazine); (Lumax; Syngenta Crop Protection, Inc.; Greensboro, North Carolina) was used as a pre-emergence residual herbicide to control early season weed establishment in the grain sorghum. No residual herbicides were used in the corn plots. When a post emergence herbicide was needed for weeds that escaped residual herbicide applications within the grain sorghum plots, pyrasulfotole (methanone, [5-hydroxy-1,3-dimethyl-1*H*-pyrazol-4-yl] [2-(methylsulfonyl)-4-(trifluoromethyl) phenyl]) plus bromoxynil octanoate (2,6-dibromo-4-cyanophenyl octanoate) plus bromoxynil heptanoate (2,6-dibromo-4-cyanophenyl heptanoate); (Huskie; Bayer CropScience LP; Research Triangle Park, North Carolina) was used. For post emergence weed control in corn plots, glyphosate (Roundup WeatherMAX; Monsanto Company; St. Louis, Missouri) was used as needed. Two rows from each grain sorghum and corn plot were harvested using a commercial combine (Model EIII, AGOCO Corporation; Duluth, Georgia) modified to harvest and weigh grain from two-row plots. Grain yields were adjusted to 155 g kg^{-1} grain moisture for corn and 125 kg g^{-1} grain moisture for grain sorghum.

After grain sorghum harvest, winter wheat cultivars were planted perpendicular to the summer crop rows. Winter wheat was planted in 19 cm row spacing at the Manhattan locations and 25.5-cm row spacing at the Hutchinson location, typical row spacing for each environment. All winter wheat cultivars were planted on the same day within each location and year (Table 2.3). Management practices of winter wheat were based on Kansas State University recommendations for optimal grain production following a grain sorghum crop at each location

(KSU 1996; KSU 1997). Kansas State University recommends increased seeding rates of winter wheat 50 to 100% when planted after summer crop harvest (KSU, 1997). Kansas State University also recommends an additional 34 kg ha^{-1} of nitrogen for winter wheat when following grain sorghum (KSU, 2003). This additional nitrogen was applied to winter wheat following both grain sorghum and corn, and seeding rates were increased 80% above recommended rates in each location. Fertility rates were based on winter wheat yield goals of 3363 kg ha^{-1}. Winter wheat grain yields were obtained by harvesting the center of the plots with a commercial combine (model EIII; AGCO Corporation, Duluth, GA) modified to harvest and weigh grain using a 1.75-m header except at the Hutchinson location in 2014. Weed populations in the winter wheat crop at Hutchinson in 2014 made it difficult to harvest the grain using a combine so two 0.25 m^{-2} areas were randomly selected within each plot and harvested by hand. Grain yields of winter wheat were adjusted to 125 g kg^{-1} grain moisture.

Wheat growth was quantified using normalized difference vegetative index (NDVI) values obtained using a GreenSeeker (Trimble Navigations Ltd.; Sunnyvale, CA) sensor. Phillips et al. (2004) found that NDVI is a reliable estimator for tiller density in winter wheat. Normalized difference vegetative index values were collected at Feekes 5 (leaf sheaths strongly erect) and Feekes 10 (boot) except at Manhattan and Hutchinson in 2013 when NDVI values were obtained only at Feekes 10.

Wheat yield components were evaluated for each cultivar by randomly selecting a 1 m length of row within each plot. Yield components recorded were spike number m^{-2}, kernels $spike^{-1}$, and kernel weight. Just prior to grain harvest, all wheat plants were removed within each 1 m row for data collection. Spikes were counted to determine spikes m^{-2}, and then 50 spikes were randomly selected and threshed using a wheat head thresher (Precision Machine Co. Inc.; Lincoln, Nebraska). Kernels were collected and counted using a seed counter (model 801 COUNT-A-PAK; Seedburo Equipment Co.; Des Plaines, Illinois) to determine kernels $spike^{-1}$, and the kernels were weighed to determine kernel weight (g 1000 $seed^{-1}$). If the 1 m rows contained fewer than 50 spikes, all spikes within the 1 m row were used to determine kernels $spike^{-1}$ and kernel weight.

Analysis of variance (ANOVA) was performed to determine main effect differences and their interactions using PROC GLIMMIX in SAS 9.2 (SAS, 2009) statistical analysis software. Block was used as a random factor when analyzing summer crop data. In a split-block design there are three sizes of experimental units resulting in three different experimental errors (Peterson, 1994). In this experiment, summer crop hybrid and wheat cultivar are whole plots and the subplot is the interaction between summer hybrid and wheat cultivar. When analyzing wheat yield data the three sources of variation used were block, summer hybrid x block, and wheat cultivar x block. Summer hybrid and winter wheat response variables were analyzed across environments to determine if environment influenced response to treatments.

Results and Discussion

Weather

In 2012 to 2013, monthly precipitation was below normal in Manhattan and Hutchinson for all months except August and April, and in May and July in Hutchinson (Figure 2.1). Similar trends of below normal precipitation occurred in 2013 to 2014, but September, October, April, and June received above normal precipitation in Manhattan, and Hutchinson received above normal precipitation in August, October, and June.

Maximum average temperatures were above normal for most of the sorghum growing season in 2012 (May, June, July) at both locations (Figure 2.2). During wheat planting at Manhattan (2012) maximum average temperatures were below normal, but for November, December, and January remained above normal at both Manhattan and Hutchinson. In 2013, maximum average temperatures in the late winter and spring (February, March, April, May) were normal to below normal at both location. Based on maximum average temperatures, the 2013 to 2014 growing season was cooler than normal compared to the 2012 to 2013 growing season at Manhattan and Hutchinson. Minimum average temperature varied month to month relative to normal temperatures, but minimum average temperatures were below normal to normal for February, March April and May at both locations in both years (Figure 2.3).

Multi-location Analysis

Statistical analysis of grain yields for both summer hybrids and winter wheat cultivars resulted in year x environment x treatment interactions. Summer hybrid response depended on environment ($Pr > F = <0.0001$), and environment x hybrid ($Pr > F = 0.0049$) and environment x variety ($Pr > F = <0.0001$) had significant effects on wheat yield. Based on significant interactions of treatment factors with environment for many response variables, especially yield, results for yield components and grain yield responses to treatment factors will be presented by location within each year.

Summer Crop Grain Yields

Treatment comparison groupings included summer crop hybrid, maturity within the grain sorghum hybrids, and plant pigmentation within grain sorghum hybrids (Table 2.4).

No summer crop comparisons were possible for Hutchinson, 2012 (Table 2.4). In Hutchinson, 2012, precipitation was 75, 49, 80, and 41 mm below normal for May, June, July, and September, respectively, during the 2012 growing season (Figure 2.1). Temperatures were also warmer than average with maximum average monthly temperatures in May, June, and July being 6, 4, and 5 °C above normal, respectively (Figure 2.2). Plants responded to these conditions by senescing earlier than normal. Sorghum plants did not produce grain, and whole corn plots (216 m^{-2}) were harvested to obtain enough grain to estimate yields. Late summer precipitation caused the grain sorghum to resume growth, producing panicles, but an early frost (October 7) killed the plant before any grain was produced. The upper portion of the grain sorghum plants were mowed to simulate a combine harvest when it was evident the grain sorghum was not going to reach physiological maturity.

Summer crop grain yields were influenced by crop hybrid at all three of the remaining locations (Table 2.4). All sorghum hybrids produced more grain compared to the corn hybrid at Hutchinson in 2013. The corn hybrid outperformed all grain sorghum hybrids except 85G03 and 4525 at Manhattan in 2012. The corn hybrid produced more grain compared to all sorghum hybrids at Manhattan in 2013. A consistent trend was evident for maturity length effect on grain yields in all three environments with medium and medium-late sorghum hybrids producing greater yields (Table 2.4). Plant pigmentation had no influence on grain sorghum yields at any location in either year.

Winter Wheat Grain Yields

At Hutchinson in 2013, there was a summer crop hybrid x wheat cultivar interaction ($Pr > F = 0.0341$). Further analysis revealed the interaction was not among sorghum hybrids and wheat cultivar, but between previous crop (corn and grain sorghum) and wheat cultivar. At Hutchinson in 2012, summer hybrids were stressed due to high temperature and insufficient moisture, senescing earlier than normal (Figure 2.1 and 2.2). From September 4 to 13 the experimental site at Hutchinson received 26 mm of precipitation, resulting in regrowth of the sorghum hybrids. All sorghum hybrids produced panicles, but before grain fill could occur, a freeze in early October terminated the sorghum crop. Due to the perennial nature of grain sorghum, the precipitation received in early September stimulated the sorghum to resume reproductive growth, resulting in less available soil water at wheat planting (Stone et al., 2002). This was evident in field observations when wheat cultivars emerged following corn in late November and early December, but emergence was not observed until February following grain sorghum. Earlier establishment of winter wheat crop following corn resulted in greater grain yields compared to wheat planted after grain sorghum. Everest and Billings produced the greatest yields following grain sorghum, but Billings, Duster, Everest, and Fuller had the greatest yields following corn (Table 2.5). All wheat cultivars yielded less after sorghum than after corn, but Billings, Fuller and SY Southwind had the greatest yield reductions, 17%, 21%, and 16%, respectively. Duster, Everest, and T-154 yields were reduced by 13%, 9%, and 6%, respectively, after sorghum compared to after corn. Winter wheat grain yield responses were similar regardless of previous crop at the other locations (Table 2.5).

At Manhattan in 2013, Everest, Fuller, and T-154 had greater yields compared to Billings and Duster (Table 2.5). Manhattan grain yields in 2014 were greater for Everest and SY Southwind compared to Billings. Wheat cultivar had no significant effect on grain yield ($\alpha = 0.05$) at Hutchinson in 2014 (Table 2.5), but similar to results from Hutchinson in 2013, Billings had the greatest grain yields of the six wheat varieties. Everest had the lowest grain yields in Hutchinson in 2014 (Table 2.5). This is opposite of the results from Hutchinson 2013 where Everest produced greater grain yields following both corn and grain sorghum. Based on Kansas State University recommendations (KSU, 1996), wheat planted in Manhattan (2013 to 2014) was 5 days beyond the optimal range of planting dates, and in Hutchinson (2013 to 2014) wheat was planted 26 days beyond the optimal range planting date. At Hutchinson during the 2013 to 2014 growing season, wheat planted later than the optimal range of planting dates, coupled with below normal temperatures (Figure 2.2) and below normal precipitation (Figure 2.1) resulted in poor yields.

Winter Wheat Growth and Yield Components

Both previous summer hybrid and winter wheat cultivar affected NDVI values at either Feekes 5 or Feekes 10 growth stages of winter wheat. At Hutchinson in 2013, NDVI was influenced by summer hybrid and wheat cultivar (Table 2.6). If the previous summer hybrid was DKC63-84, 88P68, or 86G32, wheat NDVI values were greater compared to those for wheat planted after 4525. Within grain sorghum hybrids, plant pigment influenced wheat NDVI values (Pr > F = 0.0150). If the previous grain sorghum hybrid was a red pigmented plant, wheat NDVI values (NDVI = 0.7621) were greater compared to those for wheat planted after tan pigmented plants (NDVI = 0.7427). Previous crop (Pr > F = 0.0810) and hybrid maturity within grain sorghum hybrid (Pr > F = 0.0589) , but were not significantly different. Following corn, wheat NDVI values were slightly more (NDVI = 0.7724) compared to those of wheat planted after sorghum (NDVI = 0.7543). Wheat NDVI values following early, medium, and medium-late maturity grain sorghum hybrids were 0.7608, 0.7646, and 0.7427, respectively. Normalized difference vegetative index values for Billings, Everest, and Duster were greater than for Fuller, SY Southwind, and T-154. At Manhattan in 2013, NDVI values were not influenced by summer hybrid or wheat cultivar (Table 2.6). At Hutchinson in 2014, NDVI values at both Feekes 5 and Feekes 10 were influenced by summer hybrid, but not wheat variety (Table 2.6). Values for NDVI were greater following corn compared to following grain sorghum at both wheat growth stages. Grain yields for corn in 2013 were 28% to 54% less than grain sorghum (Table 2.4). Increased grain production in the sorghum crop would have required more water and nitrogen compared to corn, reducing available nitrogen and soil water for the following wheat crop and inhibiting growth overall growth. Wheat NDVI values following pigmented grain sorghum hybrids were not significantly different at wheat growth stages Feekes 5 (Pr > F = 0.0507) and Feekes 10 (Pr > F = 0.0635). Wheat NDVI values following tan-pigmented sorghum hybrids were slightly more at both Feekes 5 (NDVI = 0.2869) and Feekes 10 (NDVI =0.3081) compared to wheat planted after red-pigmented sorghum hybrids (NDVI = 0.2687 and 0.2863, respectively). Grain sorghum hybrid maturity did not influence wheat NDVI values at Feekes 5 (Pr > F = 0.4355) or Feekes 10 (Pr > F = 0.2822) growth stages. At Manhattan in 2014, NDVI was influenced by wheat variety at both Feekes 5 and Feekes 10 growth stages, but not summer hybrid. Compared to all other wheat cultivars, Everest had the greatest NDVI value at both Feekes 5 and Feekes 10 (Table 2.6). This was a typical response at all locations except for

Hutchinson in 2014. At Manhattan in 2013, September and October had above normal precipitation (Figure 2.1) resulting in adequate soil moisture at planting, but maximum average temperatures were below normal from November 2013 to March 2014. Low temperatures can reduce germination and rate of germination, but some cultivars are affected less by low temperature stress (Ashraf and Abu-Shakra, 1978).

Previous summer crop hybrid had no influence on winter wheat yield components at any location in 2013 and 2014 ($\alpha = 0.05$) (Tables 2.7, 2.8, and 2.9). Winter wheat yield components were influenced by wheat cultivar in both years, and their responses were similar regardless of previous summer hybrid (summer hybrid x wheat cultivar NS, $\alpha = 0.05$).

Winter wheat cultivars influenced spikes m^{-2} at two of the four locations in 2013 and 2014 (Table 2.7). Duster, Everest, and T-154 had more spikes m^{-2} compared to Billings, Fuller, and SY Southwind at Hutchinson, 2013. At Manhattan in 2014, T-154 and Everest again ranked at the top, and Billings and Fuller near the bottom for spikes m^{-2} (Table 2.7).

Spike density was greater in Manhattan and Hutchinson in 2013 compared to 2014 (Table 2.7). Planting dates at Manhattan and Hutchinson in 2012 were 11 days and 21 days earlier, respectively, compared to planting dates at those locations in 2013. Thiry et al. (2002) observed similar results with delayed planting and associated the decline in spike density to fewer productive fall tillers, and less spring tiller production. Average maximum temperature was above normal for November, December and January at both Manhattan and Hutchinson in 2012 to 2013. Warmer temperatures in late fall and early winter would allow wheat plants to develop more tillers compared to if temperatures were colder. Wheat cultivar did not influence spike density when wheat was planted within the optimal planting dates at Manhattan in 2012, or when it was planted 26 days beyond the optimal planting dates at Hutchinson in 2013.

Kernels spike^{-1} was influenced by wheat cultivars at Manhattan in both years and Hutchinson in 2014. In 2013 at Manhattan, Billings, Duster, SY Southwind, and T-154 produced similar kernels spike^{-1}, and Fuller produced the fewest (Table 2.8). In 2014 T-154 and SY Southwind produced the most kernels spike^{-1} at Manhattan (Table 2.8). In 2014 at Hutchinson, Everest produced the fewest kernels spike^{-1} compared to the other five wheat cultivars (Table 2.9). This may be a result of Everest having 3% to 18% more spikes m^{-2} compared to the other five wheat cultivars. This is supported by results from Holen et al. (2001)

who reported that increased plant densities of winter wheat increased spike density, but decreased kernels spike^{-1}.

Kernel weight responded to wheat cultivar at all environments both years. Kernel weight was greatest for Billings at all locations (Table 2.9). Kernel weight was greatest for Everest and Fuller at Hutchinson in 2014 (Table 2.9). Duster and SY Southwind typically had lighter kernel weights at all four locations (Table 2.9). Thiry et al. (2002) evaluated winter wheat performance at four different planting dates and reported that kernel weight was not affected by planting date. These findings may suggest the strong influence that genetics has on kernel weight. Results from Shanahan et al. (1984) showed that as kernels spike^{-1} and kernels m^{-2} of winter wheat increased, kernel weight decreased. Data from this research showed that kernel weight varied across four locations for three wheat cultivars, but the same cultivar had the greatest kernel weight at all four locations (Shanahan et al., 1984).

In general, Everest and T-154 had more spikes compared to other wheat cultivars, but fewer kernels spike^{-1}, and T-154 generally had smaller seed weight. Duggan et al. (2000) found that winter wheat genotypes with more tillering potential had fewer kernels spike^{-1}. Inversely, Billings generally had fewer spikes m^{-2}, but had greater seed weight compared to other varieties.

Conclusion

When planting wheat after grain sorghum, grain sorghum hybrid maturity and plant pigment did not affect the performance of the following wheat crop. Winter wheat grain yields were influenced by previous crop in certain environments, but our results suggest the effect of previous crop likely depended on the available soil moisture at wheat planting and its effect on how quickly the wheat emerged. Conditions that delayed wheat planting or emergence, such as cooler temperatures, low soil water content, and late fall harvests, tended to reduce wheat performance. In this study, wheat cultivars were identified that are suitable for planting winter wheat after summer crops. Everest was suitable across all environments and management systems due to increased spike density and kernel weight. Low spike density coupled with larger kernel weight made Billings a more suitable cultivar for drier conditions at Hutchinson compared to Manhattan. SY Southwind was more suitable at Manhattan environments because of its potential to produce a large number of spikes in optimal growing conditions, but SY Southwind’s smaller kernel size limited its performance at Hutchinson.

Figures and Tables

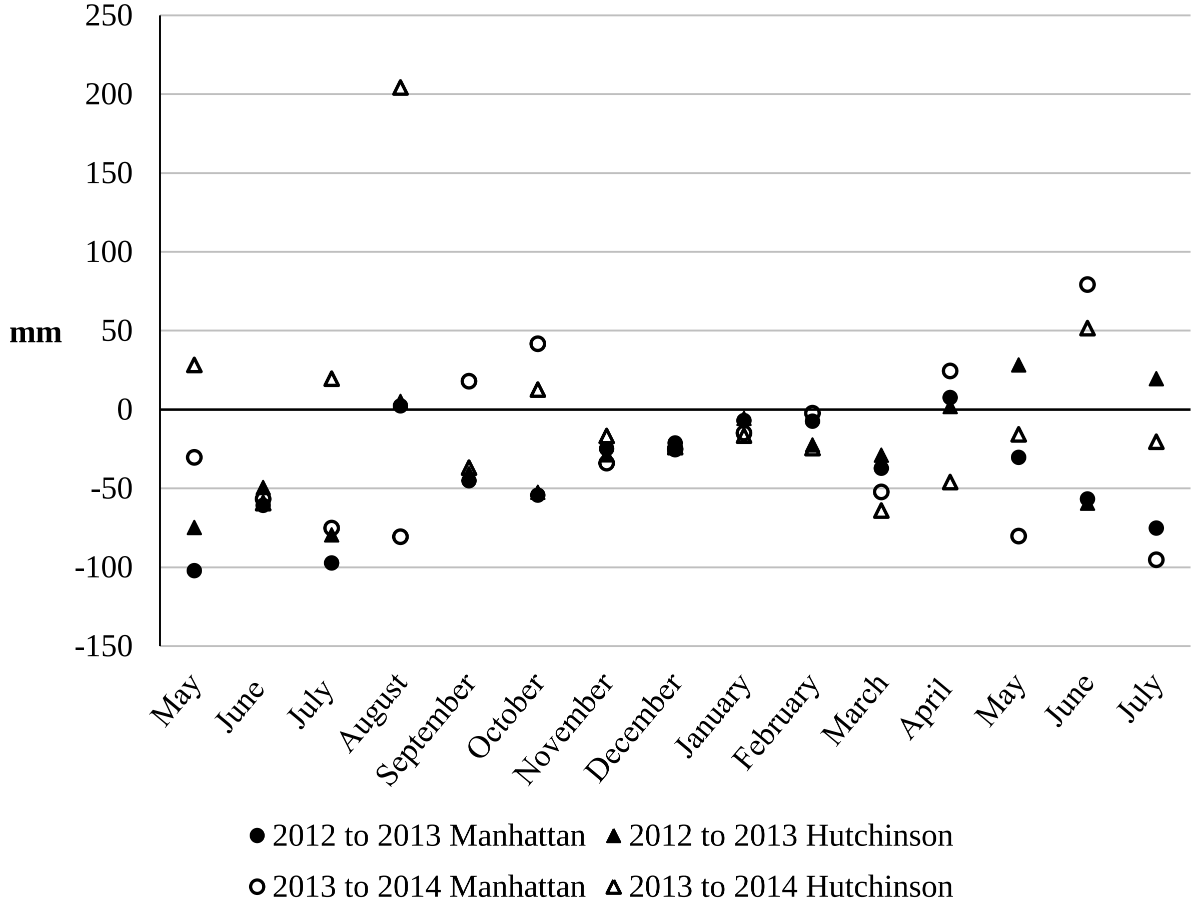

Figure 2.1 Monthly precipitation departure from normal at four experimental locations used to evaluate wheat variety response to grain sorghum hybrid characteristics.

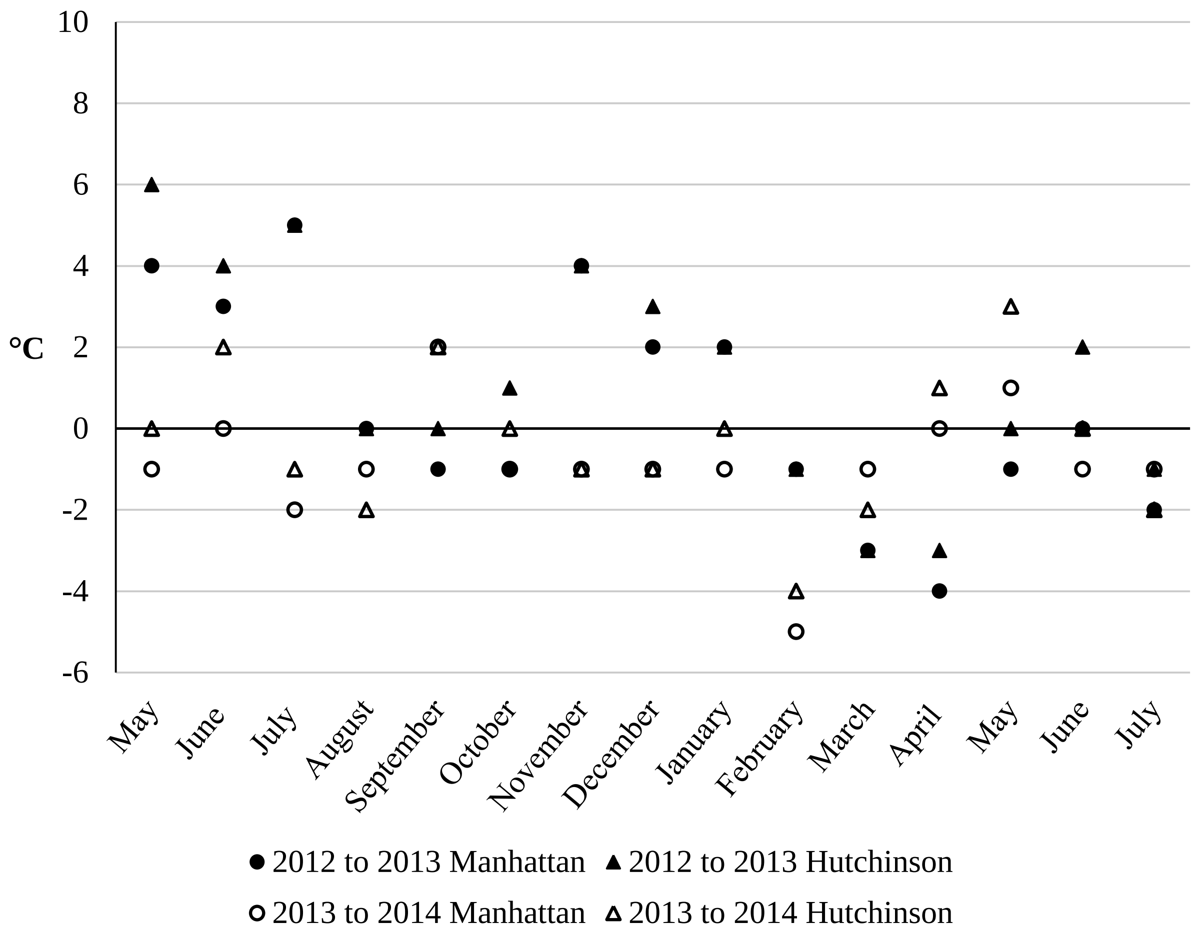

Figure 2.2 Monthly maximum temperature difference from normal at four experimental locations used to evaluate wheat variety response to grain sorghum hybrid characteristics.

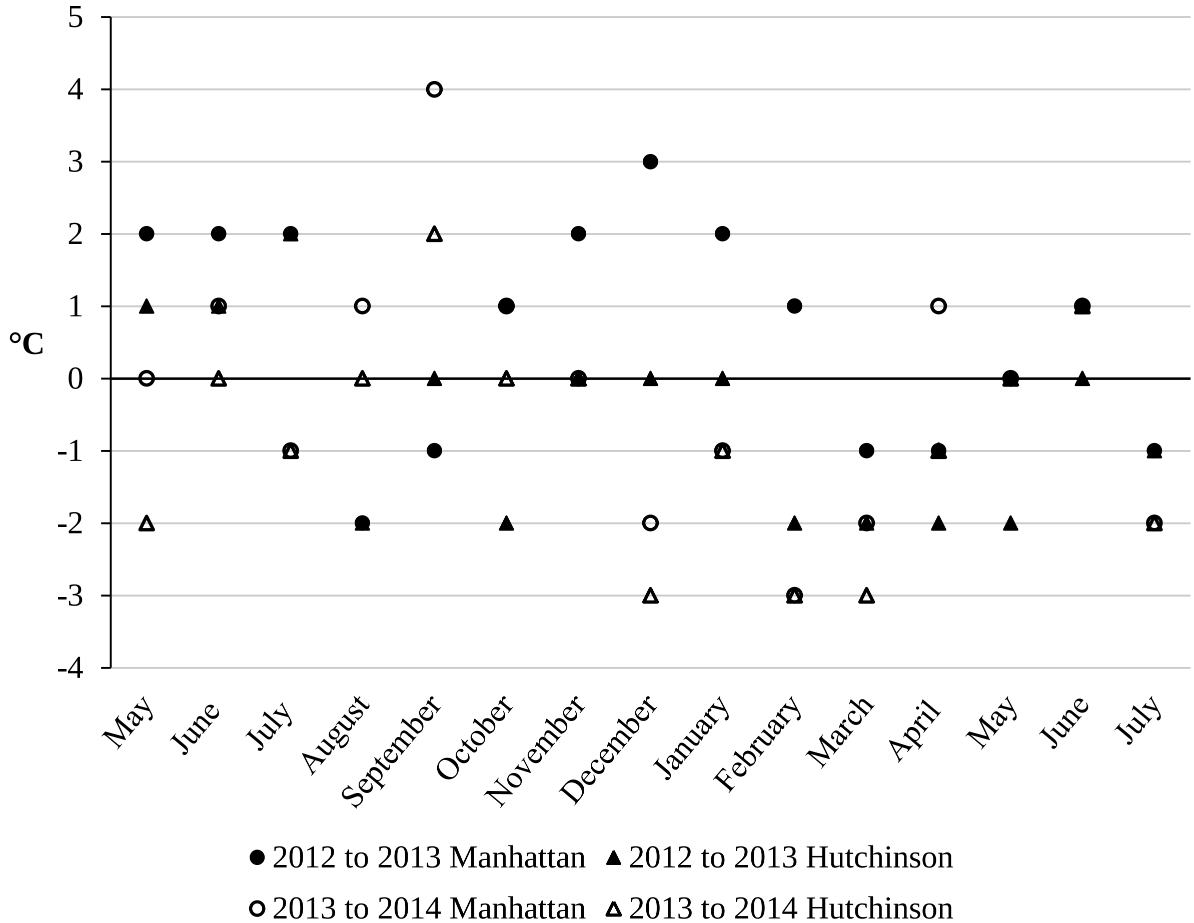

Figure 2.3 Monthly minimum temperature difference from normal at four experimental locations used to evaluate wheat variety response to grain sorghum hybrid characteristics.

Table 2.1 Environmental descriptions for four experimental locations used to evaluate wheat cultivar response to grain sorghum hybrid characteristics in Kansas from 2012 to 2014.

	Location	
Descriptor	Manhattan	Hutchinson
2012 to 2013 Growing season	39.213930, -96.594074	37.956085, -98.122087
Soil series	Reading silt loam	Taver loam
Soil classification	Fine-silty, mixed, superactive, mesic Pachic Argiudolls	Fine, smectitic, mesic Udertic Argiustolls
2013 to 2014 Growing season	39.136482, -96.641491	37.956559, -98.120383
Soil series	Rossville silt loam	Taver loam
Soil classification	Fine-silty, mixed, superactive, mesic Cumulic Hapludolls	Fine, smectitic, mesic Udertic Argiustolls
Normal spring freeze date	18-Apr	15-Oct
Normal fall freeze date	19-Apr	17-Oct
Frost free days	179	183
Normal annual precipitation (mm)	905	778

Table 2.2 Summer hybrids and wheat cultivars used in experiments conducted in Kansas in 2012 to 2014 to evaluate wheat variety response to summer crop characteristics.

Crop	Hybrid or cultivar	Company	Maturity†	Plant pigmentation	Winter Hardiness†
Corn	DKC 63-84	DeKalb Hybrids	113 day	–	–
Grain Sorghum	88P68	Pioneer Hi-Bred Intl.	early-medium	red	–
Grain Sorghum	86G32	Pioneer Hi-Bred Intl.	medium	red	–
Grain Sorghum	85G03	Pioneer Hi-Bred Intl.	medium-late	red	–
Grain Sorghum	SP3303	Sorghum Partners	early-medium	tan	–
Grain Sorghum	4525	Fontenelle Hybrids	medium-late	tan	–
Winter wheat	Billings	Oklahoma Genetics Inc.	early to medium	–	Below Average
Winter wheat	Duster	Oklahoma Genetics Inc.	medium	–	Below Average
Winter wheat	Everest	Kansas Wheat Alliance	early	–	Very Good
Winter wheat	Fuller	Kansas Wheat Alliance	early	–	Very Good
Winter wheat	SY Southwind	AgriPro / Syngenta	early to medium	–	Very good
Winter wheat	T-154	Limagrain Cereal Seeds	early	–	Very Good

† Maturity and winter hardiness information was obtained from company data sheets and variety and hybrid ratings in Kansas State University crop performance tests.

Table 2.3 Planting and harvest dates for corn, grain sorghum, and wheat across four experimental locations.

Year	Location	Crop	Planting Date	Harvest Date
2012	Manhattan	Corn	14-Apr	31-Aug
2012	Manhattan	Grain sorghum	1-Jun	25-Sep
2012	Hutchinson	Corn	18-Apr	27-Sep
2012	Hutchinson	Grain sorghum	4-Jun	15-Oct†
2013	Manhattan	Corn	30-Apr	25-Sep
2013	Manhattan	Grain sorghum	27-May	2-Oct
2013	Hutchinson	Corn	6-May	3-Oct
2013	Hutchinson	Grain sorghum	28-May	26-Oct
2012 to 2013	Manhattan	Wheat	10-Oct	3-Jul
2012 to 2013	Hutchinson	Wheat	25-Oct	2-Jul
2013 to 2014	Manhattan	Wheat	21-Oct	2-Jul
2013 to 2014	Hutchinson	Wheat	15-Nov	10-Jul

† The sorghum crop did not have any grain to harvest due to drought conditions, so the tops of the grain sorghum plants were mowed on this date to simulate combine harvest.

Table 2.4 Grain yields of six summer hybrids at four experimental sites in Kansas in 2012 and 2013.

		Environment							
		2012				2013			
Treatments		Hutchinson†		Manhattan		Hutchinson		Manhattan	
Summer Hybrid		kg ha^{-1}							
DKC63-84	C,L,–†	603‡		6484	a§	3239	d	10,065	a
88P68	S,E,R	–		4708	bc	5718	b	7558	cd
86G32	S,M,R	–		4689	bc	7052	a	8349	cb
85G03	S,ML,R	–		5061	abc	6437	ab	8959	b
SP3303	S,E,T	–		3503	c	4479	c	7372	d
4525	S,ML,T	–		5676	ab	6585	ab	8768	b
Grain sorghum maturity									
Early		–		4105	b	5099	b	7465	b
Medium		–		4689	ab	7052	a	8349	a
Medium-Late		–		5368	a	6511	a	8864	a
Grain sorghum pigmention									
Red		–		4829	a	6402	a	8289	a
Tan		–		4490	a	5532	a	8070	a

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Whole corn plots were harvested to capture enough grain to estimate yield.
§ Column means within treatment groupings followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 2.5 Winter wheat cultivar grain yield response to summer crop characteristics at four experimental sites in Kansas in 2013 and 2014.

		2013						2014			
		Hutchinson				Manhattan		Hutchinson		Manhattan	
Treatments		Following Sorghum		Following Corn							
Summer Hybrid		kg ha^{-1}									
DKC63-84	C,L, –†	–		3727		4064	a‡	1731	a	1956	a
88P68	S,E,R	3344	a	–		3700	a	1193	a	2180	a
86G32	S,M,R	3347	a	–		3663	a	1474	a	2062	a
85G03	S,ML,R	3269	a	–		3764	a	1570	a	2369	a
SP3303	S,E,T	3263	a	–		3954	a	1481	a	2121	a
4525	S,ML,T	2875	a	–		4101	a	1546	a	2172	a
Wheat Cultivar											
Billings		3368	ab	4067	a	3301	b	1823	a	1719	c
Duster		3165	bc	3652	ab	3093	b	1538	a	1876	bc
Everest		3654	a	4011	a	4366	a	1212	a	2714	a
Fuller		2947	dc	3715	ab	4429	a	1528	a	2012	bc
SY Southwind		2832	d	3359	b	3670	ab	1408	a	2358	ab
T-154		3350	b	3559	b	4388	a	1485	a	2180	abc

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Column means within treatment groupings followed by the same letter are not significantly different (α = 0.05).

Table 2.6 Winter wheat cultivar NDVI response at two growth stages to summer crop characteristics at four experimental sites in Kansas in 2013 to 2014.

		Environment											
		2013				2014							
		Hutchinson		Manhattan		Hutchinson				Manhattan			
Treatments		Feekes 10		Feekes 10		Feekes 5		Feekes 10		Feekes 5		Feekes 10	
Summer Hybrid		NDVI											
DKC63-84	C,L, –†	0.7724	a‡	0.8052	a	0.3628	a	0.3725	a	0.3216	a	0.5592	a
88P68	S,E,R	0.7678	a	0.7713	a	0.2610	c	0.2660	c	0.3485	a	0.5734	a
86G32	S,M,R	0.7646	a	0.7471	a	0.2639	c	0.2805	bc	0.3203	a	0.5423	a
85G03	S,ML,R	0.7539	ab	0.7664	a	0.2812	bc	0.3125	b	0.3449	a	0.5375	a
SP3303	S,E,T	0.7538	ab	0.7576	a	0.3012	b	0.3173	b	0.2866	a	0.5344	a
4525	S,ML,T	0.7315	b	0.7633	a	0.2726	bc	0.2990	bc	0.3017	a	0.5206	a
Wheat Cultivar													
Billings		0.7876	a	0.7581	a	0.3100	a	0.3386	a	0.3007	bc	0.5538	b
Duster		0.7816	a	0.7297	a	0.3067	a	0.3241	a	0.3205	b	0.5377	b
Everest		0.7911	a	0.8021	a	0.2896	a	0.3104	a	0.4178	a	0.6110	a
Fuller		0.7545	b	0.7961	a	0.2772	a	0.3055	a	0.2663	c	0.5302	b
SY Southwind		0.6748	c	0.7623	a	0.2840	a	0.2917	a	0.3156	b	0.5178	b
T-154		0.7544	b	0.7626	a	0.2753	a	0.2774	a	0.3028	bc	0.5169	b

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).

‡ Column means within treatment groupings followed by the same letter are not significantly different (α = 0.05).

Table 2.7 Effect of previous summer crop hybrid and wheat cultivar on spike density of winter wheat at four experimental sites in Kansas in 2013 and 2014.

		Environment							
		2013				2014			
Treatments		Hutchinson		Manhattan		Hutchinson		Manhattan	
Summer Hybrid		spikes m^{-2}							
DKC63-84	C,L, –†	603	a‡	726	a	316	a	348	a
88P68	S,E,R	605	a	694	a	296	a	388	a
86G32	S,M,R	555	a	597	a	289	a	315	a
85G03	S,ML,R	582	a	583	a	314	a	451	a
SP3303	S,E,T	620	a	716	a	318	a	408	a
4525	S,ML,T	520	a	622	a	311	a	434	a
Wheat Cultivar									
Billings		485	c	592	a	275	a	251	e
Duster		630	a	486	a	327	a	402	bc
Everest		630	a	703	a	336	a	511	ab
Fuller		529	bc	747	a	277	a	283	de
SY Southwind		544	b	695	a	312	a	382	dc
T-154		667	a	713	a	318	a	514	a

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).

‡ Column means within treatment groupings followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 2.8 Effect of previous summer crop hybrid and wheat cultivar on kernels spike^{-1} of winter wheat at four experimental sites in Kansas in 2013 and 2014.

		Environment							
		2013				2014			
Treatments		Hutchinson		Manhattan		Hutchinson		Manhattan	
Summer Hybrid		kernels spike^{-1}							
DKC63-84	C,L, –†	22.9	a‡	23.8	a	16.1	a	21.7	a
88P68	S,E,R	21.9	a	24.4	a	15.4	a	25.3	a
86G32	S,M,R	24.5	a	24.3	a	16.0	a	20.9	a
85G03	S,ML,R	25.3	a	24.1	a	18.2	a	25.2	a
SP3303	S,E,T	23.0	a	23.4	a	17.9	a	25.1	a
4525	S,ML,T	23.3	a	23.2	a	17.9	a	24.8	a
Wheat Cultivar									
Billings		25.3	a	26.5	a	17.7	a	21.2	c
Duster		22.0	a	24.8	ab	17.4	a	23.0	bc
Everest		23.5	a	22.0	bc	11.9	b	20.8	c
Fuller		22.9	a	21.4	c	17.5	a	21.6	c
SY Southwind		25.6	a	23.9	abc	20.8	a	27.7	ab
T-154		21.6	a	24.6	abc	16.3	ab	28.5	a

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Column means within treatment groupings followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 2.9 Effect of previous summer crop hybrid and wheat cultivar on kernels weight of winter wheat at four experimental sites in Kansas in 2013 and 2014.

		Environment							
		2013				2014			
Treatments		Hutchinson		Manhattan		Hutchinson		Manhattan	
Summer Hybrid		g 1000^{-1}							
DKC63-84	C,L, –†	24.0	a‡	21.2	a	26.9	a	31.6	a
88P68	S,E,R	23.4	a	22.1	a	24.7	a	31.1	a
86G32	S,M,R	22.7	a	21.4	a	24.4	a	31.8	a
85G03	S,ML,R	23.3	a	22.2	a	25.1	a	32.0	a
SP3303	S,E,T	23.3	a	21.9	a	27.1	a	32.0	a
4525	S,ML,T	23.1	a	22.6	a	24.9	a	30.8	a
Wheat cultivar									
Billings		26.3	a	25.5	a	28.8	a	35.7	a
Duster		22.0	d	20.9	c	23.5	b	28.0	d
Everest		24.5	b	23.2	b	27.6	a	33.0	b
Fuller		23.5	bc	22.0	bc	26.9	a	32.8	b
SY Southwind		21.2	d	17.7	d	22.6	b	29.8	dc
T-154		22.4	cd	22.1	bc	23.5	b	30.1	c

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Column means within treatment groupings followed by the same letter are not significantly different (α = 0.05).

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Chapter 3 - Effects of Hybrid Characteristics and Environment on Phenolic Acid Content in Grain Sorghum and Corn Residue

Introduction

The adoption of conservation tillage practices has been increasing over the past two decades. The Conservation Technology Information Center defines conservation tillage as a management system that has 30% or more of the soil surface covered with crop residue after planting (CTIC, 2015). Survey results from the Conservation Technology Information Center (CTIC, 2015) showed that conservation tillage practices increased by 15.9% from 1989 to 2008. The increase in conservation tillage practices was mainly due to the increase in no-till managed systems. In that same time period, no-till systems increased 18.7%, but ridge till and mulch till systems decreased 0.2 and 2.6%, respectively (CTIC, 2015). When implementing no-till management practices, surface residues from crops are increased, but coverage is influenced by previous crop (Claassen, 2007). Claassen (2007) reported that in continuous winter wheat (*Triticum aestivum* L.) systems no-till residue cover was 48 and 67% greater at wheat planting compared to systems where residues were tilled or burned, respectively. Results from the same study found that percent residue cover was 20% and 19% greater in corn (*Zea mays* L.) and grain sorghum [*Sorghum bicolor* (L.) Moench], respectively, compared to soybean [Glycine max. (L.) Merr.] residue (Claassen, 2007). With the increasing popularity of no-till management practices it is important to understand how crop residues left on the soil surface will impact crop rotations.

The interaction that occurs when phytochemicals are released into the environment by one plant species and affects another plant species is often referred to as allelopathy (Ben-Hammouda et al., 1995a; Ben-Hammouda et al., 1995b; Roth et al. 2000; Rice, 1984). Phytotoxicity is a common term used when phytochemicals produced by one plant species negatively affect another plant species (Ben-Hammouda et al., 1995a; Guenzie and McCalla, 1966a; Guenzi et al., 1967). Phytochemicals associated with allelopathy enter an environment by root discharges, leaching, volatilization, and by the breakdown of plant residues (Putnam, 1985). Residues of multiple crops have been associated with phytotoxic effects on other crops. Water extracts taken from sorghum, corn, wheat, and oat residues hindered both radicle and shoot growth in wheat seedlings (Guenzi et al., 1967). A greenhouse experiment conducted by Hegde and Miller (1990) found that alfalfa germination was reduced by 45 and 65% when the roots and shoots of alfalfa and grain sorghum, respectively, were incorporated into the soil.

Phenolic acids produced by plants are secondary metabolites that often are associated with allelopathy in crop production (Guenzi and McCalla, 1966a; Taiz and Zeiger, 2010). Guenzi and McCalla (1966a) identified five phenolic acids in crop residues: *p*-hydroxybenzoic, syringic, ferulic, vanillic, and *p*-coumaric as phytotoxic to wheat seedlings. Sorghum residues that inhibited wheat seedling growth were found to contain these same five same phenolic acids (Ben-Hammouda et al., 1995b). Negative growth responses of horse purslane often were associated with water extracts taken from sorghum residues that had greater concentrations of *p*-hydroxybenzoic acid and *p*-coumaric acid compounds (Cheema et al., 2007).

Phytotoxic potential of plants can depend on the crop, hybrid, and residue composition. Chemical analysis of sorghum residues collected in Missouri found that the concentration of phenolic acid compounds was dependent on the year the crop was grown, sorghum hybrid, and plant part sampled (Ben-Hammouda et al., 1995b). Guenzi et al. (1967) noted that the plant stems tended to be more phytotoxic compared to roots, glumes, husks, and seeds, but toxicity varied with crop. Compared to a control treatment, stems of grain sorghum reduced radicle growth of wheat seedlings by 81%, and stems of oats, corn, and wheat reduced growth by 55, 11, and 2%, respectively (Guenzi et al., 1967). Grain yields of guar, pearl millet, millet, and corn grown in sunflower residue were reduced by 1501, 2888, 6751, and 3337 kg ha^{-1}, respectively, compared to when they were grown in fields without sunflower residue (Batish et al., 2002). Phytotoxicity can differ among crop species, but genotypes within a species may also differ in phytotoxic potential. Observations made on six different cotton genotypes found that concentrations of phenolic acids varied with genotype (Lege et al., 1995). Lege et al. (1995) also found that as the development of the cotton plant transitioned from pinhead square to first bloom, the concentrations of gallic-, protocatechuic-, and total phenolic acids significantly decreased.

Grain sorghum often is associated with allelopathic or phytotoxic properties (Ben-Hammouda et al., 1995a; Ben-Hammouda et al., 1995b) Productivity of crops planted after sorghum often is reduced compared to other crops. Research in South Central Kansas reported that wheat yields following grain sorghum where reduced by 720 and 632 kg ha^{-1} compared to wheat after corn or soybeans, respectively (Claassen, 2007). Guenzi et al. (1967) found wheat seedling growth was hindered by water extracts taken from grain sorghum residue. Germination of peanuts in water extracts taken from soils that previously had grain sorghum grown in them were reduced by 25 to 50% compared to peanuts germinated in a water control (Sene et al., 2000). Roth et al. (2000) suggested that negative responses in winter wheat following tilled and no-till sorghum were possibly due to allelopathic effects of the sorghum residue. Guenzi and McCalla (1966b) analyzed soils from fields that had been sub-tilled and plowed and found that concentrations of ferulic acid and *p*-coumaric acids were greatest in soils of sub-tilled fields.

In Kansas, planted areas of grain sorghum have declined by 40.6% since 1996 (NASS, 2015). The reduction in planted area of grain sorghum may partially be due to the potential phytotoxic effects it may have on other crops. Not all studies are convinced that grain yield reductions are due to allelopathic effects, but attribute wheat yield reductions after grain sorghum to nitrogen mineralization (Sanford and Hairston, 1983; Staggenborg et al., 2003). Understanding how sorghum hybrid characteristics and environment influence phenolic acid production in grain sorghum will allow for better management decisions when including grain sorghum in crop rotations. Objectives of this study were to: identify differences in phenolic acid concentrations between maturity and plant pigment of grain sorghum hybrids; determine how phenolic acid concentration in grain sorghum is influenced by environment; and observe how time influences phenolic acid content in sorghum residues.

Material and Methods

Corn and grain sorghum was grown at three experimental locations over two growing seasons (Table 3.1). In 2012 and 2013, corn and grain sorghum was planted at Manhattan, KS, and a site near Hutchinson, KS was planted to corn and grain sorghum in 2013. Both locations have frost free days and annual precipitation amounts that would facilitate planting a winter wheat crop after grain sorghum harvest.

Experimental design was a randomized complete block with four replications. Treatments included six summer crop hybrids consisting of five sorghum hybrids and one corn hybrid (Table 3.2). Grain sorghum hybrids included three maturities (early-medium, medium, and medium-late) and two plant pigmentations (red, tan). The corn hybrid was selected based on past performance at the locations. Plot size for summer hybrids was 12 m wide and 18 m long.

Grain sorghum and corn were planted in 76-cm row spacing at all locations in both years. A four row planter (AGCO Corporation; Duluth, Georgia) was used at the Hutchinson locations both years, and a two row planter with John Deere (Deere & Company; Moline, Illinois) row units was used at the Manhattan locations both years. Management practices for corn and grain sorghum were based on Kansas State University recommendations for optimal grain production at each location (KSU, 1996; KSU, 1998). Before planting grain sorghum and corn, glyphosate (N-[phosphonomethyl] glycine, in the form of its potassium salt; Roundup WeatherMAX; Monsanto Company; St. Louis, Missouri) was used to control established weeds. S-Metolachlor (Acetamide, 2-chloro-N-[2-ethyl-6-methylphenly]-N-[2-methoxy-1-methylethyl]-,S) plus atrazine (2-chloro-4-[ethylamino]-6-[isopropylamino]-s-triazine; Lumax; Syngenta Crop Protection, Inc.; Greensboro, North Carolina) was used as a pre-emergence residual herbicide to control early season weed establishment in the grain sorghum. No residual herbicides were used in the corn plots. When a post emergence herbicide was needed for weeds that escaped residual herbicide applications within the grain sorghum plots pyrasulfotole (methanone, [5-hydroxy-1,3-dimethyl-1*H*-pyrazol-4-yl] [2-(methylsulfonyl)-4-(trifluoromethyl) phenyl]) plus bromoxynil octanoate (2,6-dibromo-4-cyanophenyl octanoate) plus bromoxynil heptanoate (2,6-dibromo-4-cyanophenyl heptanoate; Huskie; Bayer CropScience LP; Research Triangle Park, North Carolina) was used. For post emergence weed control in corn plots, glyphosate (Roundup WeatherMAX; Monsanto Company; St. Louis, Missouri) was used as needed. At Manhattan in 2012, corn was planted on April 14 and harvested on August 31, and grain sorghum was planted on June 1 and harvested on September 25. At Manhattan in 2013, corn was planted on April 30 and harvested on September 25, and grain sorghum was planted on May 27 and harvested on October 2. Corn was planted on May 6 and harvested on October 3, and grain sorghum was planted May 28 and harvested on October 28 at Hutchinson in 2013. Winter wheat was planted into the summer crop residue following grain sorghum harvest.

After grain sorghum harvest, residue samples were collected from each plot. Samples were collected by randomly selecting two 0.25 m^{-2} areas and collecting all surface residues within the designated area. Samples were collected three times based on the growth and development of the winter wheat crop. Residues were collected in the fall just after wheat planting (October to November), once during the winter while wheat was dormant (January to February), and again in the spring (March to April) just prior to Feekes 6, wheat jointing.

Residue samples were dried at 60 °C until no change in dry matter weight was observed. Residue samples were weighed to quantify dry matter amount and phenolic acid quantities per unit area.

Roth (2000) demonstrated that *p*-coumaric acid (PCA), ferulic acid (FA), and vanillic acid (VA) are phenolic acids found in crop residues that inhibited the development and growth of wheat seedlings. A random 50 grams was collected from each dried residue sample and ground to pass a 1 mm screen. A 20 g sub-sample of each was used for determination of PCA, FA, and VA concentrations using HPLC analysis by the Kansas State University Ruminant Nutrition Lab. Alkali-labile phenolic monomers were extracted with 10 ml of anaerobic 2N NaOH (containing 40 ppm 3, 4-dimethoxycinnamic acid as an internal standard) under N_2 for 24 h in the dark at room temperature, mixing occasionally. Samples were acidified with 2 ml of H_3PO_4 (85%) and 8 ml of water to a pH near 2.0, refrigerated overnight, and centrifuged at 25,000 x g for 20 min. The supernatant was loaded on a C_{18} extraction column, the column was rinsed with 2 ml wash solution (H_3PO_4 [pH 2]), and phenolics were eluted with two, 2.5 ml washes of 50% methanol.

Analysis of variance (ANOVA) was performed to determine main effect differences using PROC GLIMMIX in SAS 9.2 (SAS, 2009) statistical analysis software with block as a random factor. Based on significant interactions of treatment factors with environment for many response variables, results for phenolic acid concentrations and quantities will be presented by location in each year.

Results

P-Coumaric Acid

Concentrations and quantity of PCA were affected by both summer hybrid and sample time. At Manhattan in 2012 to 2013, PCA concentrations were influenced by the interaction of summer hybrid and sample time (Table 3.3). Corn residues had greater PCA concentrations at all sampling times compared to sorghum residues. Concentrations of PCA were greater in spring residue samples compared to fall for all summer hybrids. There was no difference in PCA concentration among sorghum hybrids sampled in the spring, except that hybrid 88P68 had greater concentrations compared to the other four sorghum hybrids (Table 3.3). Within sorghum hybrids, maturity and plant pigment did not influence concentrations of PCA in the spring residue samples, but for the fall sampling date, red pigmented hybrids had greater concentrations compared to tan plants. Inversely, residue sampled in the winter, concentrations of PCA were greater in tan plants versus red plants (Table 3.3). Medium maturity hybrids had greater concentrations compared to early and medium-late maturity hybrids in the fall residue samples. This was likely influenced by plant pigment because medium maturity grouping had only one red-pigmented hybrid, but the early and medium-late groupings had one tan and one red pigmented hybrid. Quantities of PCA in corn residue were greater at all sample dates compared to PCA quantities in grain sorghum residue, but the ranking of sorghum hybrids differed with each sample time (Table 3.3). The smallest quantity of PCA was found in residue of early maturity sorghum during the winter. Residue samples collected in winter and spring residues for medium-late maturity sorghum hybrids had greater quantities of PCA compared to early and medium early sorghum hybrids, but were similar in the fall (Table 3.3).

At Manhattan in 2013 to 2014, PCA concentration and quantities were affected by either summer hybrid or sample time, but not their interaction (Table 3.4). Concentrations of PCA in residues increased from fall to spring for all summer crop hybrids, but quantity did not differ between sample times. Corn residue had greater PCA concentration and quantity compared to sorghum residue. Although concentrations did not differ, quantities of PCA were greater following tan pigmented compared to red pigmented sorghum hybrids (Table 3.4). Concentration and quantity of PCA was greater in residues of medium-late sorghum hybrids compared to early or medium maturity hybrids.

At Hutchinson, effects of summer hybrid and sample time on PCA concentrations and quantities were similar to that observed at Manhattan in 2013 to 2014 (Table 3.5). Concentration of PCA was greater in corn residue compared to sorghum residue, but quantity did not differ. Tan pigmented sorghum hybrids had greater concentrations and quantities of PCA compared to red pigmented sorghum hybrids, and medium-late maturity sorghum hybrids had greater PCA concentrations and quantities compared to early and medium maturity sorghum hybrids (Table 3.5).

Ferulic Acid

Concentrations and quantities of FA were affected by both summer hybrid and sample time. At Manhattan in 2012 to 2013, concentrations and quantities of FA were affected by the interaction of summer hybrid and sample time (Table 3.6). Concentration of FA was greater in corn residue than in sorghum residues only for the winter sample date, but quantities were greater for corn at all sample dates. Although summer hybrid and characteristic rankings changed with each date, concentrations and quantities of FA were less in spring residues compared to fall and winter residues for both corn and grain sorghum (Table 3.6). In the fall, residues of early and medium maturity sorghum hybrids had greater FA concentrations compared to medium-late maturity hybrids, but for the winter sample date, residues of early and medium-late maturity hybrids had greater concentrations compared to medium maturity hybrids. Quantities of FA were greater for early and medium-late maturity sorghum hybrids for the fall sample time, but early maturity hybrids had the least at the winter sample time (Table 3.6). Concentrations and quantities of FA were not different for sorghum hybrid maturities at the spring sample time.

At Manhattan in 2013 to 2014, FA concentrations and quantities were affected by either summer hybrid or sample time, but not their interaction (Table 3.7). Concentrations and quantities of FA were greater for corn residue compared to grain sorghum. Residues of tan pigmented sorghum hybrids had greater concentrations and quantities of FA compared to red pigmented sorghum hybrids (Table 3.7). Sorghum hybrid maturity had no effect on FA concentration or quantity. Concentrations and quantities of FA were less in the winter and spring compared to quantities in the fall (Table 3.7).

At Hutchinson, FA concentrations and quantities were affected by either summer hybrid or sample time, but not their interaction (Table 3.8). Similar to Manhattan in 2013 to 2014, corn residues had greater concentrations and quantities of FA compared to sorghum residues, and tan pigmented sorghum hybrids had greater FA concentrations and quantities compared to red pigmented sorghum hybrids (Table 3.8). Although FA concentration was not affected by sorghum hybrid maturity, quantities of FA increased with later hybrid maturity. Concentrations of FA were greater in fall residue samples compared to winter residue samples, but spring residue samples were no different in FA concentration compared to fall or winter samples (Table 3.8). Quantities of FA were not influenced by sample time.

Vanillic Acid

Concentrations and quantities of VA were affected by both previous summer hybrid and sample time. Concentrations and quantities of VA responded to the interaction of summer hybrid and sample time at Manhattan in 2012 to 2013 (Table 3.9). Concentrations and quantities of VA were greater in corn residues compared to sorghum residues, but the magnitude of the difference was greatest at the winter sample time. There was no difference in VA concentrations for red pigmented sorghum hybrids and tan pigmented sorghum hybrids for the fall and spring sample times, but concentrations were greater in red pigmented hybrids compared to tan pigmented hybrids for the winter sample time (Table 3.9). Concentrations of VA for the spring sample time were less for both red and tan pigmented hybrids compared to concentrations for fall and winter samples. Quantities of VA were greater for tan pigmented hybrids in the fall compared to red pigmented hybrids, but quantities of VA were greater for red pigmented hybrids compared to tan pigmented hybrids for the winter sampling date. There was no difference in VA quantity due to pigmentation for the spring sampling date, and spring VA quantities were less than fall quantities (Table 3.9). Residues sampled in the fall had greater concentrations of VA in early maturity hybrids compared to medium-late maturity hybrids, but in residues sampled in the spring, medium maturity hybrids had greater VA concentration compared to early and medium-late maturity hybrids. Concentrations and quantities of VA were less in the spring for early and medium-late maturity hybrids, but there was no difference in concentrations for the medium maturity hybrid within any sampling date. Greater quantities of VA were found in fall residue samples for early and medium-late maturity sorghum hybrids compared to medium maturity hybrids, but quantities of VA were less following early maturing hybrids for the winter and spring sample times compared to medium and medium-late maturity hybrids (Table 3.9).

At Manhattan in 2013 to 2014, VA concentrations and quantities responded to both summer crop and sample time (Table 3.10). Corn residue had greater concentrations and quantities of VA at all sampling times compared to sorghum residues. Within sorghum hybrids there was no difference in VA concentration among sampling times except for SP3303 that had greater concentrations of VA at the fall sample time compared to residues at the winter and spring sampling times (Table 3.10). Within sorghum hybrids, concentrations did not differ with pigmentation, but quantities of VA were greater for tan pigmented hybrids compared to red pigmented hybrids. Residues of early maturity sorghum hybrids had greater concentrations of VA compared to medium and medium-late maturity hybrids, but VA quantities did not differ with sorghum maturity (Table 3.10). Quantity of VA was greater for the fall sampling date compared to winter and spring sampling dates.

At Hutchinson, concentrations and quantities of VA were affected by summer crop hybrid, but no sampling time (Table 3.11). Concentrations and quantities of VA were greater in corn residues compared to sorghum residues. Within sorghum hybrids, residues of early maturity hybrids had greater concentrations of VA compared to medium and medium-late maturity hybrids, but quantity was not affected (Table 3.11). Concentration of VA was least for sorghum hybrid 4525, but quantity was least for 88P68. Among sorghum hybrids, SP3303 had the greatest concentration and quantity (Table 3.11).

Discussion

Past research of allelopathy has highlighted the phytotoxic potential of phenolic acids (Ben-Hammouda et al., 1995b; Cheema et al., 2007; Guenzi and McCalla, 1966a). Genetic differences in phytotoxic potential have also been discovered in previous research (Ben-Hammouda et al., 1995a; Ben-Hammouda et al., 1995b). Roth (2000) found that PCA, FA, and VA inhibited wheat seedling development. This research exhibits how residues from five sorghum hybrids, differing in maturity and plant pigment, and one corn hybrid differ in concentrations and quantities of p-coumaric, ferulic and vanillic acids at three sampling times and three environments.

P-coumaric acid was found in greatest concentrations in all hybrids, and concentrations of VA were least. Concentrations of PCA, FA, and VA were greater in corn residue compared to sorghum residue at all environments, but concentrations and quantities of PCA, FA, and VA in residues at Manhattan in 2012 to 2013 depended on sampling time. This is likely due to earlier fall sample times at Manhattan in 2012 compared to the other two environments because of an earlier fall harvest. Average monthly temperatures were also above normal in November, December, and January at Manhattan in 2012 to 2013 (Figure 3.2 and 3.3), which could have influenced the decomposition of residues within this time frame (Stott et al., 1990). Sorghum hybrid maturity influenced PCA and VA concentrations at both Manhattan and Hutchinson in 2013 and 2014. The medium-late maturity hybrids had greater concentrations of PCA, but VA concentrations were greater in early maturity hybrids. Plant pigmentation of sorghum hybrids had a stronger influence on FA concentration with tan hybrids having greater concentrations at both Manhattan and Hutchinson in 2013 and 2014. Times at which residues were sampled also impacted the concentration of phenolic acid concentrations except for VA. In general, concentration of PCA increased from fall sample dates to spring sample dates, and FA typically decreased in concentration from fall sample dates to spring dates. Concentrations of VA stayed relatively constant at all sample dates. Both PCA and FA are precursors for the synthesis of lignin in plants (Heldt and Piechulla, 2011), and lignin tends to decay or breakdown more slowly compared to other plant components (Jung and Casler, 2006). With concentrations increasing over time for PCA compared to FA, it is likely that bonding within lignin is stronger for PCA compared to FA.

Conclusions

Grain sorghum hybrid characteristics and environment influenced concentrations and quantities of PCA, FA, and VA. Early fall harvest dates may encourage residues of certain hybrids to be broken down in the fall due to warmer temperatures and increased soil moisture content releasing some of these phenolic acids into the soil environment. Planting wheat following a summer crop in these conditions may inhibit growth and development of wheat seedlings due to allelopathic compounds released by the residue. In environments that favor slower decomposition of residues, the following summer crops could be at risk to inhibition of the phenolic acids, but effects would likely be determined by spring precipitation events and temperature. Results suggest selecting red pigmented sorghum hybrids that are of early to medium maturity to reduce allelopathic potential of sorghum on following crops.

Figures and Tables

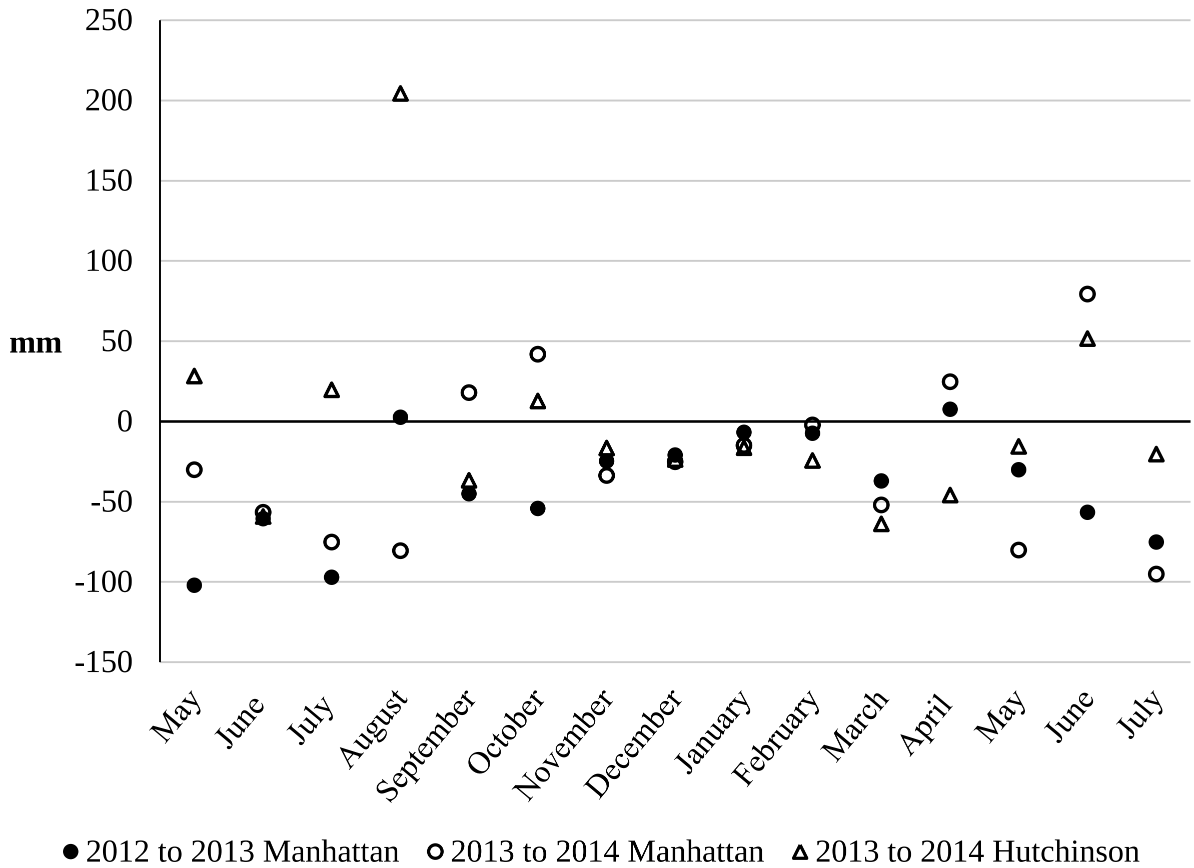

Figure 3.1 Monthly precipitation departure from normal at three experimental locations used to evaluate phenolic acid content in grain sorghum and corn residue.

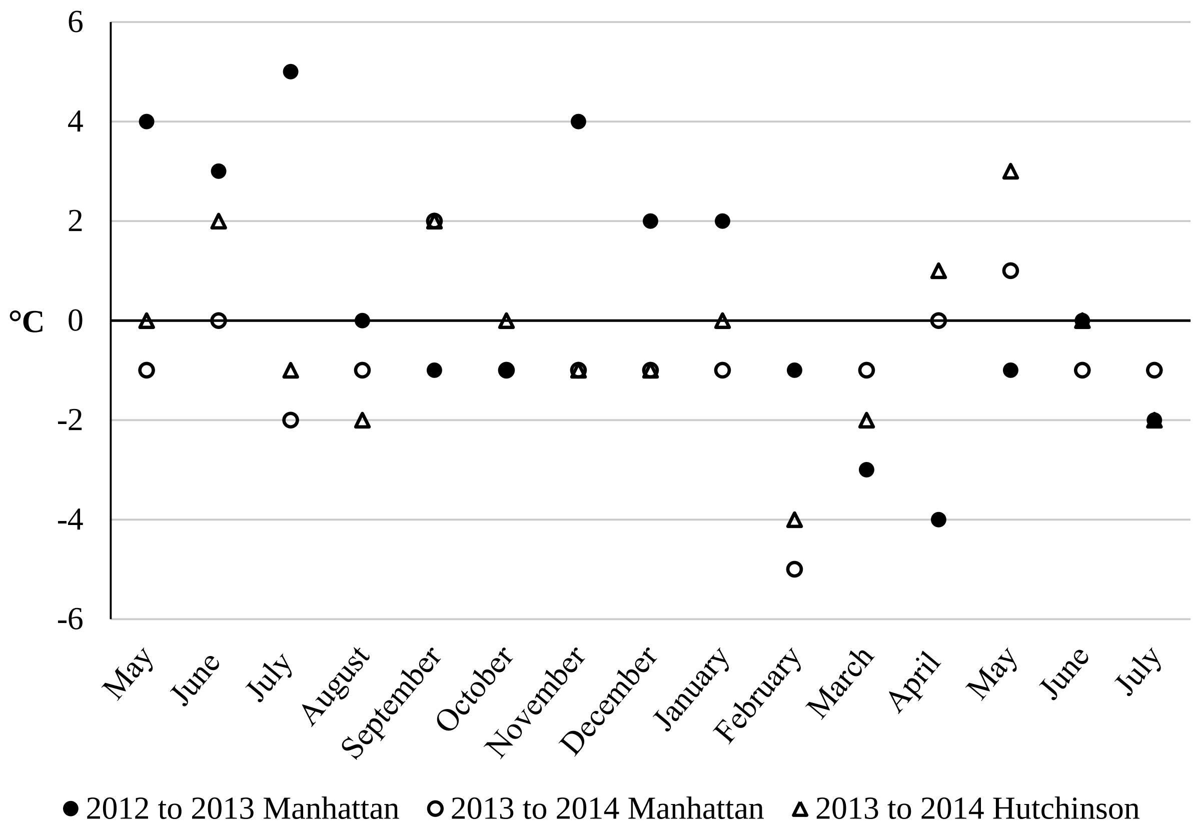

Figure 3.2 Monthly maximum temperature difference from normal at three experimental locations used to evaluate phenolic acid content in grain sorghum and corn residue.

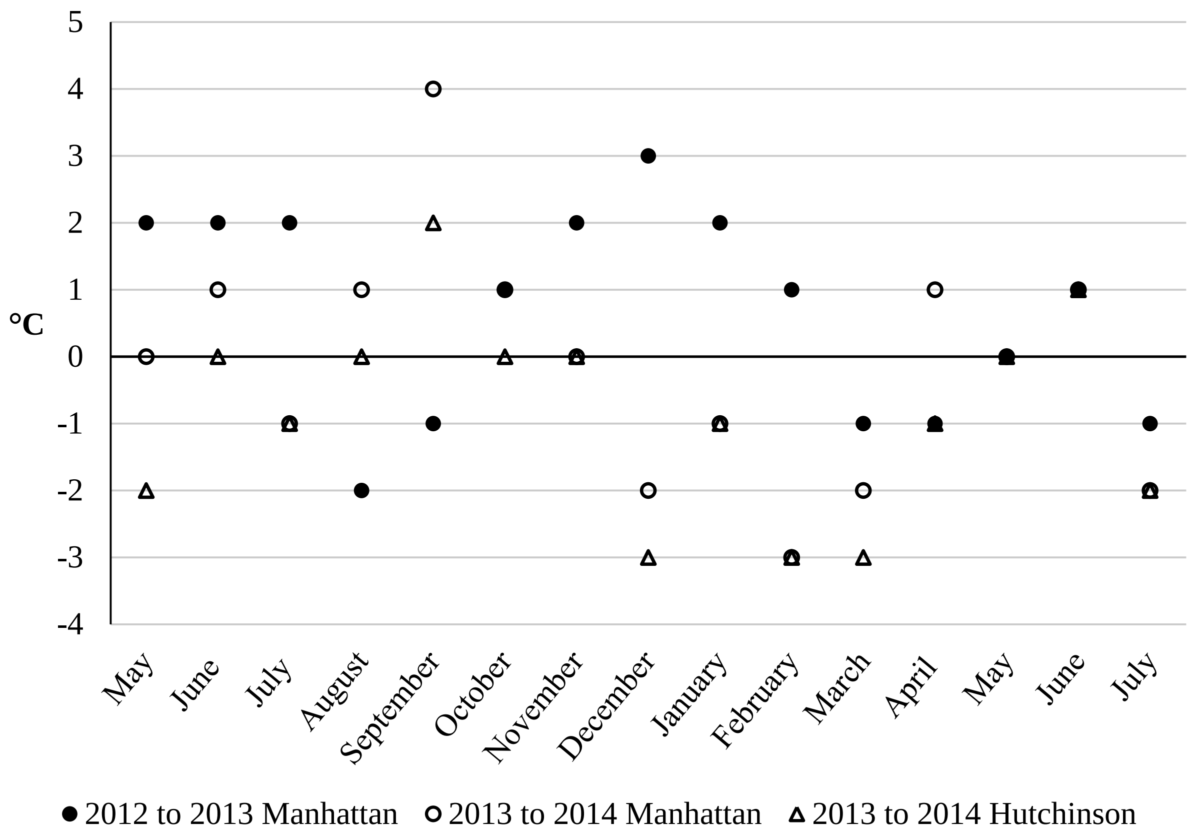

Figure 3.3 Monthly minimum temperature difference from normal at three experimental locations used to evaluate phenolic acid content in grain sorghum and corn residue.

Table 3.1 Environmental descriptions for four experimental locations used to evaluate wheat variety response to grain sorghum hybrids in Kansas from 2012 to 2014.

	Location	
Descriptor	Manhattan	Hutchinson
2012 to 2013 Growing season	39.213930, -96.594074	37.956085, -98.122087
Soil series	Reading silt loam	Taver loam
Soil classification	Fine-silty, mixed, superactive, mesic Pachic Argiudolls	Fine, smectitic, mesic Udertic Argiustolls
2013 to 2014 Growing season	39.136482, -96.641491	37.956559, -98.120383
Soil series	Rossville silt loam	Taver loam
Soil classification	Fine-silty, mixed, superactive, mesic Cumulic Hapludolls	Fine, smectitic, mesic Udertic Argiustolls
Normal spring freeze date	18-Apr	15-Oct
Normal fall freeze date	19-Apr	17-Oct
Frost free days	179	183
Normal annual precipitation (mm)	905	778

Table 3.2 Grain sorghum and corn hybrids used in experiments conducted in Kansas in 2012 to 2014 to evaluate PCA, FA, and VA concentrations and quantities.

Crop	Hybrid	Company	Maturity	Plant pigmentation
Corn	DKC 63-84	DeKalb Hybrids	113 day	–
Grain Sorghum	SP3303	Sorghum Partners	early-medium	tan
Grain Sorghum	88P68	Pioneer Hybrids	early-medium	red
Grain Sorghum	86G32	Pioneer Hybrids	medium	red
Grain Sorghum	4525	Fontenelle Hybrids	medium	tan
Grain Sorghum	85G03	Pioneer Hybrids	medium-late	red

Table 3.3 Concentration (mg g^{-1}) and quantity (g m^{-2}) of *p*-coumaric acid within treatment and sample time at Manhattan in 2012 to 2013.

Treatment		Sample time				Sample time			
		Fall	Winter	Spring	Mean	Fall	Winter	Spring	Mean
Hybrid		mg g^{-1}				g m^{-2}			
DKC63-84	C,L,–†	16.646 c‡	25.113 a	20.677 b	20.812	9.154 c	13.877 a	10.782 b	11.271
88P68	S,E,R	10.941 ghi	9.401 j	16.116 cd	12.153	4.168 ef	2.899 h	4.935 def	4.151
86G32	S,M,R	12.370 f	9.023 j	13.844 e	11.747	4.341 efg	3.982 fgh	4.254 efg	4.192
85G03	S,ML,R	9.563 ij	11.039 fgh	14.811 de	11.804	4.874 def	4.232 efg	5.121 def	4.742
SP3303	S,E,T	10.087 hij	11.639 fg	14.473 e	12.066	4.680 def	3.233 gh	4.010 fgh	3.974
4525	S,ML,T	9.450 j	15.095 de	14.123 e	12.889	4.381 efg	5.843 d	5.277 de	5.167
Crop									
Corn		16.646 c	25.113 a	20.677 b	20.812	9.154 c	13.877 a	10.782 b	11.271
Sorghum		10.482 e	11.240 e	14.673 d	12.132	4.579 de	4.038 e	4.720 d	4.445
Grain Sorghum									
Red		10.958 c	9.822 d	14.924 a	11.901	4.611	3.704	4.770	4.362
Tan		9.768 d	13.367 b	14.298 ab	12.478	4.530	4.538	4.643	4.571
Grain Sorghum									
Early		10.514 cd	10.520 c	15.294 a	12.109	4.649 abc	3.066 d	4.473 bc	4.062
Medium		12.370 b	9.028 d	13.844 ab	11.747	4.341 bc	3.982 c	4.254 bc	4.192
Medium-late		9.506 cd	13.067 b	14.467 a	12.347	4.628 abc	5.037 ab	5.199 a	4.955
Mean		11.509	13.552	15.674		5.341	5.678	5.730	

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Treatment x sample time means followed by the same lower case letter within treatment groupings are not significantly different (α=0.05).

Table 3.4 Concentration (mg g^{-1}) and quantity (g m^{-2}) of *p*-coumaric acid within treatment and sample time at Manhattan in 2013 to 2014.

Treatment		Sample time				Sample time			
		Fall	Winter	Spring	Mean	Fall	Winter	Spring	Mean
Hybrid		mg g^{-1}				g m^{-2}			
DKC63-84	C,L,–†	19.581	22.697	23.474	21.921 A‡	24.854	22.693	21.841	23.129 A
88P68	S,E,R	14.298	15.826	14.424	14.849 CD	15.709	13.760	13.661	14.249 D
86G32	S,M,R	14.476	14.352	14.489	14.439 D	15.873	14.094	13.113	14.360 D
85G03	S,ML,R	15.255	18.144	21.182	18.193 B	20.621	18.219	19.508	19.449 BC
SP3303	S,E,T	13.399	16.255	16.452	15.369 CD	15.630	16.002	18.581	16.738 CD
4525	S,ML,T	16.474	16.297	18.355	17.042 BC	25.487	17.366	18.581	20.594 AB
Crop									
Corn		19.581	22.697	23.474	21.917 A	24.852	22.693	21.841	23.128 A
Sorghum		14.780	16.281	16.980	16.014 B	18.664	15.918	16.758	17.113 B
Grain Sorghum									
Red		14.676	16.322	16.698	15.899	17.401	15.416	15.427	16.082 B
Tan		14.937	16.276	17.403	16.205	20.558	16.684	18.754	18.666 A
Grain Sorghum									
Early		13.848	16.040	15.438	15.109 B	15.670	14.689	16.121	15.493 B
Medium		14.476	14.389	14.489	14.451 B	15.873	14.203	13.113	14.397 B
Medium-late		15.864	17.221	19.769	17.618 A	23.054	17.792	19.218	20.021 A
Mean		15.582 B	17.262 AB	18.063 A		19.696	16.958	17.605	

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Treatment or sample time means followed by the same upper case letter within treatment groupings are not significantly different (α=0.05).

Table 3.5 Concentration (mg g^{-1}) and quantity (g m^{-2}) of *p*-coumaric acid within treatment and sample time at Hutchinson in 2013 to 2014.

Treatment		Sample time				Sample time			
		Fall	Winter	Spring	Mean	Fall	Winter	Spring	Mean
Hybrid		mg g^{-1}				g m^{-2}			
DKC63-84	C,L,–†	16.196	12.863	17.323	15.462 A‡	7.414	5.859	8.016	7.096 BC
88P68	S,E,R	9.851	11.534	11.002	10.796 C	4.456	5.085	4.781	4.774 D
86G32	S,M,R	10.563	11.427	10.379	10.790 C	6.324	6.459	5.926	6.236 C
85G03	S,ML,R	11.247	10.999	12.955	11.733 BC	7.445	7.247	8.252	7.648 AB
SP3303	S,E,T	11.257	12.774	11.935	11.988 BC	5.824	6.573	6.443	6.280 BC
4525	S,ML,T	13.245	12.455	14.398	13.366 B	8.896	8.221	8.946	8.688 A
Crop									
Corn		16.196	12.863	17.329	15.462 A	7.414	5.859	8.016	7.096
Sorghum		11.232	11.787	12.143	11.721 B	6.589	6.725	6.892	6.736
Grain Sorghum									
Red		10.553	11.320	11.445	11.106 B	6.075	6.234	6.319	6.219 B
Tan		12.251	12.578	13.329	12.719 A	7.360	7.532	7.891	7.594 A
Grain Sorghum									
Early		10.554	12.035	11.371	11.320 B	5.140	5.713	5.484	5.446 B
Medium		10.563	11.427	10.379	10.790 B	6.324	6.459	5.926	6.236 B
Medium-late		12.246	11.727	13.676	12.550 A	8.171	7.734	8.599	8.168 A
Mean		12.060	12.009	12.999		6.726	6.574	7.060	

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Treatment or sample time means followed by the same upper case letter within treatment groupings are not significantly different (α=0.05).

Table 3.6 Concentration (mg g^{-1}) and quantity (g m^{-2}) of ferulic acid within treatment and sample time at Manhattan in 2012 to 2013.

Treatment		Sample time: Fall	Winter	Spring	Mean	Sample time: Fall	Winter	Spring	Mean
		mg g^{-1}				g m^{-2}			
Hybrid									
DKC63-84	C,L,–†	3.179 b‡	3.675 a	2.733 cd	3.195	1.752 b	2.031 a	1.427 cd	1.736
88P68	S,E,R	2.977 bc	2.752 cd	2.400 g	2.710	1.256 de	0.849 gh	0.735 h	0.947
86G32	S,M,R	3.233 b	2.564 defg	2.495 defg	2.764	1.134 ef	1.131 ef	0.766 h	1.011
85G03	S,ML,R	2.738 cd	3.144 b	2.446 efg	2.776	1.395 cd	1.206 de	0.846 gh	1.149
SP3303	S,E,T	3.224 b	3.063 b	2.744 cd	3.010	1.496 c	0.852 gh	0.765 h	1.037
4525	S,ML,T	2.688 def	2.714 cde	2.440 fg	2.614	1.247 de	1.051 efg	0.914 fgh	1.070
Crop									
Corn		3.179 b	3.675 a	2.733 cd	3.195	1.752 b	2.031 a	1.427 c	1.736
Sorghum		2.972 bc	2.847 c	2.505 d	2.775	1.305 c	1.018 d	0.805 e	1.043
Grain Sorghum									
Red		2.983	2.820	2.447	2.750	1.262	1.062	0.782	1.035
Tan		2.956	2.889	2.592	2.812	1.371	0.951	0.839	1.054
Grain Sorghum									
Early		3.101 ab	2.908 bc	2.572 de	2.860	1.376 a	0.850 c	0.750 c	0.992
Medium		3.233 a	2.564 de	2.495 de	2.764	1.134 b	1.131 b	0.766 c	1.012
Medium-late		2.713 cd	2.929 bc	2.443 e	2.695	1.321 a	1.128 b	0.880 c	1.110
Mean		3.006	2.985	2.543		1.380	1.186	0.909	

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).

‡ Treatment x sample time means followed by the same lower case letter within treatment groupings are not significantly different (α=0.05).

Table 3.7 Concentration (mg g^{-1}) and quantity (g m^{-2}) of ferulic acid within treatment and sample time at Manhattan in 2013 to 2014.

Treatment		Sample time				Sample time			
		Fall	Winter	Spring	Mean	Fall	Winter	Spring	Mean
Hybrid		mg g^{-1}				g m^{-2}			
DKC63-84	C,L,–†	4.300	3.987	3.950	4.079 A‡	5.472	3.949	3.610	4.343 A
88P68	S,E,R	3.296	2.817	2.535	2.883 D	3.624	2.391	2.411	2.809 D
86G32	S,M,R	3.463	2.819	2.724	3.002 CD	3.800	2.786	2.452	3.013 CD
85G03	S,ML,R	3.297	3.173	3.154	3.208 C	4.463	3.204	2.891	3.519 BC
SP3303	S,E,T	3.982	3.528	3.197	3.569 B	4.659	3.489	3.608	3.919 AB
4525	S,ML,T	3.511	2.930	2.776	3.072 CD	5.429	3.160	2.865	3.818 AB
Crop									
Corn		4.300	3.987	3.950	4.079 A	5.475	3.949	3.610	4.344 A
Sorghum		3.510	3.067	2.877	3.151 B	4.395	3.020	2.845	3.420 B
Grain Sorghum									
Red		3.352	2.950	2.804	3.036 B	3.962	2.798	2.585	3.115 B
Tan		3.746	3.229	2.986	3.321 A	5.044	3.325	3.237	3.868 A
Grain Sorghum									
Early		3.639	3.172	2.866	3.226	4.141	2.940	3.010	3.364
Medium		3.463	2.833	2.724	3.007	3.800	2.812	2.452	3.021
Medium-late		3.404	3.051	2.965	3.140	4.946	3.182	2.878	3.669
Mean		3.641 A	3.209 B	3.056 B		4.574 A	3.163 B	2.973 B	

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Treatment or sample time means followed by the same upper case letter within treatment groupings are not significantly different (α=0.05).

Table 3.8 Concentration (mg g^{-1}) and quantity (g m^{-2}) of ferulic acid within treatment and sample time at Hutchinson in 2013 to 2014.

Treatment		Sample time				Sample time			
		Fall	Winter	Spring	Mean	Fall	Winter	Spring	Mean
Hybrid		mg g^{-1}				g m^{-2}			
DKC63-84	C,L,–†	5.215	4.589	4.925	4.910 A‡	2.370	2.069	2.283	2.241 A
88P68	S,E,R	2.860	2.883	2.896	2.880 C	1.300	1.264	1.258	1.274 C
86G32	S,M,R	3.079	2.899	2.817	2.932 C	1.853	1.646	1.621	1.707 B
85G03	S,ML,R	3.053	2.580	2.717	2.784 C	2.023	1.716	1.741	1.827 B
SP3303	S,E,T	3.482	3.401	3.113	3.332 B	1.804	1.751	1.646	1.743 B
4525	S,ML,T	3.210	2.622	2.991	2.941 BC	2.161	1.736	1.858	1.918 B
Crop									
Corn		5.215	4.589	4.925	4.910 A	2.370	2.069	2.283	2.241 A
Sorghum		3.137	2.848	2.894	2.960 B	1.823	1.616	1.628	1.690 B
Grain Sorghum									
Red		2.997	2.787	2.81	2.865 B	1.725	1.542	1.540	1.602 B
Tan		3.346	2.938	3.026	3.103 A	1.982	1.742	1.779	1.834 A
Grain Sorghum									
Early		3.171	3.088	2.972	3.077	1.552	1.468	1.432	1.484 B
Medium		3.079	2.899	2.817	2.932	1.853	1.646	1.621	1.707 AB
Medium-late		3.132	2.601	2.854	2.862	2.092	1.726	1.800	1.873 A
Mean		3.483 A	3.162 B	3.243 AB		1.918	1.697	1.739	

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).
‡ Treatment or sample time means followed by the same upper case letter within treatment groupings are not significantly different (α=0.05).

Table 3.9 Concentration (mg g^{-1}) and quantity (g m^{-2}) of vanillic acid within treatment and sample time at Manhattan in 2012 to 2013.

Treatment		Sample time				Sample time			
		Fall	Winter	Spring	Mean	Fall	Winter	Spring	Mean
Hybrid		mg g^{-1}				g m^{-2}			
DKC63-84	C,L,–†	0.160 a‡	0.170 a	0.127 bcd	0.152	0.088 a	0.093 a	0.066 b	0.082
88P68	S,E,R	0.129 bc	0.134 b	0.088 h	0.117	0.054 cde	0.041 fgh	0.027 i	0.041
86G32	S,M,R	0.124 bcde	0.127 bcd	0.119 cde	0.123	0.044 efg	0.056 bcd	0.037 ghi	0.045
85G03	S,ML,R	0.112 defg	0.124 bcde	0.102 fgh	0.113	0.057 bcd	0.048 def	0.035 ghi	0.047
SP3303	S,E,T	0.137 b	0.116 cdef	0.099 gh	0.117	0.064 bc	0.032 hi	0.028 i	0.041
4525	S,ML,T	0.125 bcde	0.111 efg	0.093 h	0.110	0.058 bcd	0.043 fgh	0.035 ghi	0.045
Crop									
Corn		0.160	0.170	0.127	0.152 A§	0.088 a	0.093 a	0.066 b	0.082
Sorghum		0.125	0.122	0.100	0.116 B	0.055 c	0.044 d	0.032 e	0.044
Grain Sorghum									
Red		0.122 ab	0.128 a	0.103 c	0.118	0.052 b	0.048 b	0.033 c	0.044
Tan		0.131 a	0.114 b	0.096 c	0.114	0.061 a	0.038 c	0.032 c	0.043
Grain Sorghum									
Early		0.133 a	0.125 ab	0.093 c	0.117	0.059 a	0.037 cd	0.027 e	0.041
Medium		0.124 ab	0.127 ab	0.119 b	0.123	0.044 bc	0.056 a	0.037 cd	0.045
Medium-late		0.119 b	0.117 b	0.098 c	0.111	0.057 a	0.045 b	0.035 d	0.046
Mean		0.1311	0.1302	0.1045		0.061	0.052	0.038	

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).

‡ Treatment x sample time means followed by the same lower case letter within treatment groupings are not significantly different (α=0.05).

§ Treatment or sample time means followed by the same upper case letter within treatment groupings are not significantly different (α=0.05).

Table 3.10 Concentration (mg g^{-1}) and quantity (g m^{-2}) of vanillic acid within treatment and sample time at Manhattan in 2013 to 2014.

Treatment		Sample time				Sample time			
		Fall	Winter	Spring	Mean	Fall	Winter	Spring	Mean
Hybrid		mg g^{-1}				g m^{-2}			
DKC63-84	C,L,–†	0.221 a‡	0.214 a	0.201 a	0.212	0.278	0.212	0.182	0.224 A §
88P68	S,E,R	0.122 cde	0.114 cde	0.132 c	0.123	0.134	0.097	0.125	0.119 C
86G32	S,M,R	0.103 de	0.118 cde	0.118 cde	0.110	0.113	0.119	0.100	0.111 C
85G03	S,ML,R	0.124 cd	0.108 cde	0.109 cde	0.114	0.168	0.116	0.010	0.126 BC
SP3303	S,E,T	0.165 b	0.123 cde	0.112 cde	0.133	0.192	0.122	0.126	0.147 B
4525	S,ML,T	0.107 de	0.098 e	0.109 cde	0.105	0.165	0.107	0.111	0.128 BC
Crop									
Corn		0.222	0.214	0.201	0.212 A	0.278	0.212	0.182	0.224 A
Sorghum		0.124	0.112	0.114	0.117 B	0.154	0.111	0.113	0.126 B
Grain Sorghum									
Red		0.116	0.113	0.117	0.116	0.138	0.108	0.108	0.118 B
Tan		0.136	0.110	0.110	0.119	0.178	0.115	0.119	0.137 A
Grain Sorghum									
Early		0.144	0.119	0.122	0.128 A	0.163	0.109	0.126	0.133
Medium		0.103	0.118	0.110	0.111 B	0.113	0.119	0.100	0.111
Medium-late		0.115	0.103	0.109	0.109 B	0.166	0.109	0.106	0.127
Mean		0.140	0.129	0.129		0.175 A	0.128 B	0.124 B	

Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).

‡ Treatment x sample time means followed by the same lower case letter within treatment groupings are not significantly different (α=0.05).

§Treatment or sample time means followed by the same upper case letter within treatment groupings are not significantly different (α=0.05).

Table 3.11 Concentration (mg g^{-1}) and quantity (g m^{-2}) of vanillic acid within treatment and sample time at Hutchinson in 2013 to 2014.

Treatment		Sample time				Sample time			
		Fall	Winter	Spring	Mean	Fall	Winter	Spring	Mean
Hybrid		mg g^{-1}				g m^{-2}			
DKC63-84	C,L,–†	0.349	0.307	0.352	0.336 A	0.160	0.140	0.167	0.155 A
88P68	S,E,R	0.185	0.172	0.172	0.176 C	0.086	0.078	0.071	0.078 E
86G32	S,M,R	0.166	0.170	0.188	0.174 C	0.097	0.094	0.104	0.098 CD
85G03	S,ML,R	0.188	0.171	0.182	0.180 C	0.122	0.113	0.112	0.116 CB
SP3303	S,E,T	0.252	0.257	0.213	0.241 B	0.129	0.128	0.113	0.123 B
4525	S,ML,T	0.170	0.134	0.140	0.148 D	0.117	0.089	0.087	0.097 D
Crop									
Corn		0.349	0.307	0.352	0.336 A	0.160	0.140	0.165	0.155 A
Sorghum		0.192	0.176	0.177	0.182 B	0.110	0.099	0.097	0.102 B
Grain Sorghum									
Red		0.179	0.171	0.181	0.177	0.101	0.095	0.096	0.097
Tan		0.211	0.186	0.171	0.190	0.123	0.106	0.099	0.109
Grain Sorghum									
Early		0.218	0.208	0.190	0.206 A	0.107	0.100	0.089	0.099
Medium		0.166	0.170	0.188	0.174 B	0.097	0.094	0.104	0.098
Medium-late		0.179	0.152	0.161	0.164 B	0.119	0.101	0.100	0.107
Mean		0.218	0.208	0.202		0.118	0.107	0.109	

† Hybrid characteristics for crop (C = Corn, S = Sorghum), maturity (L = Late, ML = Medium-late, M = Medium, E = Early), and plant pigment (R = Red and T = Tan).

‡ Treatment or sample time means followed by the same upper case letter within treatment groupings are not significantly different (α=0.05).

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Chapter 4 - Research Conclusions and Impacts

Planting winter wheat following a summer row crop presents many challenges, especially when the previous summer crop is grain sorghum. The purpose of this study was to better understand the mechanisms that may affect winter wheat growth and development after grain sorghum and to assess different management strategies to improve the performance of winter wheat planted after grain sorghum in no-till systems. The objectives of the study were to: (a) identify combinations of grain sorghum harvest and residue management techniques that are effective for improving the performance of the following winter wheat crop in no-till cropping systems; (b) determine grain sorghum hybrid characteristics that facilitate planting wheat following grain sorghum, and identify winter wheat cultivars that are suitable for planting after grain sorghum; (c) identify differences in phenolic acid concentrations between sorghum hybrid maturity and plant pigmentations; determine how phenolic acid concentration in grain sorghum is influenced by environment; and observe how time influences phenolic acid content in sorghum residues.

Below normal precipitation across all environments made conditions drier than normal for all growing seasons in this study and likely influenced results. In drought- stressed environments, the performance of winter wheat planted after grain sorghum was improved by sorghum harvest and residue management techniques. Termination of the grain sorghum crop prior to harvest using glyphosate required that glyphosate application be made 45 to 50 days before the first freeze to maximize winter wheat grain yields. Due to warmer temperatures, the effectiveness of glyphosate is likely improved when applications are made in late-summer or early-fall, and a longer time interval between application and the first freeze allows more time for the glyphosate to be effective. Undisturbed sorghum residue resulted in the best winter wheat performance in any environment compared to residue that had been chopped or removed. Improvements in wheat performance following undisturbed sorghum residue could be attributed to the ability of the standing sorghum stalks to catch and hold more snowfall during winter months and to reduced soil water losses due to evaporation. Winter wheat planted after grain sorghum that had depressed grain yields (3093 kg ha^{-1}) positively responded to additional nitrogen applied to the sorghum residue in the fall. Gains obtained in winter wheat grain yields following nitrogen treatments in this study did not cover the cost of additional nitrogen applications.

Grain sorghum hybrid maturity and plant pigment did not affect the performance of the following wheat crop, but wheat performance was affected by wheat cultivar. Winter wheat grain yields were influenced by previous crop in certain environments, but our results suggest that the effects of previous crop likely depended on the available soil moisture at wheat planting and its effect on how quickly the wheat emerged. Conditions that delayed wheat planting or emergence, such as cooler temperatures, low soil water content, and late fall harvests, tended to reduce wheat cultivar performance. In this study, wheat cultivars were identified that are suitable for planting winter wheat after summer crops. Everest was suitable across all environments and management systems due to increased spike densities and kernel size. Low spike density numbers coupled with larger kernel sizes made Billings a more suitable variety for drier conditions at Hutchinson compared to Manhattan. SY Southwind was more suitable in Manhattan environments because of its potential to produce a large number of spikes in optimal growing conditions, but SY Southwinds smaller kernel size limited its performance at Hutchinson.

Grain sorghum hybrid characteristics and environment influenced concentrations and quantities of PCA, FA, and VA. Of phenolic compounds analyzed in this study, *P*-coumaric acid was found in greatest concentrations in all grain sorghum hybrids, and concentrations within sorghum residues tended to increase over time. Concentrations of FA were intermediate between PCA and VA. Ferulic acid within sorghum residues decreased overtime, but VA concentrations remained level or slightly decreased. In environments where grain sorghum was harvested early and temperatures were warmer than normal, concentrations of phenolic acids were more variable within the residue during the fall and winter sample dates. Residues of tan pigmented plants were more likely to have greater concentrations of phenolic acids compared to red pigmented plants, and phenolic acid quantities were greater following medium-late maturity sorghum hybrids compared to early maturity hybrids.

In conclusion, yields of winter wheat can be improved when following grain sorghum in no-till managed systems. Grain sorghum is often harvested later than other summer crops such as corn and soybeans, delaying wheat planting following grain sorghum compared to corn and soybeans. Although pre-harvest applications of glyphosate did not affect grain sorghum harvest timing, warmer temperatures in the late-summer and early-fall would likely improve the effectiveness of glyphosate. Applications of glyphosate during this time would allow for a longer time interval between application and the first freeze date, resulting in more time for grain sorghum to be affected by glyphosate. Planting grain sorghum earlier in the summer and using an early-maturity hybrid would prompt an earlier grain sorghum harvest and potentially allow for earlier pre-harvest glyphosate applications. An early grain sorghum harvest increases the likelihood that winter wheat will be planted within the optimal recommended dates. Winter wheat performance was improved in environments where winter wheat planting was within the optimal planting date range. Using an early maturing grain sorghum hybrid that is red-pigmented may also reduce potential allelopathic effects. Although yields of winter wheat were not affected by sorghum hybrid, red pigmented sorghum hybrids that were early to medium maturity typically had the smallest concentrations and quantities of phenolic compounds. When planting winter wheat after grain sorghum, it is important to select wheat cultivars suitable for no-till planting after summer crops. Results from these experiments found that wheat cultivars with high tillering capacity and large kernel weight performed well in all environments. Wheat yields were not impacted by previous crop or wheat cultivar when wheat was planted three weeks beyond the optimal planting date ranges. In water-limited environments, leaving the sorghum residue undisturbed will provide the best opportunity for the following wheat crop. During the winter, undisturbed residue allows for more snow catch and reduces water losses due to run-off and evaporation. When planting winter wheat following grain sorghum in no-till systems, chemically desiccating the sorghum crop with glyphosate prior to harvest at least 45-50 days prior to the first freeze, leaving sorghum residue undisturbed, and planting wheat cultivars that are suitable for no-till systems can improve the overall performance of a winter wheat crop. Future research is needed to identify optimal timing of pre-harvest desiccation of grain sorghum in wheat–sorghum rotations, and to continue to identify wheat cultivars suitable for planting after grain sorghum in no-till managed systems.

Appendix A - Daily Precipitation, Maximum Temperature, and Minimum Temperature: "Harvest and Residue Management of Grain Sorghum to Facilitate Wheat Planted after Grain Sorghum in No-till Systems"

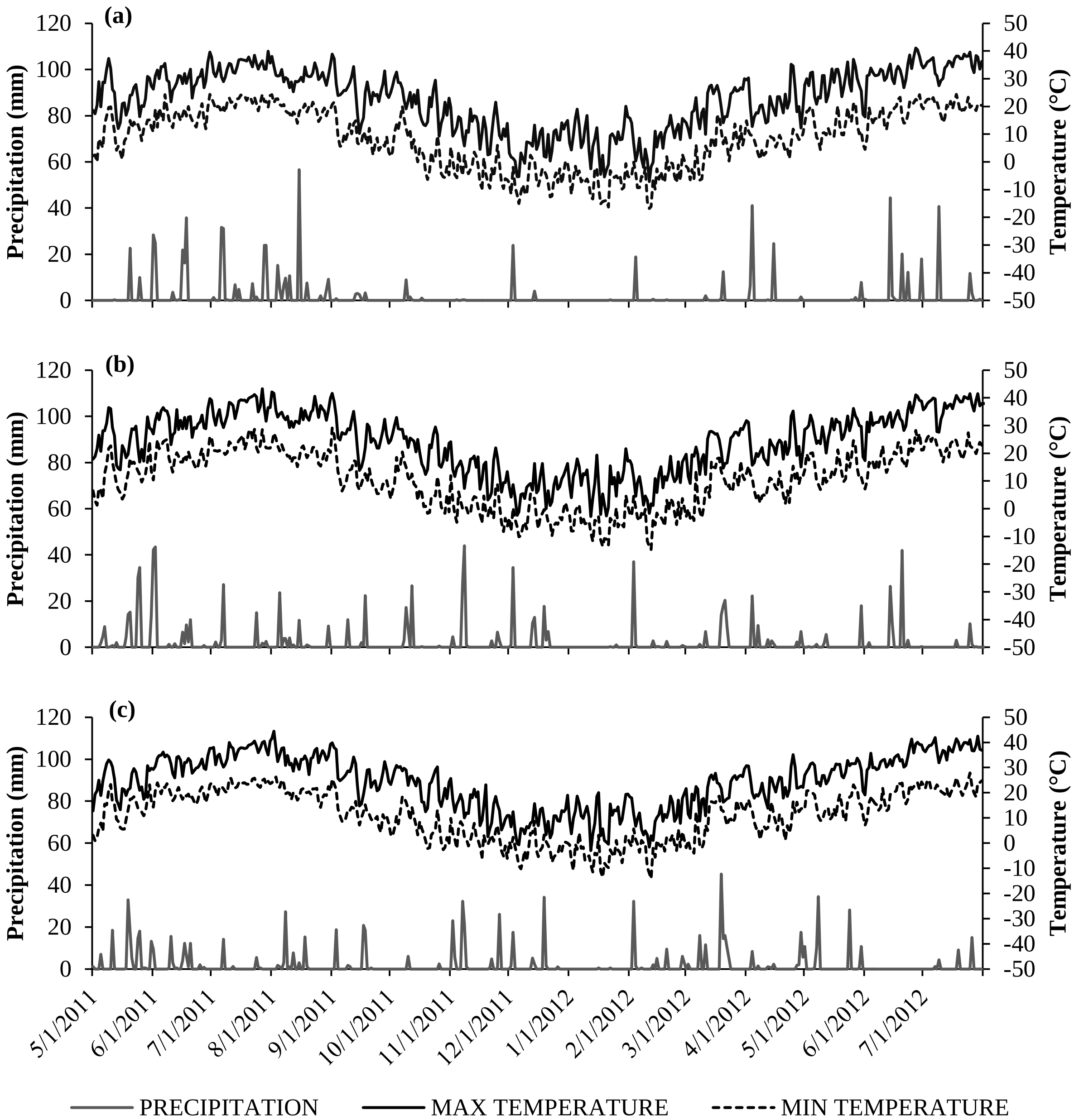

Figure A.1 Daily precipitation amounts, maximum temperature and minimum temperature from May 2011 to July 2012 at (a) Belleville, (b) Manhattan, and (c) Ottawa.

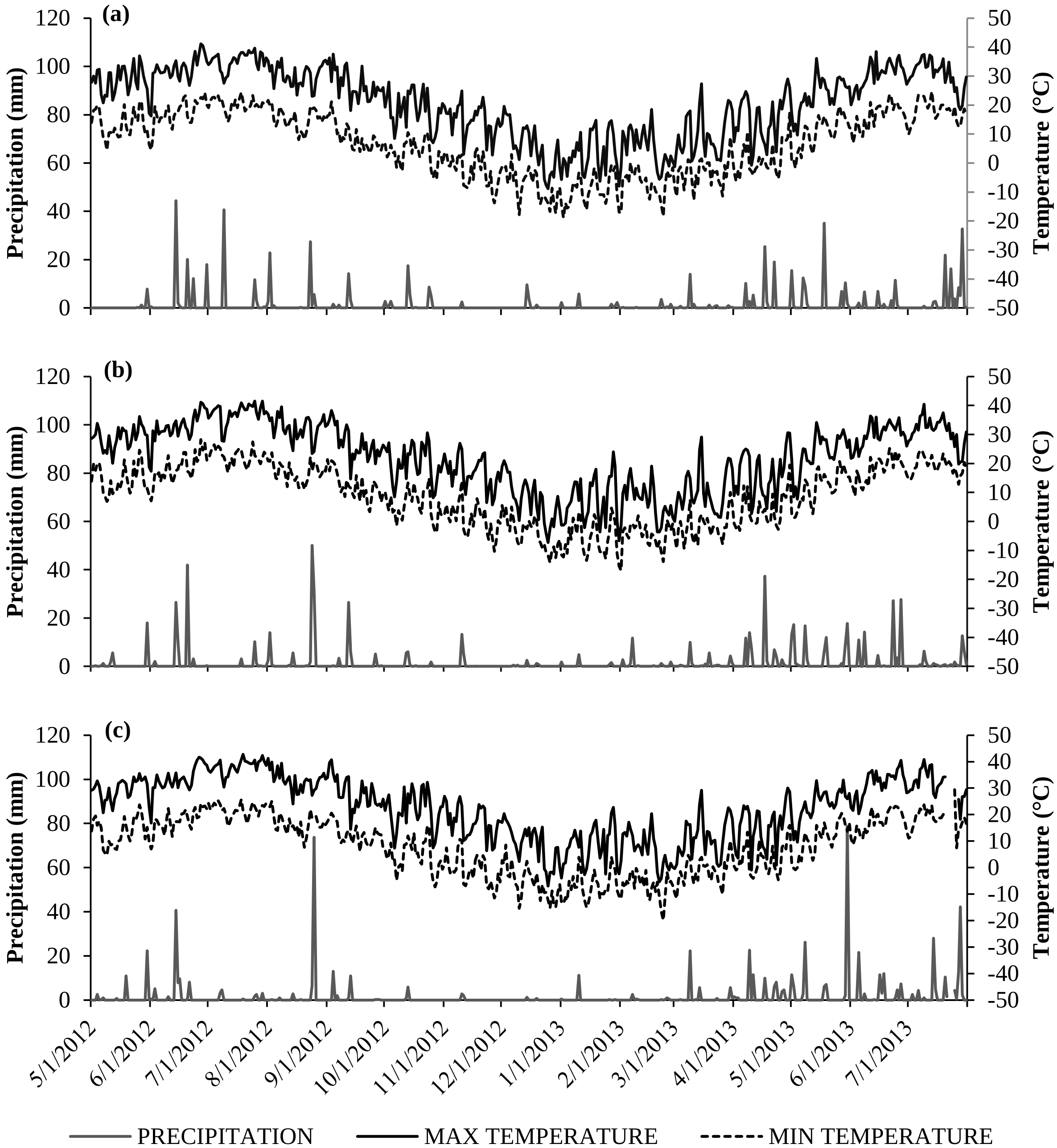

Figure A.2 Daily precipitation amounts, maximum temperatures, and minimum temperatures form May 2012 to July 2013 at (a) Belleville, (b) Manhattan, and (c) Hutchinson.

Appendix B - Raw Data: Chapter 1 "Harvest and Residue Management of Grain Sorghum to Facilitate Wheat Planted after Grain Sorghum in No-till Systems"

Table B.1 Grain sorghum harvest data, grain sorghum percent residue cover, and winter wheat grain yield.

								GRAIN SORGHUM			WHEAT
YR	ENV	LOC	BLOC	PLOT	TREATMENT			GRAIN MOISTURE	YIELD	RESIDUE COVER	YIELD
								%	kg ha^{-1}	%	kg ha^{-1}
1	1	MAN	1	101	GE	NoR	N	13.5	6439	39	3326
1	1	MAN	1	102	NoG	RC	NoN	12.6	6974	35	2293
1	1	MAN	1	103	GL	RC	NoN	13.3	6570	41	2595
1	1	MAN	1	104	GE	RR	N	12.5	6396	8	3544
1	1	MAN	1	105	GE	NoR	NoN	12.5	6836	51	3048
1	1	MAN	1	106	GE	RR	NoN	12.1	6219	13	3233
1	1	MAN	1	107	NoG	NoR	N	12.4	6726	45	2528
1	1	MAN	1	108	GL	RR	NoN	12.1	6847	8	2671
1	1	MAN	1	109	GL	NoR	N	12.2	6095	32	2612
1	1	MAN	1	110	NoG	RR	NoN	12.0	6246	18	2519
1	1	MAN	1	111	NoG	RC	N	12.6	6457	41	2603
1	1	MAN	1	112	NoG	NoR	NoN	12.6	6428	44	2057
1	1	MAN	1	113	GL	RR	N	12.9	5774	20	1940
1	1	MAN	1	114	GE	RC	NoN	12.2	5909	25	2183
1	1	MAN	1	115	GL	RC	N	12.3	6264	33	1604
1	1	MAN	1	116	GL	NoR	NoN	12.3	5814	40	1789
1	1	MAN	1	117	NoG	RR	N	12.4	5318	18	2385
1	1	MAN	1	118	GE	RC	N	11.8	5217	20	2125
1	1	MAN	2	201	GL	RR	NoN	12.9	7145	18	2629
1	1	MAN	2	202	GE	RC	N	12.3	7086	29	4165
1	1	MAN	2	203	NoG	RR	NoN	12.5	7129	34	3426
1	1	MAN	2	204	GE	NoR	N	12.3	6724	23	3250
1	1	MAN	2	205	NoG	NoR	NoN	12.5	7304	69	2998

1	1	MAN	2	206	GE	RR	N	12.1	6955	47	3972
1	1	MAN	2	207	GE	NoR	NoN	12.2	6918	11	3619
1	1	MAN	2	208	GL	RR	N	12.0	7356	46	3351
1	1	MAN	2	209	NoG	NoR	N	12.0	7051	17	2805
1	1	MAN	2	210	GL	NoR	N	11.7	7391	42	2561
1	1	MAN	2	211	GE	RR	NoN	12.2	6252	42	3074
1	1	MAN	2	212	NoG	RC	N	12.1	6926	13	2427
1	1	MAN	2	213	NoG	RC	NoN	12.5	6299	41	2830
1	1	MAN	2	214	GL	NoR	NoN	12.2	6898	36	2116
1	1	MAN	2	215	GE	RC	NoN	12.2	6516	46	2242
1	1	MAN	2	216	NoG	RR	N	11.9	6116	32	2024
1	1	MAN	2	217	GL	RC	N	12.2	6369	17	1806
1	1	MAN	2	218	GL	RC	NoN	12.2	5967	30	1470
1	1	MAN	3	301	GL	RC	N	13.3	4335	32	1915
1	1	MAN	3	302	GL	RC	NoN	12.2	5448	27	2057
1	1	MAN	3	303	GL	RR	NoN	12.5	5547	9	2499
1	1	MAN	3	304	GL	NoR	NoN	11.9	6302	54	3032
1	1	MAN	3	305	GE	RC	NoN	12.1	5798	33	3124
1	1	MAN	3	306	GL	RR	N	12.1	6533	22	3544
1	1	MAN	3	307	NoG	NoR	NoN	12.2	6683	44	2847
1	1	MAN	3	308	GE	RC	N	11.8	6497	20	3745
1	1	MAN	3	309	GE	NoR	N	11.9	6381	29	3284
1	1	MAN	3	310	GE	RR	NoN	11.6	6886	15	3628
1	1	MAN	3	311	NoG	RR	NoN	12.2	6418	18	2519
1	1	MAN	3	312	GL	NoR	N	12.3	6998	37	2469
1	1	MAN	3	313	NoG	RR	N	12.4	6785	19	2024
1	1	MAN	3	314	NoG	RC	N	12.0	6492	37	1755
1	1	MAN	3	315	NoG	RC	NoN	12.0	6718	35	1923
1	1	MAN	3	316	GE	NoR	NoN	11.7	5282	41	2738
1	1	MAN	3	317	NoG	NoR	N	11.8	6457	44	2377
1	1	MAN	3	318	GE	RR	N	11.8	5059	8	3006
1	1	MAN	4	401	NoG	NoR	NoN	12.9	3130	32	2343
1	1	MAN	4	402	GE	NoR	NoN	12.5	5761	33	3326
1	1	MAN	4	403	NoG	RR	N	12.7	5768	32	2645
1	1	MAN	4	404	GL	RR	N	12.3	6049	23	3250

1	1	MAN	4	405	GL	NoR	N	12.2	5125	32	2477
1	1	MAN	4	406	GL	NoR	NoN	12.1	5533	42	2486
1	1	MAN	4	407	GE	NoR	N	12.0	5107	26	2595
1	1	MAN	4	408	NoG	RC	NoN	11.9	5634	21	2125
1	1	MAN	4	409	GE	RR	NoN	11.7	5075	6	2880
1	1	MAN	4	410	GE	RC	N	11.7	5183	15	2326
1	1	MAN	4	411	GE	RR	N	11.9	5447	5	3057
1	1	MAN	4	412	GL	RR	NoN	12.3	5638	13	2293
1	1	MAN	4	413	GL	RC	NoN	12.0	6099	25	2402
1	1	MAN	4	414	NoG	RR	NoN	12.2	5879	7	2570
1	1	MAN	4	415	NoG	NoR	N	11.8	6566	37	2360
1	1	MAN	4	416	GL	RC	N	12.1	6406	23	2057
1	1	MAN	4	417	NoG	RC	N	11.9	6057	29	1999
1	1	MAN	4	418	GE	RC	NoN	11.6	4736	19	1957
1	2	BEL	1	101	GE	RC	N	11.1	8896	63	1790
1	2	BEL	1	102	GL	NoR	NoN	11.5	8922	87	2468
1	2	BEL	1	103	NoG	NoR	NoN	11.4	9163	83	2900
1	2	BEL	1	104	NoG	RC	NoN	11.6	9274	59	2715
1	2	BEL	1	105	GL	RC	NoN	11.8	9056	76	2530
1	2	BEL	1	106	NoG	RR	N	11.0	9039	22	1975
1	2	BEL	1	107	GE	RR	N	11.6	8912	10	2222
1	2	BEL	1	108	GE	NoR	N	11.1	8896	71	2407
1	2	BEL	1	109	NoG	RR	NoN	12.0	8741	5	1728
1	2	BEL	1	110	NoG	RC	N	11.4	8800	71	3209
1	2	BEL	1	111	NoG	NoR	N	11.3	8381	84	3209
1	2	BEL	1	112	GL	RR	NoN	11.5	9449	8	2407
1	2	BEL	1	113	GE	RR	NoN	11.0	8774	11	1481
1	2	BEL	1	114	GL	RC	N	11.6	8188	60	2900
1	2	BEL	1	115	GL	RR	N	11.6	8912	7	1728
1	2	BEL	1	116	GE	RC	NoN	11.1	9260	62	3456
1	2	BEL	1	117	GL	NoR	N	11.5	8922	71	3271
1	2	BEL	1	118	GE	NoR	NoN	11.5	9153	81	3518
1	2	BEL	2	201	NoG	RC	N	11.2	9316	67	2900
1	2	BEL	2	202	GE	RC	N	11.4	8800	72	3086
1	2	BEL	2	203	GE	RC	NoN	11.2	8589	51	2839

1	2	BEL	2	204	GL	RC	NoN	11.7	9723	73	2468
1	2	BEL	2	205	GE	NoR	NoN	11.7	8771	79	3579
1	2	BEL	2	206	GE	RR	NoN	11.4	9295	9	2530
1	2	BEL	2	207	GL	RR	N	11.9	9603	10	1666
1	2	BEL	2	208	GL	RC	N	11.9	9472	62	3394
1	2	BEL	2	209	GL	NoR	N	12.0	9035	91	3086
1	2	BEL	2	210	NoG	NoR	N	11.3	9239	89	2962
1	2	BEL	2	211	GE	NoR	N	11.1	8665	74	3147
1	2	BEL	2	212	NoG	RC	NoN	11.2	8952	73	2592
1	2	BEL	2	213	NoG	RR	NoN	11.4	9822	6	2160
1	2	BEL	2	214	NoG	RR	N	11.8	9121	9	1234
1	2	BEL	2	215	GL	NoR	NoN	12.0	9526	82	2839
1	2	BEL	2	216	GL	RR	NoN	12.0	8381	9	1975
1	2	BEL	2	217	GE	RR	N	11.2	8886	9	2468
1	2	BEL	2	218	NoG	NoR	NoN	11.8	8957	85	2777
1	2	BEL	3	301	GE	RR	NoN	10.9	8054	10	1481
1	2	BEL	3	302	NoG	RC	N	11.4	8372	68	2839
1	2	BEL	3	303	GE	NoR	NoN	11.1	8301	71	3147
1	2	BEL	3	304	NoG	RC	NoN	11.8	8104	63	3024
1	2	BEL	3	305	GE	RC	NoN	11.4	9229	49	3209
1	2	BEL	3	306	GL	NoR	N	11.5	8856	84	2962
1	2	BEL	3	307	GE	NoR	N	11.4	8800	73	3641
1	2	BEL	3	308	NoG	NoR	NoN	11.8	8236	82	3703
1	2	BEL	3	309	GE	RC	N	11.1	9392	63	3518
1	2	BEL	3	310	NoG	RR	N	11.6	9208	13	2283
1	2	BEL	3	311	NoG	NoR	N	11.0	8178	78	3024
1	2	BEL	3	312	GL	RC	N	11.2	9316	77	2777
1	2	BEL	3	313	GL	RR	NoN	11.6	9570	10	1790
1	2	BEL	3	314	GL	RR	N	11.3	8942	8	1605
1	2	BEL	3	315	GL	NoR	NoN	11.6	8715	80	2468
1	2	BEL	3	316	NoG	RR	NoN	11.4	9657	9	2037
1	2	BEL	3	317	GL	RC	NoN	11.4	8866	58	2777
1	2	BEL	3	318	GE	RR	N	11.2	8457	10	2222
1	2	BEL	4	401	GE	NoR	N	11.0	9204	77	3209
1	2	BEL	4	402	GL	NoR	NoN	11.3	9239	88	3147

1	2	BEL	4	403	NoG	NoR	N	11.8	8957	95	3086
1	2	BEL	4	404	GL	NoR	N	11.6	9800	91	3579
1	2	BEL	4	405	NoG	RR	N	11.9	9537	13	2468
1	2	BEL	4	406	NoG	NoR	NoN	11.9	8882	85	3209
1	2	BEL	4	407	GE	RR	NoN	12.0	8806	17	2715
1	2	BEL	4	408	GL	RR	N	11.5	9515	8	2407
1	2	BEL	4	409	GE	RR	N	11.8	9417	11	3024
1	2	BEL	4	410	GE	RC	NoN	11.1	9029	64	2530
1	2	BEL	4	411	GL	RC	NoN	11.5	9350	69	2592
1	2	BEL	4	412	GE	NoR	NoN	11.2	8952	68	2407
1	2	BEL	4	413	GE	RC	N	11.6	8419	62	2777
1	2	BEL	4	414	GL	RC	N	11.4	8372	78	2468
1	2	BEL	4	415	NoG	RC	N	12.0	9461	70	2530
1	2	BEL	4	416	NoG	RC	NoN	12.0	9592	73	1790
1	2	BEL	4	417	NoG	RR	NoN	11.2	8886	9	2037
1	2	BEL	4	418	GL	RR	NoN	10.1	9431	8	1790
1	3	OTT	1	101	GL	RR	N	12.3	1958	14	4115
1	3	OTT	1	102	GE	RC	N	12.4	2477	22	3891
1	3	OTT	1	103	GL	NoR	NoN	12.7	3020	23	2911
1	3	OTT	1	104	GE	NoR	N	11.8	2887	33	3611
1	3	OTT	1	105	GE	RC	NoN	12.2	3266	36	3863
1	3	OTT	1	106	NoG	NoR	N	12.3	3328	47	3471
1	3	OTT	1	107	GL	RC	N	11.7	2135	34	3695
1	3	OTT	1	108	GE	RR	NoN	11.5	2041	19	3359
1	3	OTT	1	109	NoG	RR	N	11.8	2231	14	3611
1	3	OTT	1	110	GE	RR	N	12.2	2221	14	3163
1	3	OTT	1	111	NoG	RR	NoN	12.4	2705	20	3443
1	3	OTT	1	112	NoG	RC	NoN	12.5	2799	37	3219
1	3	OTT	1	113	GL	NoR	N	11.7	2234	42	3723
1	3	OTT	1	114	GL	RR	NoN	11.8	2658	10	3555
1	3	OTT	1	115	GE	NoR	NoN	12.1	2812	33	3555
1	3	OTT	1	116	NoG	NoR	NoN	11.9	2491	44	3331
1	3	OTT	1	117	NoG	RC	N	11.9	2622	44	3611
1	3	OTT	1	118	GL	RC	NoN	11.5	2831	35	3387
1	3	OTT	2	201	NoG	RR	NoN	12.5	3678	16	3023

1	3	OTT	2	202	GE	NoR	N	12.1	3237	47	3499
1	3	OTT	2	203	NoG	RR	N	12.2	3038	23	3275
1	3	OTT	2	204	GE	RR	NoN	11.9	2360	19	3415
1	3	OTT	2	205	GE	RC	NoN	11.9	2982	44	3471
1	3	OTT	2	206	GL	RC	NoN	12.5	3157	36	3079
1	3	OTT	2	207	NoG	NoR	NoN	11.8	2264	43	3163
1	3	OTT	2	208	NoG	NoR	N	11.9	2851	50	3555
1	3	OTT	2	209	GE	NoR	NoN	11.8	2920	37	3387
1	3	OTT	2	210	GL	RC	N	12.6	2991	31	3471
1	3	OTT	2	211	GE	RR	N	12.4	3259	16	3415
1	3	OTT	2	212	GL	RR	NoN	12.4	2998	9	3079
1	3	OTT	2	213	GL	NoR	NoN	11.7	2431	62	3499
1	3	OTT	2	214	GE	RC	N	11.7	3055	36	3723
1	3	OTT	2	215	GL	NoR	N	12.0	3110	52	3583
1	3	OTT	2	216	GL	RR	N	11.9	2458	19	3639
1	3	OTT	2	217	NoG	RC	NoN	12.0	2848	52	3583
1	3	OTT	2	218	NoG	RC	N	12.0	2946	41	3415
1	3	OTT	3	301	GL	RR	N	12.2	2809	16	3331
1	3	OTT	3	302	GL	RR	NoN	12.7	3897	20	2911
1	3	OTT	3	303	NoG	RC	NoN	12.9	3402	47	2659
1	3	OTT	3	304	GE	NoR	NoN	11.8	2986	52	3163
1	3	OTT	3	305	NoG	NoR	N	12.2	2842	42	3219
1	3	OTT	3	306	NoG	RR	NoN	12.6	2991	21	2855
1	3	OTT	3	307	NoG	RC	N	12.3	2382	54	3359
1	3	OTT	3	308	GL	RC	N	12.4	3226	36	3723
1	3	OTT	3	309	GL	NoR	N	12.3	3067	34	3247
1	3	OTT	3	310	GL	RC	NoN	12.5	2864	41	3107
1	3	OTT	3	311	GE	RR	N	12.3	3263	11	3667
1	3	OTT	3	312	GE	RC	N	12.3	3491	41	3695
1	3	OTT	3	313	GE	RC	NoN	12.1	2976	50	3443
1	3	OTT	3	314	NoG	NoR	NoN	12.5	3223	46	3135
1	3	OTT	3	315	NoG	RR	N	12.6	3642	20	3555
1	3	OTT	3	316	GE	RR	NoN	12.0	2946	13	3527
1	3	OTT	3	317	GL	NoR	NoN	12.3	3426	47	3415
1	3	OTT	3	318	GE	NoR	N	12.1	3139	23	3471

1	3	OTT	4	401	NoG	RC	N	12.6	3576	50	3191
1	3	OTT	4	402	GE	RC	NoN	12.7	4384	52	3415
1	3	OTT	4	403	GE	RR	NoN	12.6	3999	9	3415
1	3	OTT	4	404	GL	RR	N	12.4	2737	15	3331
1	3	OTT	4	405	GE	NoR	NoN	12.3	3295	31	3331
1	3	OTT	4	406	GE	RC	N	12.7	2955	43	3583
1	3	OTT	4	407	GE	NoR	N	11.9	3212	35	3779
1	3	OTT	4	408	NoG	RR	NoN	12.3	3197	24	3219
1	3	OTT	4	409	GL	RR	NoN	12.7	3118	7	3107
1	3	OTT	4	410	GL	RC	N	12.6	3154	31	3583
1	3	OTT	4	411	GE	RR	N	12.9	3305	10	3527
1	3	OTT	4	412	GL	NoR	N	13.5	3894	31	3275
1	3	OTT	4	413	GL	NoR	NoN	13.0	3301	48	3415
1	3	OTT	4	414	NoG	RC	NoN	12.9	3337	46	2939
1	3	OTT	4	415	GL	RC	NoN	12.9	3273	55	2631
1	3	OTT	4	416	NoG	NoR	NoN	12.3	3621	52	3135
1	3	OTT	4	417	NoG	RR	N	12.8	3276	26	3415
1	3	OTT	4	418	NoG	NoR	N	12.6	3446	51	3527
2	4	MAN	1	101	NoG	RR	NoN	12.5	5289	9	2750
2	4	MAN	1	102	GE	RR	N	10.9	7030	9	2656
2	4	MAN	1	103	GE	NoR	N	.	.	63	3188
2	4	MAN	1	104	NoG	NoR	N	.	.	69	3449
2	4	MAN	1	105	GL	RC	N	.	.	90	3374
2	4	MAN	1	106	GE	RC	N	.	.	64	2724
2	4	MAN	1	107	GL	NoR	NoN	.	.	92	2992
2	4	MAN	1	108	NoG	RR	N	.	.	3	2805
2	4	MAN	1	109	GL	RC	NoN	.	.	77	3530
2	4	MAN	1	110	NoG	NoR	NoN	12.0	6602	74	3819
2	4	MAN	1	111	NoG	RC	N	12.3	6607	85	3540
2	4	MAN	1	112	GE	NoR	NoN	.	.	74	3656
2	4	MAN	1	113	NoG	RC	NoN	.	.	79	4145
2	4	MAN	1	114	GL	RR	N	.	.	15	3468
2	4	MAN	1	115	GL	RR	NoN	.	.	11	3191
2	4	MAN	1	116	GE	RC	NoN	.	.	90	3584
2	4	MAN	1	117	GL	NoR	N	.	.	65	3505

2	4	MAN	1	118	GE	RR	NoN	.	.	13	3512
2	4	MAN	2	201	GE	RC	N	.	.	67	3572
2	4	MAN	2	202	GL	RR	N	.	.	5	3040
2	4	MAN	2	203	GE	RC	NoN	.	.	89	3160
2	4	MAN	2	204	GE	RR	NoN	11.1	5980	9	3270
2	4	MAN	2	205	GE	RR	N	.	.	8	3298
2	4	MAN	2	206	NoG	RC	NoN	.	.	73	3505
2	4	MAN	2	207	GE	NoR	N	.	.	61	2940
2	4	MAN	2	208	NoG	NoR	N	.	.	85	3508
2	4	MAN	2	209	NoG	RR	NoN	.	.	10	3018
2	4	MAN	2	210	GL	NoR	N	.	.	81	3525
2	4	MAN	2	211	NoG	RC	N	.	.	66	3554
2	4	MAN	2	212	GL	RR	NoN	.	.	13	3442
2	4	MAN	2	213	NoG	NoR	NoN	11.8	5851	85	3896
2	4	MAN	2	214	NoG	RR	N	.	.	10	3642
2	4	MAN	2	215	GL	RC	N	.	.	70	3613
2	4	MAN	2	216	GL	RC	NoN	.	.	70	3551
2	4	MAN	2	217	GL	NoR	NoN	.	.	67	3523
2	4	MAN	2	218	GE	NoR	NoN	.	.	63	3631
2	4	MAN	3	301	GE	RR	NoN	11.8	6015	12	3527
2	4	MAN	3	302	NoG	NoR	N	11.6	6084	91	3686
2	4	MAN	3	303	GL	NoR	NoN	.	.	58	3826
2	4	MAN	3	304	NoG	RR	NoN	.	.	10	3517
2	4	MAN	3	305	NoG	RC	NoN	.	.	59	4069
2	4	MAN	3	306	GE	NoR	NoN	.	.	61	3717
2	4	MAN	3	307	NoG	RR	N	.	.	17	3603
2	4	MAN	3	308	NoG	NoR	NoN	.	.	56	3378
2	4	MAN	3	309	GL	RR	NoN	.	.	9	3420
2	4	MAN	3	310	GE	RC	NoN	11.7	5269	74	3288
2	4	MAN	3	311	GE	RR	N	11.7	5872	7	3192
2	4	MAN	3	312	GL	NoR	N	.	.	71	3374
2	4	MAN	3	313	NoG	RC	N	.	.	69	3457
2	4	MAN	3	314	GL	RC	N	.	.	64	3355
2	4	MAN	3	315	GE	RC	N	.	.	44	3320
2	4	MAN	3	316	GL	RR	N	.	.	9	3411

2	4	MAN	3	317	GE	NoR	N	.	.	62	3539
2	4	MAN	3	318	GL	RC	NoN	.	.	83	3491
2	4	MAN	4	401	GL	RR	N	.	.	7	3526
2	4	MAN	4	402	GL	NoR	NoN	.	.	61	3519
2	4	MAN	4	403	GE	RR	N	.	.	10	3660
2	4	MAN	4	404	GE	NoR	NoN	11.2	6442	65	3831
2	4	MAN	4	405	GL	NoR	N	.	.	79	3952
2	4	MAN	4	406	GE	NoR	N	.	.	90	3682
2	4	MAN	4	407	GE	RC	N	11.3	6586	65	3566
2	4	MAN	4	408	GE	RC	NoN	.	.	68	3408
2	4	MAN	4	409	NoG	RC	NoN	.	.	59	3521
2	4	MAN	4	410	GL	RC	N	.	.	67	3201
2	4	MAN	4	411	NoG	RR	NoN	.	.	15	3598
2	4	MAN	4	412	GE	RR	NoN	.	.	11	3557
2	4	MAN	4	413	NoG	NoR	N	10.8	6111	64	3530
2	4	MAN	4	414	GL	RR	NoN	.	.	13	3239
2	4	MAN	4	415	NoG	RR	N	.	.	10	3496
2	4	MAN	4	416	NoG	RC	N	10.5	6590	69	3307
2	4	MAN	4	417	GL	RC	NoN	.	.	48	3162
2	4	MAN	4	418	NoG	NoR	NoN	.	.	60	3576
2	5	BEL	1	101	GL	RC	N	13.7	7072	94	2723
2	5	BEL	1	102	NoG	RR	NoN	13.3	7105	17	2426
2	5	BEL	1	103	GE	RC	NoN	13.8	7417	89	2486
2	5	BEL	1	104	NoG	RC	NoN	12.9	7316	95	2541
2	5	BEL	1	105	GE	RR	NoN	13.2	7291	14	2120
2	5	BEL	1	106	GL	RR	NoN	12.4	6999	22	2299
2	5	BEL	1	107	NoG	RC	N	13.7	6895	93	2307
2	5	BEL	1	108	GL	RR	N	13.0	7070	21	2368
2	5	BEL	1	109	GE	RR	N	13.7	6895	16	2249
2	5	BEL	1	110	GL	NoR	NoN	14.0	6871	93	2911
2	5	BEL	1	111	GE	NoR	NoN	13.3	7105	96	3025
2	5	BEL	1	112	NoG	NoR	N	13.6	7670	95	2656
2	5	BEL	1	113	GE	RC	N	12.8	7384	94	2783
2	5	BEL	1	114	NoG	NoR	NoN	13.3	7342	99	2729
2	5	BEL	1	115	GE	NoR	N	12.7	7214	97	3035

2	5	BEL	1	116	NoG	RR	N	13.7	7426	26	2365
2	5	BEL	1	117	GL	NoR	N	12.9	7138	97	2607
2	5	BEL	1	118	GL	RC	NoN	13.6	5900	93	2428
2	5	BEL	2	201	NoG	RC	N	13.2	7410	97	2464
2	5	BEL	2	202	GE	RR	N	13.7	7308	10	2671
2	5	BEL	2	203	GL	RC	N	13.8	7064	93	2489
2	5	BEL	2	204	GE	RR	NoN	13.3	6276	12	2188
2	5	BEL	2	205	GL	NoR	NoN	12.9	6186	94	2965
2	5	BEL	2	206	GE	NoR	N	13.0	5110	94	2927
2	5	BEL	2	207	GE	RC	N	12.7	5843	89	2921
2	5	BEL	2	208	GE	RC	NoN	13.0	5941	80	2428
2	5	BEL	2	209	NoG	NoR	NoN	12.7	4829	82	3079
2	5	BEL	2	210	GL	NoR	N	12.7	5425	96	2921
2	5	BEL	2	211	GL	RR	NoN	13.1	4392	8	2786
2	5	BEL	2	212	NoG	RR	N	13.1	5282	11	2481
2	5	BEL	2	213	GE	NoR	NoN	12.6	6446	94	2492
2	5	BEL	2	214	GL	RR	N	13.2	6105	9	2550
2	5	BEL	2	215	GL	RC	NoN	12.6	6565	91	2599
2	5	BEL	2	216	NoG	NoR	N	13.1	6231	97	2840
2	5	BEL	2	217	NoG	RC	NoN	13.0	6654	93	2668
2	5	BEL	2	218	NoG	RR	NoN	13.2	6698	7	1936
2	5	BEL	3	301	GL	RC	NoN	14.8	6633	96	2605
2	5	BEL	3	302	GE	NoR	N	13.7	6070	97	2856
2	5	BEL	3	303	GE	NoR	NoN	13.3	6394	97	3018
2	5	BEL	3	304	NoG	RR	N	13.3	6039	11	2492
2	5	BEL	3	305	NoG	RR	NoN	13.4	6151	10	2406
2	5	BEL	3	306	GE	RC	NoN	13.4	6210	97	2738
2	5	BEL	3	307	GL	RR	N	12.6	5193	13	2478
2	5	BEL	3	308	GE	RR	N	13.0	4812	17	2412
2	5	BEL	3	309	NoG	NoR	N	12.6	4715	90	2533
2	5	BEL	3	310	NoG	RC	N	13.7	6601	92	2059
2	5	BEL	3	311	GL	RR	NoN	13.2	5750	15	1943
2	5	BEL	3	312	GL	NoR	NoN	12.9	4996	97	2662
2	5	BEL	3	313	NoG	NoR	NoN	13.3	5802	95	2547
2	5	BEL	3	314	GL	RC	N	12.7	5366	94	2118

2	5	BEL	3	315	GE	RC	N	13.4	5559	90	2115
2	5	BEL	3	316	NoG	RC	NoN	13.1	5044	91	2420
2	5	BEL	3	317	GL	NoR	N	13.9	6174	93	2555
2	5	BEL	3	318	GE	RR	NoN	12.8	5836	11	2236
2	5	BEL	4	401	GE	RR	N	13.4	4554	13	2610
2	5	BEL	4	402	GL	NoR	NoN	12.9	5829	96	3086
2	5	BEL	4	403	NoG	RC	N	13.3	6335	94	2911
2	5	BEL	4	404	NoG	RC	NoN	13.1	6647	90	2610
2	5	BEL	4	405	NoG	NoR	NoN	13.9	6821	94	2780
2	5	BEL	4	406	NoG	RR	NoN	12.9	6424	19	2431
2	5	BEL	4	407	GL	NoR	N	13.1	6587	99	2850
2	5	BEL	4	408	GE	NoR	NoN	13.3	6691	94	2965
2	5	BEL	4	409	GE	RR	NoN	13.1	6469	25	2729
2	5	BEL	4	410	GE	RC	NoN	13.9	5645	94	2729
2	5	BEL	4	411	NoG	NoR	N	13.8	6475	93	2904
2	5	BEL	4	412	GL	RR	NoN	13.4	6387	13	2428
2	5	BEL	4	413	GE	RC	N	12..9	6483	89	2481
2	5	BEL	4	414	GE	NoR	N	13.2	7410	96	2495
2	5	BEL	4	415	GL	RC	NoN	13.1	7240	92	2486
2	5	BEL	4	416	NoG	RR	N	13.0	6833	9	2246
2	5	BEL	4	417	GL	RR	N	13.0	7070	12	2677
2	5	BEL	4	418	GL	RC	N	13.1	6647	96	2428
2	6	HUT	1	101	GE	RC	NoN			47	2248
2	6	HUT	1	102	GE	RR	NoN			8	1924
2	6	HUT	1	103	NoG	RR	N			7	2086
2	6	HUT	1	104	NoG	NoR	N			58	2367
2	6	HUT	1	105	GL	RR	N			10	2072
2	6	HUT	1	106	GE	NoR	N			50	2508
2	6	HUT	1	107	NoG	RC	NoN			51	2419
2	6	HUT	1	108	GL	NoR	NoN			51	2966
2	6	HUT	1	109	NoG	NoR	NoN			46	2901
2	6	HUT	1	110	GE	RR	N			6	2203
2	6	HUT	1	111	GL	RC	N			55	2564
2	6	HUT	1	112	GE	NoR	NoN			43	2658
2	6	HUT	1	113	GL	NoR	N			39	2497

2	6	HUT	1	114	NoG	RR	NoN			7	1931
2	6	HUT	1	115	GE	RC	N			62	1830
2	6	HUT	1	116	GL	RC	NoN			39	2283
2	6	HUT	1	117	GL	RR	NoN			1	2015
2	6	HUT	1	118	NoG	RC	N			43	2638
2	6	HUT	2	201	NoG	NoR	N			38	3048
2	6	HUT	2	202	GL	RC	N			58	2200
2	6	HUT	2	203	NoG	RC	N			46	2192
2	6	HUT	2	204	NoG	RR	NoN			5	2170
2	6	HUT	2	205	GL	NoR	NoN			65	2995
2	6	HUT	2	206	GL	RR	NoN			6	2589
2	6	HUT	2	207	GE	RR	N			6	2591
2	6	HUT	2	208	NoG	RC	NoN			44	2784
2	6	HUT	2	209	NoG	RR	N			9	2400
2	6	HUT	2	210	GL	RC	NoN			46	2669
2	6	HUT	2	211	GL	RR	N			10	2503
2	6	HUT	2	212	GL	NoR	N			44	2714
2	6	HUT	2	213	GE	RC	NoN			38	2436
2	6	HUT	2	214	GE	NoR	N			52	2691
2	6	HUT	2	215	NoG	NoR	NoN			39	.
2	6	HUT	2	216	GE	RR	NoN			4	1868
2	6	HUT	2	217	GE	RC	N			65	2250
2	6	HUT	2	218	GE	NoR	NoN			56	2536
2	6	HUT	3	301	NoG	NoR	NoN			47	2691
2	6	HUT	3	302	GL	RC	NoN			43	2658
2	6	HUT	3	303	NoG	RC	NoN			45	1952
2	6	HUT	3	304	GE	RR	NoN			8	1646
2	6	HUT	3	305	GL	RC	N			72	2200
2	6	HUT	3	306	NoG	RR	N			2	2353
2	6	HUT	3	307	NoG	RR	NoN			6	2671
2	6	HUT	3	308	GL	NoR	NoN			53	3157
2	6	HUT	3	309	NoG	RC	N			56	2981
2	6	HUT	3	310	NoG	NoR	N			37	2815
2	6	HUT	3	311	GE	RR	N			3	2472
2	6	HUT	3	312	GL	RR	NoN			5	.

2	6	HUT	3	313	GL	RR	N			7	2216
2	6	HUT	3	314	GE	RC	NoN			57	2788
2	6	HUT	3	315	GE	NoR	NoN			47	3004
2	6	HUT	3	316	GE	RC	N			35	2892
2	6	HUT	3	317	GE	NoR	N			54	2740
2	6	HUT	3	318	GL	NoR	N			56	2918
2	6	HUT	4	401	NoG	NoR	N			38	2745
2	6	HUT	4	402	GL	NoR	N			53	3038
2	6	HUT	4	403	GL	NoR	NoN			35	2788
2	6	HUT	4	404	NoG	RC	NoN			52	2722
2	6	HUT	4	405	GL	RR	NoN			10	2350
2	6	HUT	4	406	GE	NoR	N			61	2680
2	6	HUT	4	407	GL	RR	N			5	2297
2	6	HUT	4	408	GE	RR	N			4	2107
2	6	HUT	4	409	GL	RC	N			43	2176
2	6	HUT	4	410	NoG	RR	N			4	2400
2	6	HUT	4	411	GE	RR	NoN			3	2175
2	6	HUT	4	412	NoG	RC	N			36	2525
2	6	HUT	4	413	NoG	NoR	NoN			50	2822
2	6	HUT	4	414	GL	RC	NoN			43	2807
2	6	HUT	4	415	GE	RC	N			35	2494
2	6	HUT	4	416	NoG	RR	NoN			5	2170
2	6	HUT	4	417	GE	NoR	NoN			47	3019
2	6	HUT	4	418	GE	RC	NoN			34	2679

Table B.2 Winter wheat plant density, fall tiller, spring tiller, spike density, plant height, kernels spike^{-1}, and kernel weight data.

YR	ENV	LOC	BLOC	PLOT	TREATMENT			PLANT DENSITY	FALL TILLER	SPRING TILLERS	SPIKE DENSI-TY	PLANT HT.	KERNELS SPIKE^{-1}	KERNEL WEIGHT
								——— m^{-2} ———				cm		g 1000 seeds^{-1}
1	1	MAN	1	101	GE	NoR	N	191	772	480	520	78.3	23.2	27.6
1	1	MAN	1	102	NoG	RC	NoN	198	619	423	399	71.3	20.4	28.1
1	1	MAN	1	103	GL	RC	NoN	208	714	451	420	74.0	22.0	28.1
1	1	MAN	1	104	GE	RR	N	196	593	535	499	80.0	24.6	28.9
1	1	MAN	1	105	GE	NoR	NoN	177	693	315	407	76.0	27.2	27.5
1	1	MAN	1	106	GE	RR	NoN	181	703	396	378	78.3	30.3	28.3
1	1	MAN	1	107	NoG	NoR	N	193	619	480	399	73.3	23.5	26.9
1	1	MAN	1	108	GL	RR	NoN	202	688	396	467	73.0	20.4	28.1
1	1	MAN	1	109	GL	NoR	N	194	614	507	404	70.3	22.1	29.3
1	1	MAN	1	110	NoG	RR	NoN	172	688	433	378	70.7	23.9	27.9
1	1	MAN	1	111	NoG	RC	N	185	672	451	412	70.3	22.4	28.2
1	1	MAN	1	112	NoG	NoR	NoN	195	572	591	404	69.3	18.0	28.3
1	1	MAN	1	113	GL	RR	N	178	514	517	388	69.3	19.0	26.3
1	1	MAN	1	114	GE	RC	NoN	174	593	525	333	67.3	24.1	27.2
1	1	MAN	1	115	GL	RC	N	182	530	483	402	70.0	12.5	32.1
1	1	MAN	1	116	GL	NoR	NoN	188	588	493	417	66.7	16.6	25.9
1	1	MAN	1	117	NoG	RR	N	180	362	423	336	68.3	28.7	24.8
1	1	MAN	1	118	GE	RC	N	201	520	454	365	66.3	24.2	24.1
1	1	MAN	2	201	GL	RR	NoN	179	556	333	409	77.7	23.1	27.9
1	1	MAN	2	202	GE	RC	N	189	567	496	556	81.7	25.5	29.3
1	1	MAN	2	203	NoG	RR	NoN	188	556	467	417	79.7	28.1	29.2
1	1	MAN	2	204	GE	NoR	N	177	593	593	394	81.3	30.7	26.9
1	1	MAN	2	205	NoG	NoR	NoN	189	656	381	472	74.0	22.9	27.8
1	1	MAN	2	206	GE	RR	N	185	609	517	551	81.7	25.8	27.9
1	1	MAN	2	207	GE	NoR	NoN	182	667	517	517	78.0	25.3	27.6
1	1	MAN	2	208	GL	RR	N	180	619	357	551	79.0	21.3	28.6
1	1	MAN	2	209	NoG	NoR	N	177	661	546	407	73.3	24.4	28.2
1	1	MAN	2	210	GL	NoR	N	186	604	472	399	74.7	21.6	29.7

1	1	MAN	2	211	GE	RR	NoN	188	598	512	409	73.3	26.2	28.7
1	1	MAN	2	212	NoG	RC	N	170	546	472	404	71.0	20.3	29.6
1	1	MAN	2	213	NoG	RC	NoN	175	630	404	367	68.7	27.7	27.8
1	1	MAN	2	214	GL	NoR	NoN	182	577	349	370	69.7	21.4	26.7
1	1	MAN	2	215	GE	RC	NoN	204	583	457	446	69.3	18.9	26.5
1	1	MAN	2	216	NoG	RR	N	218	598	438	310	68.7	24.8	26.3
1	1	MAN	2	217	GL	RC	N	189	530	436	470	68.3	15.5	24.8
1	1	MAN	2	218	GL	RC	NoN	180	446	462	255	66.0	23.3	24.8
1	1	MAN	3	301	GL	RC	N	203	604	354	331	68.3	20.5	28.3
1	1	MAN	3	302	GL	RC	NoN	189	593	373	488	75.0	15.7	26.9
1	1	MAN	3	303	GL	RR	NoN	185	504	357	446	76.0	19.6	28.6
1	1	MAN	3	304	GL	NoR	NoN	181	546	409	480	77.0	21.5	29.4
1	1	MAN	3	305	GE	RC	NoN	188	577	375	438	78.7	24.8	28.8
1	1	MAN	3	306	GL	RR	N	199	604	318	504	76.7	25.7	27.3
1	1	MAN	3	307	NoG	NoR	NoN	185	556	333	454	75.0	22.0	28.5
1	1	MAN	3	308	GE	RC	N	176	499	512	572	78.7	23.3	28.1
1	1	MAN	3	309	GE	NoR	N	191	635	318	472	75.7	24.0	29.0
1	1	MAN	3	310	GE	RR	NoN	187	546	294	417	78.0	31.6	27.6
1	1	MAN	3	311	NoG	RR	NoN	180	514	255	391	74.3	23.5	27.4
1	1	MAN	3	312	GL	NoR	N	173	583	268	388	73.3	22.5	28.2
1	1	MAN	3	313	NoG	RR	N	183	488	165	388	72.0	19.4	26.9
1	1	MAN	3	314	NoG	RC	N	198	530	202	262	65.0	23.0	29.1
1	1	MAN	3	315	NoG	RC	NoN	203	520	354	391	67.0	20.1	24.5
1	1	MAN	3	316	GE	NoR	NoN	191	593	333	496	76.7	20.7	26.7
1	1	MAN	3	317	NoG	NoR	N	181	430	388	475	71.7	18.8	26.6
1	1	MAN	3	318	GE	RR	N	188	551	344	378	74.3	29.8	26.7
1	1	MAN	4	401	NoG	NoR	NoN	178	583	454	381	75.7	23.4	26.3
1	1	MAN	4	402	GE	NoR	NoN	186	703	412	475	77.3	25.5	27.4
1	1	MAN	4	403	NoG	RR	N	192	577	415	457	75.0	21.4	27.1
1	1	MAN	4	404	GL	RR	N	189	588	486	433	77.7	26.5	28.3
1	1	MAN	4	405	GL	NoR	N	178	572	436	357	70.3	24.1	28.8
1	1	MAN	4	406	GL	NoR	NoN	193	598	391	370	70.3	23.0	29.2
1	1	MAN	4	407	GE	NoR	N	198	541	462	388	73.0	22.9	29.2
1	1	MAN	4	408	NoG	RC	NoN	186	546	438	362	70.0	21.5	27.3
1	1	MAN	4	409	GE	RR	NoN	168	551	472	467	74.7	21.6	28.5

1	1	MAN	4	410	GE	RC	N	180	514	514	360	70.3	23.1	28.0
1	1	MAN	4	411	GE	RR	N	175	514	462	360	76.0	29.6	28.7
1	1	MAN	4	412	GL	RR	NoN	231	556	402	420	72.7	19.0	28.7
1	1	MAN	4	413	GL	RC	NoN	173	562	375	409	68.7	21.3	27.5
1	1	MAN	4	414	NoG	RR	NoN	197	472	433	320	73.3	31.7	25.3
1	1	MAN	4	415	NoG	NoR	N	201	520	370	352	73.0	25.4	26.4
1	1	MAN	4	416	GL	RC	N	183	509	436	428	67.0	17.9	26.9
1	1	MAN	4	417	NoG	RC	N	182	483	370	391	67.0	20.7	24.7
1	1	MAN	4	418	GE	RC	NoN	177	514	407	336	66.3	23.4	24.9
1	2	BEL	1	101	GE	RC	N	153	155	564	459	87.0	21.3	18.3
1	2	BEL	1	102	GL	NoR	NoN	184	207	740	606	83.0	22.3	18.3
1	2	BEL	1	103	NoG	NoR	NoN	181	223	470	591	80.0	26.2	18.8
1	2	BEL	1	104	NoG	RC	NoN	182	289	751	559	75.0	25.6	19.0
1	2	BEL	1	105	GL	RC	NoN	189	286	709	627	78.0	21.2	19.0
1	2	BEL	1	106	NoG	RR	N	137	262	520	507	80.0	22.9	17.0
1	2	BEL	1	107	GE	RR	N	182	312	617	583	76.0	22.8	16.8
1	2	BEL	1	108	GE	NoR	N	213	276	777	717	79.0	17.9	18.8
1	2	BEL	1	109	NoG	RR	NoN	136	234	546	499	70.0	19.2	18.0
1	2	BEL	1	110	NoG	RC	N	210	278	795	525	80.3	30.6	20.0
1	2	BEL	1	111	NoG	NoR	N	198	331	832	551	85.0	31.1	18.8
1	2	BEL	1	112	GL	RR	NoN	168	218	402	462	77.0	26.4	19.8
1	2	BEL	1	113	GE	RR	NoN	153	283	451	420	75.0	19.6	18.0
1	2	BEL	1	114	GL	RC	N	210	260	667	457	78.0	33.0	19.3
1	2	BEL	1	115	GL	RR	N	167	210	472	436	77.0	22.0	18.0
1	2	BEL	1	116	GE	RC	NoN	194	210	528	475	82.0	37.8	19.3
1	2	BEL	1	117	GL	NoR	N	193	228	745	436	75.3	38.5	19.5
1	2	BEL	1	118	GE	NoR	NoN	203	273	520	465	73.3	39.9	19.0
1	2	BEL	2	201	NoG	RC	N	198	207	664	525	81.0	27.0	20.5
1	2	BEL	2	202	GE	RC	N	174	281	659	696	83.0	22.8	19.5
1	2	BEL	2	203	GE	RC	NoN	177	312	486	533	72.0	27.0	19.8
1	2	BEL	2	204	GL	RC	NoN	79	207	457	396	75.0	31.5	19.8
1	2	BEL	2	205	GE	NoR	NoN	143	247	520	564	77.0	27.6	23.0
1	2	BEL	2	206	GE	RR	NoN	242	370	252	493	73.0	26.3	19.5
1	2	BEL	2	207	GL	RR	N	190	344	367	517	73.0	17.4	18.5
1	2	BEL	2	208	GL	RC	N	208	236	499	556	80.0	32.5	18.8

1	2	BEL	2	209	GL	NoR	N	185	262	420	575	79.0	27.2	19.8
1	2	BEL	2	210	NoG	NoR	N	188	297	588	504	82.3	30.9	19.0
1	2	BEL	2	211	GE	NoR	N	167	231	491	556	80.0	29.0	19.5
1	2	BEL	2	212	NoG	RC	NoN	151	283	425	467	77.0	27.7	20.0
1	2	BEL	2	213	NoG	RR	NoN	128	278	207	378	73.7	27.2	21.0
1	2	BEL	2	214	NoG	RR	N	88	202	281	417	72.3	15.8	18.8
1	2	BEL	2	215	GL	NoR	NoN	220	286	465	517	74.3	26.5	20.8
1	2	BEL	2	216	GL	RR	NoN	168	184	257	407	74.7	25.2	19.3
1	2	BEL	2	217	GE	RR	N	126	260	357	412	77.3	33.7	17.8
1	2	BEL	2	218	NoG	NoR	NoN	196	231	367	352	77.7	41.0	19.3
1	2	BEL	3	301	GE	RR	NoN	140	186	612	525	78.0	15.7	18.0
1	2	BEL	3	302	NoG	RC	N	176	239	874	454	82.0	31.3	20.0
1	2	BEL	3	303	GE	NoR	NoN	198	228	717	512	77.7	30.0	20.5
1	2	BEL	3	304	NoG	RC	NoN	203	286	811	430	76.7	36.5	19.3
1	2	BEL	3	305	GE	RC	NoN	192	270	701	507	83.0	33.8	18.8
1	2	BEL	3	306	GL	NoR	N	198	249	722	567	81.0	27.9	18.8
1	2	BEL	3	307	GE	NoR	N	208	273	913	522	81.7	37.2	18.8
1	2	BEL	3	308	NoG	NoR	NoN	197	291	682	525	80.7	32.8	21.5
1	2	BEL	3	309	GE	RC	N	190	276	701	499	79.3	32.1	22.0
1	2	BEL	3	310	NoG	RR	N	113	252	651	420	77.0	28.6	19.0
1	2	BEL	3	311	NoG	NoR	N	172	247	690	533	80.3	28.0	20.3
1	2	BEL	3	312	GL	RC	N	172	236	682	444	78.3	32.1	19.5
1	2	BEL	3	313	GL	RR	NoN	147	281	415	430	74.7	22.5	18.5
1	2	BEL	3	314	GL	RR	N	140	265	478	423	77.7	21.1	18.0
1	2	BEL	3	315	GL	NoR	NoN	181	247	533	459	79.3	27.6	19.5
1	2	BEL	3	316	NoG	RR	NoN	198	294	454	459	74.3	22.4	19.8
1	2	BEL	3	317	GL	RC	NoN	161	239	580	441	79.7	32.7	19.3
1	2	BEL	3	318	GE	RR	N	110	268	486	436	76.0	26.1	19.5
1	2	BEL	4	401	GE	NoR	N	181	318	475	491	81.3	30.8	21.3
1	2	BEL	4	402	GL	NoR	NoN	180	291	577	486	76.7	32.8	19.8
1	2	BEL	4	403	NoG	NoR	N	182	357	507	433	79.7	35.6	20.0
1	2	BEL	4	404	GL	NoR	N	212	304	509	446	80.3	38.2	21.0
1	2	BEL	4	405	NoG	RR	N	141	249	528	409	72.3	30.5	19.8
1	2	BEL	4	406	NoG	NoR	NoN	158	231	520	462	77.0	31.6	22.0
1	2	BEL	4	407	GE	RR	NoN	178	360	446	396	72.7	33.0	20.8

1	2	BEL	4	408	GL	RR	N	193	375	454	407	73.0	28.2	21.0
1	2	BEL	4	409	GE	RR	N	133	318	360	415	76.0	33.9	21.5
1	2	BEL	4	410	GE	RC	NoN	158	265	606	512	78.0	24.4	20.3
1	2	BEL	4	411	GL	RC	NoN	154	223	596	425	78.3	31.3	19.5
1	2	BEL	4	412	GE	NoR	NoN	168	273	370	465	77.7	26.2	19.8
1	2	BEL	4	413	GE	RC	N	174	294	659	512	74.3	28.2	19.3
1	2	BEL	4	414	GL	RC	N	173	307	567	501	74.0	24.0	20.5
1	2	BEL	4	415	NoG	RC	N	159	236	596	402	74.0	29.3	21.5
1	2	BEL	4	416	NoG	RC	NoN	174	299	504	339	64.7	24.3	21.8
1	2	BEL	4	417	NoG	RR	NoN	116	304	449	339	71.3	30.8	19.5
1	2	BEL	4	418	GL	RR	NoN	132	333	454	357	73.0	23.6	21.3
1	3	OTT	1	101	GL	RR	N	173	533	743	756	82.3	17.0	32.1
1	3	OTT	1	102	GE	RC	N	240	580	843	780	84.3	14.1	35.5
1	3	OTT	1	103	GL	NoR	NoN	147	299	824	530	79.7	17.8	30.8
1	3	OTT	1	104	GE	NoR	N	163	396	940	685	81.7	17.5	30.1
1	3	OTT	1	105	GE	RC	NoN	261	575	774	764	81.0	16.2	31.3
1	3	OTT	1	106	NoG	NoR	N	151	412	871	656	78.0	18.7	28.3
1	3	OTT	1	107	GL	RC	N	188	462	942	882	84.0	14.3	29.4
1	3	OTT	1	108	GE	RR	NoN	211	467	856	572	333.3	19.9	29.5
1	3	OTT	1	109	NoG	RR	N	190	346	780	640	80.7	19.3	29.2
1	3	OTT	1	110	GE	RR	N	178	425	803	619	80.3	17.4	29.4
1	3	OTT	1	111	NoG	RR	NoN	155	577	845	661	78.7	17.1	30.5
1	3	OTT	1	112	NoG	RC	NoN	204	535	885	772	80.3	12.7	32.7
1	3	OTT	1	113	GL	NoR	N	153	488	882	627	82.7	19.9	29.9
1	3	OTT	1	114	GL	RR	NoN	160	714	690	787	79.0	15.2	29.7
1	3	OTT	1	115	GE	NoR	NoN	211	472	850	640	82.0	17.7	31.3
1	3	OTT	1	116	NoG	NoR	NoN	171	325	1021	619	82.0	17.4	30.9
1	3	OTT	1	117	NoG	RC	N	136	454	963	598	79.7	21.2	28.5
1	3	OTT	1	118	GL	RC	NoN	253	633	585	698	81.0	16.5	29.4
1	3	OTT	2	201	NoG	RR	NoN	193	554	919	562	80.7	17.3	31.0
1	3	OTT	2	202	GE	NoR	N	165	559	722	698	81.3	17.0	29.5
1	3	OTT	2	203	NoG	RR	N	197	394	887	614	80.0	17.7	30.2
1	3	OTT	2	204	GE	RR	NoN	180	525	790	656	80.3	17.4	29.8
1	3	OTT	2	205	GE	RC	NoN	162	499	672	667	82.0	17.4	29.9
1	3	OTT	2	206	GL	RC	NoN	187	622	554	604	78.0	16.5	30.9

1	3	OTT	2	207	NoG	NoR	NoN	190	378	871	609	79.3	17.5	29.7
1	3	OTT	2	208	NoG	NoR	N	153	199	483	667	83.3	17.9	29.8
1	3	OTT	2	209	GE	NoR	NoN	205	470	798	724	80.0	15.9	29.3
1	3	OTT	2	210	GL	RC	N	178	383	756	630	84.3	17.7	31.1
1	3	OTT	2	211	GE	RR	N	205	357	598	509	78.3	21.9	30.7
1	3	OTT	2	212	GL	RR	NoN	179	220	772	478	79.7	20.9	30.8
1	3	OTT	2	213	GL	NoR	NoN	183	391	538	504	80.3	22.4	31.0
1	3	OTT	2	214	GE	RC	N	223	528	759	514	84.3	24.1	30.0
1	3	OTT	2	215	GL	NoR	N	171	609	583	808	80.7	14.8	29.9
1	3	OTT	2	216	GL	RR	N	189	507	748	706	84.0	17.4	29.7
1	3	OTT	2	217	NoG	RC	NoN	158	396	591	630	81.0	17.9	31.8
1	3	OTT	2	218	NoG	RC	N	182	373	575	593	81.7	19.2	30.0
1	3	OTT	3	301	GL	RR	N	203	541	593	727	83.0	14.9	30.8
1	3	OTT	3	302	GL	RR	NoN	199	541	294	598	79.3	16.4	29.6
1	3	OTT	3	303	NoG	RC	NoN	154	336	344	609	79.3	13.4	32.7
1	3	OTT	3	304	GE	NoR	NoN	191	430	556	535	82.3	16.2	36.5
1	3	OTT	3	305	NoG	NoR	N	217	483	583	633	80.0	15.8	32.2
1	3	OTT	3	306	NoG	RR	NoN	150	465	520	588	78.3	14.0	34.8
1	3	OTT	3	307	NoG	RC	N	209	438	661	693	83.3	16.3	29.8
1	3	OTT	3	308	GL	RC	N	237	556	643	661	85.3	17.3	32.6
1	3	OTT	3	309	GL	NoR	N	133	451	619	598	82.3	18.4	29.6
1	3	OTT	3	310	GL	RC	NoN	222	423	591	451	78.3	22.1	31.2
1	3	OTT	3	311	GE	RR	N	160	685	378	724	82.3	16.7	30.4
1	3	OTT	3	312	GE	RC	N	237	436	717	635	81.7	17.3	33.6
1	3	OTT	3	313	GE	RC	NoN	179	438	299	517	84.7	20.6	32.3
1	3	OTT	3	314	NoG	NoR	NoN	183	449	564	451	80.0	21.9	31.8
1	3	OTT	3	315	NoG	RR	N	191	465	507	640	79.7	17.7	31.4
1	3	OTT	3	316	GE	RR	NoN	213	667	470	630	82.3	18.0	31.1
1	3	OTT	3	317	GL	NoR	NoN	160	451	483	572	80.0	17.6	33.9
1	3	OTT	3	318	GE	NoR	N	183	470	538	609	81.7	19.9	28.6
1	3	OTT	4	401	NoG	RC	N	203	362	457	501	78.7	19.8	32.2
1	3	OTT	4	402	GE	RC	NoN	178	509	281	753	81.3	14.2	31.9
1	3	OTT	4	403	GE	RR	NoN	243	436	491	522	79.7	21.4	30.6
1	3	OTT	4	404	GL	RR	N	191	480	404	564	80.0	19.5	30.3
1	3	OTT	4	405	GE	NoR	NoN	170	514	394	625	82.3	17.3	30.8

1	3	OTT	4	406	GE	RC	N	177	483	370	593	81.0	19.9	30.4
1	3	OTT	4	407	GE	NoR	N	200	430	462	556	80.7	23.1	29.4
1	3	OTT	4	408	NoG	RR	NoN	127	289	346	535	78.7	18.6	32.3
1	3	OTT	4	409	GL	RR	NoN	166	391	501	591	80.0	15.8	33.2
1	3	OTT	4	410	GL	RC	N	152	514	467	656	83.7	16.7	32.7
1	3	OTT	4	411	GE	RR	N	200	425	585	717	83.3	15.4	32.0
1	3	OTT	4	412	GL	NoR	N	173	328	517	564	80.3	17.1	33.9
1	3	OTT	4	413	GL	NoR	NoN	195	449	488	530	82.0	21.0	30.7
1	3	OTT	4	414	NoG	RC	NoN	193	454	501	635	81.3	13.1	35.4
1	3	OTT	4	415	GL	RC	NoN	189	551	386	593	78.3	14.4	30.9
1	3	OTT	4	416	NoG	NoR	NoN	133	457	514	567	82.3	17.5	31.5
1	3	OTT	4	417	NoG	RR	N	165	262	541	475	82.0	22.8	31.5
1	3	OTT	4	418	NoG	NoR	N	132	244	638	588	84.3	16.8	35.8
2	4	MAN	1	101	NoG	RR	NoN	168	.	583	320	71.3	32.6	19.65
2	4	MAN	1	102	GE	RR	N	142	.	530	383	71.7	25.9	21.85
2	4	MAN	1	103	GE	NoR	N	126	.	575	365	76.0	26.4	23.81
2	4	MAN	1	104	NoG	NoR	N	168	.	769	493	73.0	29.3	21.83
2	4	MAN	1	105	GL	RC	N	163	.	871	546	76.3	32.9	21.90
2	4	MAN	1	106	GE	RC	N	184	.	745	441	70.0	30.4	18.43
2	4	MAN	1	107	GL	NoR	NoN	155	.	682	438	74.7	34.3	16.47
2	4	MAN	1	108	NoG	RR	N	123	.	735	556	70.0	31.9	19.74
2	4	MAN	1	109	GL	RC	NoN	223	.	929	625	72.7	25.9	21.59
2	4	MAN	1	110	NoG	NoR	NoN	194	.	911	520	76.0	26.7	23.25
2	4	MAN	1	111	NoG	RC	N	202	.	808	759	74.3	25.8	21.24
2	4	MAN	1	112	GE	NoR	NoN	202	.	995	711	76.3	28.3	20.18
2	4	MAN	1	113	NoG	RC	NoN	236	.	1115	386	77.7	30.0	19.42
2	4	MAN	1	114	GL	RR	N	184	.	782	598	71.0	25.9	20.65
2	4	MAN	1	115	GL	RR	NoN	286	.	864	577	68.0	26.3	19.87
2	4	MAN	1	116	GE	RC	NoN	163	.	832	564	73.7	29.9	20.71
2	4	MAN	1	117	GL	NoR	N	168	.	829	407	74.0	25.2	23.61
2	4	MAN	1	118	GE	RR	NoN	144	.	753	627	74.0	32.2	20.48
2	4	MAN	2	201	GE	RC	N	236	.	1123	470	71.0	27.9	21.47
2	4	MAN	2	202	GL	RR	N	210	.	659	609	68.7	23.5	18.72
2	4	MAN	2	203	GE	RC	NoN	184	.	913	360	73.7	24.3	20.58
2	4	MAN	2	204	GE	RR	NoN	142	.	609	493	69.3	24.9	20.36

2	4	MAN	2	205	GE	RR	N	165	.	777	499	71.3	21.5	21.40
2	4	MAN	2	206	NoG	RC	NoN	176	.	945	541	71.0	27.4	21.87
2	4	MAN	2	207	GE	NoR	N	176	.	827	638	72.3	36.3	22.25
2	4	MAN	2	208	NoG	NoR	N	168	.	948	612	75.7	28.2	19.21
2	4	MAN	2	209	NoG	RR	NoN	181	.	711	496	69.3	27.5	18.18
2	4	MAN	2	210	GL	NoR	N	207	.	1029	570	73.7	21.6	22.54
2	4	MAN	2	211	NoG	RC	N	192	.	948	630	75.3	24.8	20.48
2	4	MAN	2	212	GL	RR	NoN	163	.	753	467	72.0	20.7	21.37
2	4	MAN	2	213	NoG	NoR	NoN	168	.	816	491	74.7	20.3	21.72
2	4	MAN	2	214	NoG	RR	N	236	.	811	549	74.0	18.2	22.60
2	4	MAN	2	215	GL	RC	N	147	.	546	444	73.0	24.5	22.88
2	4	MAN	2	216	GL	RC	NoN	202	.	693	535	72.0	17.5	21.29
2	4	MAN	2	217	GL	NoR	NoN	171	.	835	585	76.3	22.7	20.68
2	4	MAN	2	218	GE	NoR	NoN	165	.	583	661	75.7	28.3	20.61
2	4	MAN	3	301	GE	RR	NoN	234	.	948	556	69.3	26.8	20.88
2	4	MAN	3	302	NoG	NoR	N	231	.	885	564	77.0	20.7	23.12
2	4	MAN	3	303	GL	NoR	NoN	152	.	974	509	76.3	22.9	35.00
2	4	MAN	3	304	NoG	RR	NoN	228	.	801	504	70.0	27.2	19.41
2	4	MAN	3	305	NoG	RC	NoN	160	.	984	530	78.7	21.2	19.31
2	4	MAN	3	306	GE	NoR	NoN	339	.	1089	688	79.7	26.4	21.49
2	4	MAN	3	307	NoG	RR	N	210	.	882	533	75.3	25.2	21.22
2	4	MAN	3	308	NoG	NoR	NoN	244	.	874	514	72.7	28.3	24.73
2	4	MAN	3	309	GL	RR	NoN	192	.	764	404	73.7	28.7	20.35
2	4	MAN	3	310	GE	RC	NoN	202	.	1047	625	74.7	28.0	20.24
2	4	MAN	3	311	GE	RR	N	131	.	766	383	69.3	26.3	19.95
2	4	MAN	3	312	GL	NoR	N	241	.	1021	622	75.7	23.3	20.66
2	4	MAN	3	313	NoG	RC	N	228	.	882	638	77.7	28.7	20.94
2	4	MAN	3	314	GL	RC	N	239	.	932	745	75.7	24.3	22.22
2	4	MAN	3	315	GE	RC	N	294	.	887	520	74.3	22.7	21.34
2	4	MAN	3	316	GL	RR	N	150	.	948	462	74.7	28.7	19.67
2	4	MAN	3	317	GE	NoR	N	168	.	751	554	73.3	26.0	20.98
2	4	MAN	3	318	GL	RC	NoN	249	.	1013	667	72.3	33.7	17.79
2	4	MAN	4	401	GL	RR	N	228	.	916	480	71.0	27.5	23.53
2	4	MAN	4	402	GL	NoR	NoN	126	.	916	420	77.7	21.2	21.43
2	4	MAN	4	403	GE	RR	N	283	.	871	509	72.7	25.6	21.95

2	4	MAN	4	404	GE	NoR	NoN	186	.	974	457	75.0	24.3	18.49
2	4	MAN	4	405	GL	NoR	N	202	.	995	491	75.0	24.9	22.12
2	4	MAN	4	406	GE	NoR	N	197	.	850	601	75.7	26.9	22.55
2	4	MAN	4	407	GE	RC	N	281	.	911	640	77.7	21.7	23.34
2	4	MAN	4	408	GE	RC	NoN	202	.	934	525	74.7	26.7	22.34
2	4	MAN	4	409	NoG	RC	NoN	231	.	979	690	73.7	25.5	22.68
2	4	MAN	4	410	GL	RC	N	255	.	919	643	75.0	28.3	20.49
2	4	MAN	4	411	NoG	RR	NoN	160	.	664	480	75.7	27.4	20.42
2	4	MAN	4	412	GE	RR	NoN	249	.	963	596	71.7	26.9	21.03
2	4	MAN	4	413	NoG	NoR	N	255	.	1079	680	72.7	26.6	21.04
2	4	MAN	4	414	GL	RR	NoN	165	.	903	472	72.7	25.7	18.92
2	4	MAN	4	415	NoG	RR	N	147	.	911	404	72.7	23.3	19.81
2	4	MAN	4	416	NoG	RC	N	241	.	1003	664	74.3	27.0	20.28
2	4	MAN	4	417	GL	RC	NoN	160	.	795	480	72.0	28.6	19.72
2	4	MAN	4	418	NoG	NoR	NoN	152	.	829	467	76.3	17.5	20.52
2	5	BEL	1	101	GL	RC	N	268	444	412	538	72.3	25.6	23.47
2	5	BEL	1	102	NoG	RR	NoN	281	640	115	591	68.7	26.2	20.61
2	5	BEL	1	103	GE	RC	NoN	291	646	262	656	69.3	21.8	24.82
2	5	BEL	1	104	NoG	RC	NoN	202	507	310	549	72.0	25.6	15.61
2	5	BEL	1	105	GE	RR	NoN	265	462	165	509	71.7	27.7	21.69
2	5	BEL	1	106	GL	RR	NoN	197	320	226	499	68.7	26.2	21.34
2	5	BEL	1	107	NoG	RC	N	276	570	304	577	68.7	28.9	20.76
2	5	BEL	1	108	GL	RR	N	252	388	210	462	65.7	21.6	20.69
2	5	BEL	1	109	GE	RR	N	357	496	265	580	66.3	22.9	23.84
2	5	BEL	1	110	GL	NoR	NoN	339	635	404	625	72.7	25.6	22.67
2	5	BEL	1	111	GE	NoR	NoN	268	507	349	648	78.7	21.0	24.14
2	5	BEL	1	112	NoG	NoR	N	323	688	270	504	75.7	27.5	21.80
2	5	BEL	1	113	GE	RC	N	370	640	346	756	74.0	23.5	18.16
2	5	BEL	1	114	NoG	NoR	NoN	333	509	375	685	77.0	21.0	22.17
2	5	BEL	1	115	GE	NoR	N	205	420	509	622	77.0	24.5	23.44
2	5	BEL	1	116	NoG	RR	N	255	383	331	446	71.3	21.0	23.13
2	5	BEL	1	117	GL	NoR	N	425	564	472	696	74.3	24.1	23.26
2	5	BEL	1	118	GL	RC	NoN	328	541	501	622	73.7	19.3	24.26
2	5	BEL	2	201	NoG	RC	N	352	517	291	509	72.3	20.5	23.85
2	5	BEL	2	202	GE	RR	N	325	504	210	394	73.3	18.6	22.77

2	5	BEL	2	203	GL	RC	N	339	562	417	756	75.0	32.9	19.65
2	5	BEL	2	204	GE	RR	NoN	325	619	123	433	68.3	28.9	20.21
2	5	BEL	2	205	GL	NoR	NoN	315	470	360	625	77.3	27.3	22.01
2	5	BEL	2	206	GE	NoR	N	302	478	512	714	79.7	26.2	19.95
2	5	BEL	2	207	GE	RC	N	289	554	381	551	78.3	24.4	18.76
2	5	BEL	2	208	GE	RC	NoN	341	667	378	717	72.3	20.3	20.67
2	5	BEL	2	209	NoG	NoR	NoN	307	488	381	580	78.0	19.1	27.46
2	5	BEL	2	210	GL	NoR	N	220	318	664	585	80.3	28.6	18.89
2	5	BEL	2	211	GL	RR	NoN	207	559	286	580	78.7	23.6	22.00
2	5	BEL	2	212	NoG	RR	N	228	486	276	499	75.0	23.0	23.00
2	5	BEL	2	213	GE	NoR	NoN	346	570	367	743	78.7	19.3	22.03
2	5	BEL	2	214	GL	RR	N	281	577	163	577	70.7	18.9	21.00
2	5	BEL	2	215	GL	RC	NoN	354	570	360	659	74.0	21.2	23.05
2	5	BEL	2	216	NoG	NoR	N	312	517	438	682	78.3	14.3	23.94
2	5	BEL	2	217	NoG	RC	NoN	276	428	289	509	72.3	20.7	23.42
2	5	BEL	2	218	NoG	RR	NoN	234	394	299	420	68.3	20.4	23.31
2	5	BEL	3	301	GL	RC	NoN	268	483	567	493	72.3	22.8	22.25
2	5	BEL	3	302	GE	NoR	N	302	417	585	480	77.7	33.4	18.80
2	5	BEL	3	303	GE	NoR	NoN	417	693	472	635	76.3	26.9	19.35
2	5	BEL	3	304	NoG	RR	N	171	420	171	428	70.0	24.6	18.96
2	5	BEL	3	305	NoG	RR	NoN	249	436	218	525	72.3	22.7	21.84
2	5	BEL	3	306	GE	RC	NoN	407	530	451	630	73.3	30.6	16.36
2	5	BEL	3	307	GL	RR	N	268	438	333	512	70.7	21.0	19.08
2	5	BEL	3	308	GE	RR	N	252	417	318	496	73.3	25.1	21.48
2	5	BEL	3	309	NoG	NoR	N	312	509	420	598	75.0	25.7	23.36
2	5	BEL	3	310	NoG	RC	N	297	488	386	486	71.7	26.5	21.15
2	5	BEL	3	311	GL	RR	NoN	291	533	257	528	68.7	25.7	16.37
2	5	BEL	3	312	GL	NoR	NoN	281	575	423	664	74.0	20.3	26.00
2	5	BEL	3	313	NoG	NoR	NoN	328	714	304	680	73.3	24.2	17.69
2	5	BEL	3	314	GL	RC	N	270	554	325	567	72.0	28.0	16.73
2	5	BEL	3	315	GE	RC	N	339	585	294	682	70.7	29.4	15.79
2	5	BEL	3	316	NoG	RC	NoN	223	454	362	567	74.7	23.6	17.21
2	5	BEL	3	317	GL	NoR	N	286	562	244	554	72.0	33.9	14.88
2	5	BEL	3	318	GE	RR	NoN	252	386	252	454	69.7	28.6	16.49
2	5	BEL	4	401	GE	RR	N	189	365	396	441	71.3	30.1	15.21

2	5	BEL	4	402	GL	NoR	NoN	375	562	441	777	75.7	21.8	19.63
2	5	BEL	4	403	NoG	RC	N	318	538	362	593	71.7	19.1	29.28
2	5	BEL	4	404	NoG	RC	NoN	331	546	215	572	70.7	21.9	23.25
2	5	BEL	4	405	NoG	NoR	NoN	252	336	454	.	72.0	.	.
2	5	BEL	4	406	NoG	RR	NoN	244	465	244	538	69.3	23.7	22.75
2	5	BEL	4	407	GL	NoR	N	360	475	604	766	72.3	27.0	22.24
2	5	BEL	4	408	GE	NoR	NoN	312	507	352	648	78.7	23.1	19.88
2	5	BEL	4	409	GE	RR	NoN	276	486	302	559	70.3	29.0	19.30
2	5	BEL	4	410	GE	RC	NoN	388	682	218	696	74.0	15.0	29.60
2	5	BEL	4	411	NoG	NoR	N	472	580	352	698	77.0	16.5	26.63
2	5	BEL	4	412	GL	RR	NoN	276	520	194	541	69.7	20.3	25.93
2	5	BEL	4	413	GE	RC	N	352	541	318	651	73.7	23.9	18.74
2	5	BEL	4	414	GE	NoR	N	354	612	318	646	76.7	31.5	16.61
2	5	BEL	4	415	GL	RC	NoN	276	507	420	588	71.7	32.6	14.89
2	5	BEL	4	416	NoG	RR	N	176	433	231	417	71.3	34.6	16.91
2	5	BEL	4	417	GL	RR	N	228	402	268	593	70.7	17.5	27.73
2	5	BEL	4	418	GL	RC	N	289	472	402	591	74.0	29.8	15.69
2	6	HUT	1	101	GE	RC	NoN	270	.	783	640	60.0	23.0	24.33
2	6	HUT	1	102	GE	RR	NoN	240	.	719	617	51.7	23.5	21.19
2	6	HUT	1	103	NoG	RR	N	262	.	654	496	58.0	21.4	23.71
2	6	HUT	1	104	NoG	NoR	N	199	.	683	549	58.3	27.1	19.93
2	6	HUT	1	105	GL	RR	N	234	.	724	433	55.0	34.3	.
2	6	HUT	1	106	GE	NoR	N	281	.	874	617	59.7	23.3	23.83
2	6	HUT	1	107	NoG	RC	NoN	197	.	650	444	56.3	23.6	26.23
2	6	HUT	1	108	GL	NoR	NoN	215	.	713	619	64.0	22.9	27.03
2	6	HUT	1	109	NoG	NoR	NoN	270	.	774	654	61.7	.	.
2	6	HUT	1	110	GE	RR	N	157	.	547	496	59.0	18.5	27.96
2	6	HUT	1	111	GL	RC	N	219	.	695	604	57.0	16.0	26.84
2	6	HUT	1	112	GE	NoR	NoN	181	.	736	717	59.7	28.6	23.78
2	6	HUT	1	113	GL	NoR	N	246	.	778	633	60.0	25.6	24.24
2	6	HUT	1	114	NoG	RR	NoN	154	.	675	601	54.3	27.3	24.14
2	6	HUT	1	115	GE	RC	N	224	.	677	512	58.0	23.9	24.28
2	6	HUT	1	116	GL	RC	NoN	256	.	732	514	52.3	31.0	19.37
2	6	HUT	1	117	GL	RR	NoN	232	.	594	478	57.3	24.3	24.67
2	6	HUT	1	118	NoG	RC	N	230	.	815	617	57.0	22.5	24.84

2	6	HUT	2	201	NoG	NoR	N	262	.	837	606	60.0	42.2	15.81
2	6	HUT	2	202	GL	RC	N	238	.	677	446	52.7	31.9	13.86
2	6	HUT	2	203	NoG	RC	N	197	.	654	462	55.3	26.8	28.38
2	6	HUT	2	204	NoG	RR	NoN	201	.	717	491	57.3	25.8	24.88
2	6	HUT	2	205	GL	NoR	NoN	207	.	628	585	65.3	25.2	24.04
2	6	HUT	2	206	GL	RR	NoN	232	.	539	467	56.7	17.0	24.56
2	6	HUT	2	207	GE	RR	N	236	.	846	795	52.7	.	.
2	6	HUT	2	208	NoG	RC	NoN	343	.	939	667	61.0	20.6	26.36
2	6	HUT	2	209	NoG	RR	N	211	.	638	688	60.7	24.4	24.63
2	6	HUT	2	210	GL	RC	NoN	201	.	524	249	54.3	.	.
2	6	HUT	2	211	GL	RR	N	195	.	709	585	58.0	35.1	17.11
2	6	HUT	2	212	GL	NoR	N	177	.	929	567	65.7	26.8	23.24
2	6	HUT	2	213	GE	RC	NoN	191	.	685	480	51.0	28.1	24.93
2	6	HUT	2	214	GE	NoR	N	240	.	783	556	60.7	23.5	24.74
2	6	HUT	2	215	NoG	NoR	NoN	222	.	594	472	64.7	24.1	21.78
2	6	HUT	2	216	GE	RR	NoN	224	.	709	496	59.7	23.4	24.77
2	6	HUT	2	217	GE	RC	N	238	.	805	583	53.0	.	.
2	6	HUT	2	218	GE	NoR	NoN	217	.	691	648	56.7	28.6	23.97
2	6	HUT	3	301	NoG	NoR	NoN	256	.	831	769	60.0	23.8	22.15
2	6	HUT	3	302	GL	RC	NoN	215	.	675	606	59.7	22.1	26.23
2	6	HUT	3	303	NoG	RC	NoN	195	.	528	349	53.7	30.0	25.32
2	6	HUT	3	304	GE	RR	NoN	213	.	598	764	49.7	17.8	22.98
2	6	HUT	3	305	GL	RC	N	248	.	663	525	53.7	22.0	29.14
2	6	HUT	3	306	NoG	RR	N	238	.	608	438	51.7	20.4	24.83
2	6	HUT	3	307	NoG	RR	NoN	173	.	498	409	56.0	29.5	24.44
2	6	HUT	3	308	GL	NoR	NoN	246	.	665	504	70.0	23.9	20.96
2	6	HUT	3	309	NoG	RC	N	217	.	774	690	59.7	24.4	21.37
2	6	HUT	3	310	NoG	NoR	N	244	.	699	722	65.0	27.0	23.10
2	6	HUT	3	311	GE	RR	N	234	.	575	601	56.0	22.3	25.99
2	6	HUT	3	312	GL	RR	NoN	177	.	514	339	54.7	21.2	20.91
2	6	HUT	3	313	GL	RR	N	248	.	632	638	54.3	22.8	24.36
2	6	HUT	3	314	GE	RC	NoN	201	.	608	546	56.3	22.8	23.91
2	6	HUT	3	315	GE	NoR	NoN	215	.	616	549	62.7	20.7	22.20
2	6	HUT	3	316	GE	RC	N	258	.	866	895	61.0	23.7	24.47
2	6	HUT	3	317	GE	NoR	N	240	.	801	693	65.0	33.0	17.25

2	6	HUT	3	318	GL	NoR	N	244	.	760	751	59.3	25.5	22.33
2	6	HUT	4	401	NoG	NoR	N	256	.	760	824	62.3	.	.
2	6	HUT	4	402	GL	NoR	N	238	.	732	753	56.3	25.6	21.32
2	6	HUT	4	403	GL	NoR	NoN	276	.	705	861	68.0	18.2	23.45
2	6	HUT	4	404	NoG	RC	NoN	250	.	740	848	52.7	23.1	22.81
2	6	HUT	4	405	GL	RR	NoN	201	.	539	420	57.3	23.3	25.79
2	6	HUT	4	406	GE	NoR	N	280	.	722	614	63.7	24.5	22.91
2	6	HUT	4	407	GL	RR	N	228	.	628	541	60.7	30.4	23.07
2	6	HUT	4	408	GE	RR	N	278	.	689	627	49.3	23.2	25.40
2	6	HUT	4	409	GL	RC	N	213	.	561	409	64.0	28.4	22.23
2	6	HUT	4	410	NoG	RR	N	185	.	467	388	58.0	35.5	18.26
2	6	HUT	4	411	GE	RR	NoN	228	.	705	612	52.0	.	.
2	6	HUT	4	412	NoG	RC	N	222	.	738	572	59.3	19.3	24.12
2	6	HUT	4	413	NoG	NoR	NoN	254	.	906	677	60.0	29.8	16.23
2	6	HUT	4	414	GL	RC	NoN	258	.	754	627	63.3	36.0	16.66
2	6	HUT	4	415	GE	RC	N	278	.	766	659	60.3	21.4	25.58
2	6	HUT	4	416	NoG	RR	NoN	252	.	799	640	58.0	24.0	22.70
2	6	HUT	4	417	GE	NoR	NoN	254	.	807	837	58.7	20.5	25.81
2	6	HUT	4	418	GE	RC	NoN	252	.	661	580	59.7	25.8	23.24

Appendix C - Raw Data: Chapter 2 "Grain Sorghum Hybrid and Wheat Variety Traits for Planting Wheat after Grain Sorghum in No-till Systems"

Table C.1 Summer crop yield data.

YR	ENV	LOC	BLOC	PLOT	HYBRID	CROP	MATURITY	PLANT TYPE	YLD
									kg ha^{-1}
2	2	HUT	1	101	85G03	S	ML	RED	7324
2	2	HUT	1	102	SP3303	S	E	TAN	5820
2	2	HUT	1	103	4525	S	ML	TAN	7193
2	2	HUT	1	104	DKC63-84	C	L	C	1514
2	2	HUT	1	105	86G32	S	M	RED	7613
2	2	HUT	1	106	88P68	S	E	RED	6334
2	2	HUT	2	201	86G32	S	M	RED	6406
2	2	HUT	2	202	DKC63-84	C	L	C	3024
2	2	HUT	2	203	88P68	S	E	RED	4670
2	2	HUT	2	204	SP3303	S	E	TAN	4039
2	2	HUT	2	205	4525	S	ML	TAN	5839
2	2	HUT	2	206	85G03	S	ML	RED	5836
2	2	HUT	3	301	4525	S	ML	TAN	6607
2	2	HUT	3	302	85G03	S	ML	RED	6079
2	2	HUT	3	303	SP3303	S	E	TAN	3440
2	2	HUT	3	304	86G32	S	M	RED	7128
2	2	HUT	3	305	88P68	S	E	RED	5737
2	2	HUT	3	306	DKC63-84	C	L	C	4122
2	2	HUT	4	401	88P68	S	E	RED	6130
2	2	HUT	4	402	86G32	S	M	RED	7059
2	2	HUT	4	403	85G03	S	ML	RED	6508
2	2	HUT	4	404	4525	S	ML	TAN	6700
2	2	HUT	4	405	DKC63-84	C	L	C	4296
2	2	HUT	4	406	SP3303	S	E	TAN	4618
1	3	MAN	1	101	SP3303	S	E	TAN	5099
1	3	MAN	1	102	86G32	S	M	RED	5530
1	3	MAN	1	103	88P68	S	E	RED	4526
1	3	MAN	1	104	DKC63-84	C	L	C	8804
1	3	MAN	1	105	85G03	S	ML	RED	5631
1	3	MAN	1	106	4525	S	ML	TAN	6711
1	3	MAN	2	201	SP3303	S	E	TAN	3584

1	3	MAN	2	202	DKC63-84	C	L	C	8130
1	3	MAN	2	203	4525	S	ML	TAN	5693
1	3	MAN	2	204	85G03	S	ML	RED	5785
1	3	MAN	2	205	88P68	S	E	RED	3586
1	3	MAN	2	206	86G32	S	M	RED	4976
1	3	MAN	3	301	88P68	S	E	RED	4596
1	3	MAN	3	302	85G03	S	ML	RED	4821
1	3	MAN	3	303	86G32	S	M	RED	4086
1	3	MAN	3	304	DKC63-84	C	L	C	5366
1	3	MAN	3	305	SP3303	S	E	RED	3347
1	3	MAN	3	306	4525	S	ML	RED	6309
1	3	MAN	4	401	85G03	S	ML	RED	4005
1	3	MAN	4	402	DKC63-84	C	L	C	3634
1	3	MAN	4	403	SP3303	S	E	TAN	1980
1	3	MAN	4	404	88P68	S	E	RED	6124
1	3	MAN	4	405	86G32	S	M	RED	4165
1	3	MAN	4	406	4525	S	ML	TAN	3992
2	4	MAN	1	101	85G03	S	ML	RED	10177
2	4	MAN	1	102	4525	S	ML	TAN	9303
2	4	MAN	1	103	SP3303	S	E	TAN	7542
2	4	MAN	1	104	86G32	S	M	RED	8921
2	4	MAN	1	105	88P68	S	E	RED	7334
2	4	MAN	1	106	DKC63-84	C	L	C	10097
2	4	MAN	2	201	88P68	S	E	RED	7911
2	4	MAN	2	202	86G32	S	M	RED	8705
2	4	MAN	2	203	DKC63-84	C	L	C	9791
2	4	MAN	2	204	4525	S	ML	TAN	9051
2	4	MAN	2	205	SP3303	S	E	TAN	7517
2	4	MAN	2	206	85G03	S	ML	RED	8355
2	4	MAN	3	301	SP3303	S	E	TAN	7496
2	4	MAN	3	302	85G03	S	ML	RED	8751
2	4	MAN	3	303	4525	S	ML	TAN	9128
2	4	MAN	3	304	88P68	S	E	RED	7337
2	4	MAN	3	305	DKC63-84	C	L	C	9726
2	4	MAN	3	306	86G32	S	M	RED	8366
2	4	MAN	4	401	DKC63-84	C	L	C	10647
2	4	MAN	4	402	88P68	S	E	RED	7650
2	4	MAN	4	403	85G03	S	ML	RED	8553
2	4	MAN	4	404	SP3303	S	E	TAN	6934
2	4	MAN	4	405	86G32	S	M	RED	7403
2	4	MAN	4	406	4525	S	ML	TAN	7590

Table C.2 Winter wheat grain yield and NDVI data.

YR	ENV	LOC	BLOC	PLOT	HYBRID	CROP	CULTIVAR	MAT-URITY	PIG-MENT	YLD	NDVI-1	NDVI-2
										kg ha^{-1}		
1	1	HUT	1	101	4525	S	SOUTHWIND	ML	TAN	2352		0.606
1	1	HUT	1	102	86G32	S	SOUTHWIND	M	RED	2924		0.706
1	1	HUT	1	103	88P68	S	SOUTHWIND	E	RED	3211		0.628
1	1	HUT	1	104	DKC63-84	C	SOUTHWIND	L	C	3015		0.629
1	1	HUT	1	105	SP3303	S	SOUTHWIND	E	TAN	1309		0.537
1	1	HUT	1	106	85G03	S	SOUTHWIND	ML	RED	1888		0.611
1	1	HUT	1	107	4525	S	DUSTER	ML	TAN	3278		0.740
1	1	HUT	1	108	86G32	S	DUSTER	M	RED	3564		0.778
1	1	HUT	1	109	88P68	S	DUSTER	E	RED	3531		0.749
1	1	HUT	1	110	DKC63-84	C	DUSTER	L	C	4042		0.785
1	1	HUT	1	111	SP3303	S	DUSTER	E	TAN	2784		0.739
1	1	HUT	1	112	85G03	S	DUSTER	ML	RED	2454		0.770
1	1	HUT	1	113	4525	S	BILLINGS	ML	TAN	3154		0.743
1	1	HUT	1	114	86G32	S	BILLINGS	M	RED	3181		0.783
1	1	HUT	1	115	88P68	S	BILLINGS	E	RED	3169		0.749
1	1	HUT	1	116	DKC63-84	C	BILLINGS	L	C	3770		0.780
1	1	HUT	1	117	SP3303	S	BILLINGS	E	TAN	2332		0.743
1	1	HUT	1	118	85G03	S	BILLINGS	ML	RED	2213		0.670
1	1	HUT	1	119	4525	S	FULLER	ML	TAN	3188		0.718
1	1	HUT	1	120	86G32	S	FULLER	M	RED	3189		0.746
1	1	HUT	1	121	88P68	S	FULLER	E	RED	2868		0.680
1	1	HUT	1	122	DKC63-84	C	FULLER	L	C	3931		0.775
1	1	HUT	1	123	SP3303	S	FULLER	E	TAN	2750		0.740
1	1	HUT	1	124	85G03	S	FULLER	ML	RED	2474		0.735
1	1	HUT	1	125	4525	S	EVEREST	ML	TAN	3335		0.726
1	1	HUT	1	126	86G32	S	EVEREST	M	RED	3735		0.787
1	1	HUT	1	127	88P68	S	EVEREST	E	RED	3448		0.775
1	1	HUT	1	128	DKC63-84	C	EVEREST	L	C	3666		0.683
1	1	HUT	1	129	SP3303	S	EVEREST	E	TAN	3655		0.795
1	1	HUT	1	130	85G03	S	EVEREST	ML	RED	3704		0.809

1	1	HUT	1	131	4525	S	T-154	ML	TAN	3566		0.736
1	1	HUT	1	132	86G32	S	T-154	M	RED	3122		0.705
1	1	HUT	1	133	88P68	S	T-154	E	RED	3495		0.731
1	1	HUT	1	134	DKC63-84	C	T-154	L	C	3651		0.721
1	1	HUT	1	135	SP3303	S	T-154	E	TAN	2948		0.682
1	1	HUT	1	136	85G03	S	T-154	ML	RED	2978		0.684
1	1	HUT	2	201	85G03	S	BILLINGS	ML	RED	4147		0.749
1	1	HUT	2	202	86G32	S	BILLINGS	M	RED	3561		0.786
1	1	HUT	2	203	88P68	S	BILLINGS	E	RED	3452		0.770
1	1	HUT	2	204	SP3303	S	BILLINGS	E	TAN	3516		0.780
1	1	HUT	2	205	DKC63-84	C	BILLINGS	L	C	4248		0.816
1	1	HUT	2	206	4525	S	BILLINGS	ML	TAN	3129		0.774
1	1	HUT	2	207	85G03	S	FULLER	ML	RED	3349		0.733
1	1	HUT	2	208	86G32	S	FULLER	M	RED	3219		0.780
1	1	HUT	2	209	88P68	S	FULLER	E	RED	3308		0.784
1	1	HUT	2	210	SP3303	S	FULLER	E	TAN	3285		0.775
1	1	HUT	2	211	DKC63-84	C	FULLER	L	C	4048		0.833
1	1	HUT	2	212	4525	S	FULLER	ML	TAN	2489		0.719
1	1	HUT	2	213	85G03	S	EVEREST	ML	RED	4341		0.792
1	1	HUT	2	214	86G32	S	EVEREST	M	RED	3616		0.824
1	1	HUT	2	215	88P68	S	EVEREST	E	RED	4032		0.816
1	1	HUT	2	216	SP3303	S	EVEREST	E	TAN	3822		0.813
1	1	HUT	2	217	DKC63-84	C	EVEREST	L	C	4221		0.834
1	1	HUT	2	218	4525	S	EVEREST	ML	TAN	3117		0.798
1	1	HUT	2	219	85G03	S	T-154	ML	RED	4190		0.790
1	1	HUT	2	220	86G32	S	T-154	M	RED	3685		0.810
1	1	HUT	2	221	88P68	S	T-154	E	RED	3778		0.792
1	1	HUT	2	222	SP3303	S	T-154	E	TAN	3499		0.791
1	1	HUT	2	223	DKC63-84	C	T-154	L	C	3493		0.736
1	1	HUT	2	224	4525	S	T-154	ML	TAN	2994		0.759
1	1	HUT	2	225	85G03	S	DUSTER	ML	RED	3944		0.816
1	1	HUT	2	226	86G32	S	DUSTER	M	RED	3298		0.815
1	1	HUT	2	227	88P68	S	DUSTER	E	RED	3457		0.814
1	1	HUT	2	228	SP3303	S	DUSTER	E	TAN	3179		0.805
1	1	HUT	2	229	DKC63-84	C	DUSTER	L	C	3315		0.783

1	1	HUT	2	230	4525	S	DUSTER	ML	TAN	2224		0.771
1	1	HUT	2	231	85G03	S	SOUTHWIND	ML	RED	3828		0.681
1	1	HUT	2	232	86G32	S	SOUTHWIND	M	RED	3185		0.695
1	1	HUT	2	233	88P68	S	SOUTHWIND	E	RED	3343		0.655
1	1	HUT	2	234	SP3303	S	SOUTHWIND	E	TAN	2948		0.643
1	1	HUT	2	235	DKC63-84	C	SOUTHWIND	L	C	3349		0.650
1	1	HUT	2	236	4525	S	SOUTHWIND	ML	TAN	2622		0.651
1	1	HUT	3	301	SP3303	S	EVEREST	E	TAN	4420		0.790
1	1	HUT	3	302	DKC63-84	C	EVEREST	L	C	4046		0.820
1	1	HUT	3	303	88P68	S	EVEREST	E	RED	3775		0.796
1	1	HUT	3	304	85G03	S	EVEREST	ML	RED	3642		0.788
1	1	HUT	3	305	86G32	S	EVEREST	M	RED	.		0.809
1	1	HUT	3	306	4525	S	EVEREST	ML	TAN	.		0.759
1	1	HUT	3	307	SP3303	S	FULLER	E	TAN	3568		0.778
1	1	HUT	3	308	DKC63-84	C	FULLER	L	C	3146		0.791
1	1	HUT	3	309	88P68	S	FULLER	E	RED	2864		0.766
1	1	HUT	3	310	85G03	S	FULLER	ML	RED	2829		0.769
1	1	HUT	3	311	86G32	S	FULLER	M	RED	2912		0.795
1	1	HUT	3	312	4525	S	FULLER	ML	TAN	2126		0.698
1	1	HUT	3	313	SP3303	S	BILLINGS	E	TAN	4650		0.836
1	1	HUT	3	314	DKC63-84	C	BILLINGS	L	C	4084		0.854
1	1	HUT	3	315	88P68	S	BILLINGS	E	RED	3744		0.827
1	1	HUT	3	316	85G03	S	BILLINGS	ML	RED	3521		0.793
1	1	HUT	3	317	86G32	S	BILLINGS	M	RED	3557		0.803
1	1	HUT	3	318	4525	S	BILLINGS	ML	TAN	3235		0.793
1	1	HUT	3	319	SP3303	S	T-154	E	TAN	3805		0.754
1	1	HUT	3	320	DKC63-84	C	T-154	L	C	3506		0.757
1	1	HUT	3	321	88P68	S	T-154	E	RED	2973		0.759
1	1	HUT	3	322	85G03	S	T-154	ML	RED	3333		0.770
1	1	HUT	3	323	86G32	S	T-154	M	RED	3402		0.764
1	1	HUT	3	324	4525	S	T-154	ML	TAN	2856		0.728
1	1	HUT	3	325	SP3303	S	SOUTHWIND	E	TAN	3002		0.661
1	1	HUT	3	326	DKC63-84	C	SOUTHWIND	L	C	3170		0.664
1	1	HUT	3	327	88P68	S	SOUTHWIND	E	RED	3021		0.751
1	1	HUT	3	328	85G03	S	SOUTHWIND	ML	RED	3063		0.744

1	1	HUT	3	329	86G32	S	SOUTHWIND	M	RED	2811		0.745
1	1	HUT	3	330	4525	S	SOUTHWIND	ML	TAN	2083		0.631
1	1	HUT	3	331	SP3303	S	DUSTER	E	TAN	3694		0.774
1	1	HUT	3	332	DKC63-84	C	DUSTER	L	C	3408		0.808
1	1	HUT	3	333	88P68	S	DUSTER	E	RED	3018		0.789
1	1	HUT	3	334	85G03	S	DUSTER	ML	RED	2780		0.772
1	1	HUT	3	335	86G32	S	DUSTER	M	RED	3022		0.755
1	1	HUT	3	336	4525	S	DUSTER	ML	TAN	3121		0.798
1	1	HUT	4	401	86G32	S	BILLINGS	M	RED	3468		0.799
1	1	HUT	4	402	85G03	S	BILLINGS	ML	RED	3484		0.827
1	1	HUT	4	403	4525	S	BILLINGS	ML	TAN	2890		0.763
1	1	HUT	4	404	88P68	S	BILLINGS	E	RED	3565		0.817
1	1	HUT	4	405	DKC63-84	C	BILLINGS	L	C	4165		0.817
1	1	HUT	4	406	SP3303	S	BILLINGS	E	TAN	3384		0.829
1	1	HUT	4	407	86G32	S	FULLER	M	RED	.		0.669
1	1	HUT	4	408	85G03	S	FULLER	ML	RED	2629		0.763
1	1	HUT	4	409	4525	S	FULLER	ML	TAN	2512		0.694
1	1	HUT	4	410	88P68	S	FULLER	E	RED	3010		0.777
1	1	HUT	4	411	DKC63-84	C	FULLER	L	C	3736		0.789
1	1	HUT	4	412	SP3303	S	FULLER	E	TAN	3176		0.801
1	1	HUT	4	413	86G32	S	SOUTHWIND	M	RED	3347		0.661
1	1	HUT	4	414	85G03	S	SOUTHWIND	ML	RED	3089		0.718
1	1	HUT	4	415	4525	S	SOUTHWIND	ML	TAN	2674		0.683
1	1	HUT	4	416	88P68	S	SOUTHWIND	E	RED	2943		0.762
1	1	HUT	4	417	DKC63-84	C	SOUTHWIND	L	C	3899		0.779
1	1	HUT	4	418	SP3303	S	SOUTHWIND	E	TAN	2990		0.704
1	1	HUT	4	419	86G32	S	EVEREST	M	RED	3957		0.759
1	1	HUT	4	420	85G03	S	EVEREST	ML	RED	3644		0.814
1	1	HUT	4	421	4525	S	EVEREST	ML	TAN	3136		0.753
1	1	HUT	4	422	88P68	S	EVEREST	E	RED	3578		0.813
1	1	HUT	4	423	DKC63-84	C	EVEREST	L	C	4111		0.824
1	1	HUT	4	424	SP3303	S	EVEREST	E	TAN	3423		0.809
1	1	HUT	4	425	86G32	S	T-154	M	RED	3274		0.766
1	1	HUT	4	426	85G03	S	T-154	ML	RED	3670		0.777
1	1	HUT	4	427	4525	S	T-154	ML	TAN	3042		0.757

1	1	HUT	4	428	88P68	S	T-154	E	RED	3284		0.812
1	1	HUT	4	429	DKC63-84	C	T-154	L	C	3586		0.778
1	1	HUT	4	430	SP3303	S	T-154	E	TAN	3106		0.747
1	1	HUT	4	431	86G32	S	DUSTER	M	RED	3435		0.812
1	1	HUT	4	432	85G03	S	DUSTER	ML	RED	3256		0.717
1	1	HUT	4	433	4525	S	DUSTER	ML	TAN	2818		0.758
1	1	HUT	4	434	88P68	S	DUSTER	E	RED	3392		0.815
1	1	HUT	4	435	DKC63-84	C	DUSTER	L	C	3842		0.832
1	1	HUT	4	436	SP3303	S	DUSTER	E	TAN	3059		0.764
2	2	HUT	1	101	85G03	S	T-154	ML	RED	1391	0.264	0.231
2	2	HUT	1	102	SP3303	S	T-154	E	TAN	1147	0.240	0.220
2	2	HUT	1	103	4525	S	T-154	ML	TAN	1689	0.255	0.241
2	2	HUT	1	104	DKC63-84	C	T-154	L	C	1850	0.336	0.340
2	2	HUT	1	105	86G32	S	T-154	M	RED	1555	0.241	0.241
2	2	HUT	1	106	88P68	S	T-154	E	RED	1360	0.232	0.245
2	2	HUT	1	107	88P68	S	SOUTHWIND	E	RED	1203	0.258	0.251
2	2	HUT	1	108	86G32	S	SOUTHWIND	M	RED	1442	0.243	0.257
2	2	HUT	1	109	DKC63-84	C	SOUTHWIND	L	C	2205	0.331	0.340
2	2	HUT	1	110	4525	S	SOUTHWIND	ML	TAN	1758	0.252	0.266
2	2	HUT	1	111	SP3303	S	SOUTHWIND	E	TAN	1298	0.245	0.235
2	2	HUT	1	112	85G03	S	SOUTHWIND	ML	RED	2408	0.291	0.298
2	2	HUT	1	113	85G03	S	DUSTER	ML	RED	1521	0.317	0.312
2	2	HUT	1	114	SP3303	S	DUSTER	E	TAN	1730	0.295	0.278
2	2	HUT	1	115	4525	S	DUSTER	ML	TAN	1897	0.293	0.284
2	2	HUT	1	116	DKC63-84	C	DUSTER	L	C	2421	0.394	0.388
2	2	HUT	1	117	86G32	S	DUSTER	M	RED	1682	0.285	0.301
2	2	HUT	1	118	88P68	S	DUSTER	E	RED	1333	0.266	0.272
2	2	HUT	1	119	88P68	S	FULLER	E	RED	739	0.228	0.244
2	2	HUT	1	120	86G32	S	FULLER	M	RED	1781	0.263	0.287
2	2	HUT	1	121	DKC63-84	C	FULLER	L	C	1717	0.355	0.367
2	2	HUT	1	122	4525	S	FULLER	ML	TAN	1657	0.296	0.286
2	2	HUT	1	123	SP3303	S	FULLER	E	TAN	1833	0.281	0.263
2	2	HUT	1	124	85G03	S	FULLER	ML	RED	1970	0.279	0.291
2	2	HUT	1	125	85G03	S	BILLINGS	ML	RED	3290	0.324	0.355
2	2	HUT	1	126	SP3303	S	BILLINGS	E	TAN	1952	0.280	0.267

2	2	HUT	1	127	4525	S	BILLINGS	ML	TAN	2508	0.313	0.367
2	2	HUT	1	128	DKC63-84	C	BILLINGS	L	C	2144	0.351	0.350
2	2	HUT	1	129	86G32	S	BILLINGS	M	RED	1602	0.280	0.313
2	2	HUT	1	130	88P68	S	BILLINGS	E	RED	1331	0.262	0.257
2	2	HUT	1	131	88P68	S	EVEREST	E	RED	848	0.260	0.278
2	2	HUT	1	132	86G32	S	EVEREST	M	RED	1239	0.281	0.284
2	2	HUT	1	133	DKC63-84	C	EVEREST	L	C	1272	0.339	0.363
2	2	HUT	1	134	4525	S	EVEREST	ML	TAN	1281	0.322	0.373
2	2	HUT	1	135	SP3303	S	EVEREST	E	TAN	1023	0.295	0.315
2	2	HUT	1	136	85G03	S	EVEREST	ML	RED	1509	0.315	0.339
2	2	HUT	2	201	86G32	S	T-154	M	RED	1699	0.238	0.226
2	2	HUT	2	202	DKC63-84	C	T-154	L	C	1230	0.284	0.248
2	2	HUT	2	203	88P68	S	T-154	E	RED	1057	0.246	0.215
2	2	HUT	2	204	SP3303	S	T-154	E	TAN	1493	0.319	0.303
2	2	HUT	2	205	4525	S	T-154	ML	TAN	1331	0.264	0.252
2	2	HUT	2	206	85G03	S	T-154	ML	RED	1222	0.231	0.216
2	2	HUT	2	207	85G03	S	SOUTHWIND	ML	RED	1150	0.249	0.242
2	2	HUT	2	208	4525	S	SOUTHWIND	ML	TAN	1147	0.259	0.283
2	2	HUT	2	209	SP3303	S	SOUTHWIND	E	TAN	1393	0.285	0.271
2	2	HUT	2	210	88P68	S	SOUTHWIND	E	RED	1161	0.247	0.219
2	2	HUT	2	211	DKC63-84	C	SOUTHWIND	L	C	1127	0.278	0.247
2	2	HUT	2	212	86G32	S	SOUTHWIND	M	RED	1480	0.254	0.234
2	2	HUT	2	213	86G32	S	BILLINGS	M	RED	2304	0.342	0.378
2	2	HUT	2	214	DKC63-84	C	BILLINGS	L	C	1801	0.327	0.325
2	2	HUT	2	215	88P68	S	BILLINGS	E	RED	1349	0.316	0.314
2	2	HUT	2	216	SP3303	S	BILLINGS	E	TAN	1915	0.372	0.404
2	2	HUT	2	217	4525	S	BILLINGS	ML	TAN	1465	0.327	0.366
2	2	HUT	2	218	85G03	S	BILLINGS	ML	RED	1792	0.282	0.375
2	2	HUT	2	219	85G03	S	EVEREST	ML	RED	962	0.252	0.280
2	2	HUT	2	220	4525	S	EVEREST	ML	TAN	1477	0.252	0.287
2	2	HUT	2	221	SP3303	S	EVEREST	E	TAN	996	0.299	0.314
2	2	HUT	2	222	88P68	S	EVEREST	E	RED	695	0.252	0.249
2	2	HUT	2	223	DKC63-84	C	EVEREST	L	C	1073	0.282	0.306
2	2	HUT	2	224	86G32	S	EVEREST	M	RED	1157	0.241	0.247
2	2	HUT	2	225	86G32	S	DUSTER	M	RED	1870	0.307	0.298

2	2	HUT	2	226	DKC63-84	C	DUSTER	L	C	1566	0.361	0.341
2	2	HUT	2	227	88P68	S	DUSTER	E	RED	1891	0.358	0.333
2	2	HUT	2	228	SP3303	S	DUSTER	E	TAN	1523	0.337	0.368
2	2	HUT	2	229	4525	S	DUSTER	ML	TAN	1641	0.293	0.345
2	2	HUT	2	230	85G03	S	DUSTER	ML	RED	1470	0.317	0.384
2	2	HUT	2	231	85G03	S	FULLER	ML	RED	1589	0.244	0.302
2	2	HUT	2	232	4525	S	FULLER	ML	TAN	1515	0.242	0.248
2	2	HUT	2	233	SP3303	S	FULLER	E	TAN	1333	0.247	0.252
2	2	HUT	2	234	88P68	S	FULLER	E	RED	1442	0.286	0.270
2	2	HUT	2	235	DKC63-84	C	FULLER	L	C	1260	0.376	0.380
2	2	HUT	2	236	86G32	S	FULLER	M	RED	1667	0.247	0.245
2	2	HUT	3	301	4525	S	EVEREST	ML	TAN	1692	0.286	0.313
2	2	HUT	3	302	85G03	S	EVEREST	ML	RED	1653	0.296	0.334
2	2	HUT	3	303	SP3303	S	EVEREST	E	TAN	1520	0.324	0.319
2	2	HUT	3	304	86G32	S	EVEREST	M	RED	1062	0.269	0.258
2	2	HUT	3	305	88P68	S	EVEREST	E	RED	935	0.268	0.270
2	2	HUT	3	306	DKC63-84	C	EVEREST	L	C	1424	0.401	0.391
2	2	HUT	3	307	DKC63-84	C	DUSTER	L	C	2208	0.369	0.380
2	2	HUT	3	308	88P68	S	DUSTER	E	RED	1126	0.262	0.272
2	2	HUT	3	309	86G32	S	DUSTER	M	RED	959	0.222	0.239
2	2	HUT	3	310	SP3303	S	DUSTER	E	TAN	1108	0.270	0.300
2	2	HUT	3	311	85G03	S	DUSTER	ML	RED	835	0.255	0.261
2	2	HUT	3	312	4525	S	DUSTER	ML	TAN	909	0.227	0.265
2	2	HUT	3	313	4525	S	SOUTHWIND	ML	TAN	1160	0.248	0.254
2	2	HUT	3	314	85G03	S	SOUTHWIND	ML	RED	1261	0.285	0.291
2	2	HUT	3	315	SP3303	S	SOUTHWIND	E	TAN	1442	0.305	0.296
2	2	HUT	3	316	86G32	S	SOUTHWIND	M	RED	1160	0.266	0.254
2	2	HUT	3	317	88P68	S	SOUTHWIND	E	RED	1136	0.273	0.251
2	2	HUT	3	318	DKC63-84	C	SOUTHWIND	L	C	1414	0.356	0.346
2	2	HUT	3	319	DKC63-84	C	BILLINGS	L	C	1802	0.389	0.405
2	2	HUT	3	320	88P68	S	BILLINGS	E	RED	1576	0.274	0.295
2	2	HUT	3	321	86G32	S	BILLINGS	M	RED	1257	0.315	0.316
2	2	HUT	3	322	SP3303	S	BILLINGS	E	TAN	1854	0.334	0.346
2	2	HUT	3	323	85G03	S	BILLINGS	ML	RED	1364	0.287	0.333
2	2	HUT	3	324	4525	S	BILLINGS	ML	TAN	1498	0.259	0.295

2	2	HUT	3	325	4525	S	T-154	ML	TAN	1707	0.245	0.285
2	2	HUT	3	326	85G03	S	T-154	ML	RED	1737	0.279	0.306
2	2	HUT	3	327	SP3303	S	T-154	E	TAN	1543	0.296	0.333
2	2	HUT	3	328	86G32	S	T-154	M	RED	1149	0.253	0.257
2	2	HUT	3	329	88P68	S	T-154	E	RED	1163	0.269	0.283
2	2	HUT	3	330	DKC63-84	C	T-154	L	C	2403	0.382	0.396
2	2	HUT	3	331	DKC63-84	C	FULLER	L	C	2235	0.372	0.469
2	2	HUT	3	332	88P68	S	FULLER	E	RED	1125	0.242	0.272
2	2	HUT	3	333	86G32	S	FULLER	M	RED	1457	0.238	0.283
2	2	HUT	3	334	SP3303	S	FULLER	E	TAN	1551	0.269	0.322
2	2	HUT	3	335	85G03	S	FULLER	ML	RED	1141	0.228	0.260
2	2	HUT	3	336	4525	S	FULLER	ML	TAN	1493	0.204	0.250
2	2	HUT	4	401	88P68	S	FULLER	E	RED	.	0.241	0.266
2	2	HUT	4	402	86G32	S	FULLER	M	RED	.	0.226	0.284
2	2	HUT	4	403	85G03	S	FULLER	ML	RED	.	0.265	0.329
2	2	HUT	4	404	4525	S	FULLER	ML	TAN	.	0.289	0.307
2	2	HUT	4	405	DKC63-84	C	FULLER	L	C	.	0.414	0.435
2	2	HUT	4	406	SP3303	S	FULLER	E	TAN	.	0.323	0.418
2	2	HUT	4	407	SP3303	S	EVEREST	E	TAN	.	0.314	0.357
2	2	HUT	4	408	DKC63-84	C	EVEREST	L	C	.	0.384	0.412
2	2	HUT	4	409	4525	S	EVEREST	ML	TAN	.	0.262	0.284
2	2	HUT	4	410	85G03	S	EVEREST	ML	RED	.	0.276	0.348
2	2	HUT	4	411	86G32	S	EVEREST	M	RED	.	0.244	0.273
2	2	HUT	4	412	88P68	S	EVEREST	E	RED	.	0.235	0.256
2	2	HUT	4	413	88P68	S	BILLINGS	E	RED	.	0.232	0.255
2	2	HUT	4	414	86G32	S	BILLINGS	M	RED	.	0.236	0.295
2	2	HUT	4	415	85G03	S	BILLINGS	ML	RED	.	0.311	0.360
2	2	HUT	4	416	4525	S	BILLINGS	ML	TAN	.	0.266	0.296
2	2	HUT	4	417	DKC63-84	C	BILLINGS	L	C	.	0.436	0.487
2	2	HUT	4	418	SP3303	S	BILLINGS	E	TAN	.	0.326	0.373
2	2	HUT	4	419	SP3303	S	T-154	E	TAN	.	0.306	0.328
2	2	HUT	4	420	DKC63-84	C	T-154	L	C	.	0.377	0.387
2	2	HUT	4	421	4525	S	T-154	ML	TAN	.	0.280	0.290
2	2	HUT	4	422	85G03	S	T-154	ML	RED	.	0.281	0.312
2	2	HUT	4	423	86G32	S	T-154	M	RED	.	0.255	0.269

2	2	HUT	4	424	88P68	S	T-154	E	RED	.	0.233	0.232
2	2	HUT	4	425	88P68	S	DUSTER	E	RED	.	0.270	0.299
2	2	HUT	4	426	86G32	S	DUSTER	M	RED	.	0.295	0.348
2	2	HUT	4	427	85G03	S	DUSTER	ML	RED	.	0.296	0.350
2	2	HUT	4	428	4525	S	DUSTER	ML	TAN	.	0.315	0.370
2	2	HUT	4	429	DKC63-84	C	DUSTER	L	C	.	0.437	0.439
2	2	HUT	4	430	SP3303	S	DUSTER	E	TAN	.	0.321	0.351
2	2	HUT	4	431	SP3303	S	SOUTHWIND	E	TAN	.	0.349	0.382
2	2	HUT	4	432	DKC63-84	C	SOUTHWIND	L	C	.	0.376	0.395
2	2	HUT	4	433	4525	S	SOUTHWIND	ML	TAN	.	0.294	0.367
2	2	HUT	4	434	85G03	S	SOUTHWIND	ML	RED	.	0.326	0.392
2	2	HUT	4	435	86G32	S	SOUTHWIND	M	RED	.	0.292	0.346
2	2	HUT	4	436	88P68	S	SOUTHWIND	E	RED	.	0.255	0.286
1	3	MAN	1	101	SP3303	S	FULLER	E	TAN	4901		0.844
1	3	MAN	1	102	86G32	S	FULLER	M	RED	4327		0.803
1	3	MAN	1	103	88P68	S	FULLER	E	RED	5236		0.899
1	3	MAN	1	104	DKC63-84	C	FULLER	L	C	5315		0.885
1	3	MAN	1	105	85G03	S	FULLER	ML	RED	4605		0.826
1	3	MAN	1	106	4525	S	FULLER	ML	TAN	4069		0.747
1	3	MAN	1	107	SP3303	S	BILLINGS	E	TAN	4640		0.844
1	3	MAN	1	108	86G32	S	BILLINGS	M	RED	4532		0.812
1	3	MAN	1	109	88P68	S	BILLINGS	S	RED	4486		0.914
1	3	MAN	1	110	DKC63-84	C	BILLINGS	L	C	4523		0.885
1	3	MAN	1	111	85G03	S	BILLINGS	ML	RED	4522		0.840
1	3	MAN	1	112	4525	S	BILLINGS	ML	TAN	3730		0.809
1	3	MAN	1	113	SP3303	S	T-154	E	TAN	.		.
1	3	MAN	1	114	86G32	S	T-154	M	RED	.		.
1	3	MAN	1	115	88P68	S	T-154	E	RED	.		.
1	3	MAN	1	116	DKC63-84	C	T-154	L	C	.		.
1	3	MAN	1	117	85G03	S	T-154	ML	RED	.		.
1	3	MAN	1	118	4525	S	T-154	ML	TAN	.		.
1	3	MAN	1	119	SP3303	S	EVEREST	E	TAN	4872		0.832
1	3	MAN	1	120	86G32	S	EVEREST	M	RED	4814		0.806
1	3	MAN	1	121	88P68	S	EVEREST	E	RED	4625		0.845
1	3	MAN	1	122	DKC63-84	C	EVEREST	L	C	5335		0.841

1	3	MAN	1	123	85G03	S	EVEREST	ML	RED	4812		0.792
1	3	MAN	1	124	4525	S	EVEREST	ML	TAN	3948		0.764
1	3	MAN	1	125	SP3303	S	DUSTER	E	TAN	5010		0.814
1	3	MAN	1	126	86G32	S	DUSTER	M	RED	4703		0.815
1	3	MAN	1	127	88P68	S	DUSTER	S	RED	4130		0.858
1	3	MAN	1	128	DKC63-84	C	DUSTER	L	C	4708		0.832
1	3	MAN	1	129	85G03	S	DUSTER	ML	RED	4594		0.805
1	3	MAN	1	130	4525	S	DUSTER	ML	TAN	3947		0.753
1	3	MAN	1	131	SP3303	S	SOUTHWIND	S	TAN	5170		0.838
1	3	MAN	1	132	86G32	S	SOUTHWIND	M	RED	5121		0.820
1	3	MAN	1	133	88P68	S	SOUTHWIND	E	RED	4742		0.864
1	3	MAN	1	134	DKC63-84	C	SOUTHWIND	L	C	4950		0.834
1	3	MAN	1	135	85G03	S	SOUTHWIND	ML	RED	4596		0.784
1	3	MAN	1	136	4525	S	SOUTHWIND	ML	TAN	3999		0.763
1	3	MAN	2	201	SP3303	S	SOUTHWIND	E	TAN	4877		0.830
1	3	MAN	2	202	DKC63-84	C	SOUTHWIND	L	C	4724		0.792
1	3	MAN	2	203	4525	S	SOUTHWIND	ML	TAN	4479		0.763
1	3	MAN	2	204	85G03	S	SOUTHWIND	ML	RED	4568		0.787
1	3	MAN	2	205	88P68	S	SOUTHWIND	E	RED	4191		0.813
1	3	MAN	2	206	86G32	S	SOUTHWIND	M	RED	3659		0.780
1	3	MAN	2	207	SP3303	S	FULLER	E	TAN	4581		0.796
1	3	MAN	2	208	DKC63-84	C	FULLER	L	C	4534		0.789
1	3	MAN	2	209	4525	S	FULLER	ML	TAN	4661		0.771
1	3	MAN	2	210	85G03	S	FULLER	ML	RED	5025		0.800
1	3	MAN	2	211	88P68	S	FULLER	E	RED	5267		0.831
1	3	MAN	2	212	86G32	S	FULLER	M	RED	4572		0.759
1	3	MAN	2	213	SP3303	S	DUSTER	E	TAN	4449		0.806
1	3	MAN	2	214	DKC63-84	C	DUSTER	L	C	4238		0.823
1	3	MAN	2	215	4525	S	DUSTER	ML	TAN	3896		0.817
1	3	MAN	2	216	85G03	S	DUSTER	ML	RED	3496		0.810
1	3	MAN	2	217	88P68	S	DUSTER	E	RED	3023		0.829
1	3	MAN	2	218	86G32	S	DUSTER	M	RED	2748		0.758
1	3	MAN	2	219	SP3303	S	BILLINGS	E	TAN	4364		0.798
1	3	MAN	2	220	DKC63-84	C	BILLINGS	L	C	4590		0.821
1	3	MAN	2	221	4525	S	BILLINGS	ML	TAN	4238		0.806

1	3	MAN	2	222	85G03	S	BILLINGS	ML	RED	4069		0.813
1	3	MAN	2	223	88P68	S	BILLINGS	E	RED	3547		0.827
1	3	MAN	2	224	86G32	S	BILLINGS	M	RED	3443		0.817
1	3	MAN	2	225	SP3303	S	EVEREST	E	TAN	5051		0.814
1	3	MAN	2	226	DKC63-84	C	EVEREST	L	C	4529		0.825
1	3	MAN	2	227	4525	S	EVEREST	ML	TAN	4336		0.785
1	3	MAN	2	228	85G03	S	EVEREST	ML	RED	4364		0.802
1	3	MAN	2	229	88P68	S	EVEREST	E	RED	3928		0.837
1	3	MAN	2	230	86G32	S	EVEREST	M	RED	4308		0.817
1	3	MAN	2	231	SP3303	S	T-154	E	TAN	4853		0.802
1	3	MAN	2	232	DKC63-84	C	T-154	L	C	4763		0.830
1	3	MAN	2	233	4525	S	T-154	ML	TAN	4224		0.804
1	3	MAN	2	234	85G03	S	T-154	ML	RED	3861		0.708
1	3	MAN	2	235	88P68	S	T-154	E	RED	3257		0.619
1	3	MAN	2	236	86G32	S	T-154	M	RED	3593		0.676
1	3	MAN	3	301	88P68	S	T-154	E	RED	4022		0.696
1	3	MAN	3	302	85G03	S	T-154	ML	RED	4426		0.753
1	3	MAN	3	303	86G32	S	T-154	M	RED	4200		0.821
1	3	MAN	3	304	DKC63-84	C	T-154	L	C	4346		0.824
1	3	MAN	3	305	SP3303	S	T-154	E	TAN	4111		0.802
1	3	MAN	3	306	4525	S	T-154	ML	TAN	4930		0.776
1	3	MAN	3	307	88P68	S	DUSTER	E	RED	1040		0.449
1	3	MAN	3	308	85G03	S	DUSTER	ML	RED	2275		0.745
1	3	MAN	3	309	86G32	S	DUSTER	M	RED	1323		0.502
1	3	MAN	3	310	DKC63-84	C	DUSTER	L	C	1841		0.576
1	3	MAN	3	311	SP3303	S	DUSTER	S	TAN	2317		0.723
1	3	MAN	3	312	4525	S	DUSTER	ML	TAN	3036		0.719
1	3	MAN	3	313	88P68	S	BILLINGS	E	RED	359		0.373
1	3	MAN	3	314	85G03	S	BILLINGS	ML	RED	1164		0.572
1	3	MAN	3	315	86G32	S	BILLINGS	M	RED	995		0.562
1	3	MAN	3	316	DKC63-84	C	BILLINGS	L	C	2482		0.754
1	3	MAN	3	317	SP3303	S	BILLINGS	E	TAN	1959		0.598
1	3	MAN	3	318	4525	S	BILLINGS	ML	TAN	3006		0.668
1	3	MAN	3	319	88P68	S	FULLER	E	RED	4431		0.786
1	3	MAN	3	320	85G03	S	FULLER	ML	RED	4059		0.750

1	3	MAN	3	321	86G32	S	FULLER	M	RED	4347		0.801
1	3	MAN	3	322	DKC63-84	C	FULLER	L	C	4007		0.827
1	3	MAN	3	323	SP3303	S	FULLER	E	TAN	4516		0.791
1	3	MAN	3	324	4525	S	FULLER	ML	TAN	4403		0.692
1	3	MAN	3	325	88P68	S	SOUTHWIND	L	RED	1954		0.645
1	3	MAN	3	326	85G03	S	SOUTHWIND	ML	RED	1783		0.776
1	3	MAN	3	327	86G32	S	SOUTHWIND	M	RED	2773		0.710
1	3	MAN	3	328	DKC63-84	C	SOUTHWIND	L	C	2952		0.723
1	3	MAN	3	329	SP3303	S	SOUTHWIND	E	TAN	2631		0.721
1	3	MAN	3	330	4525	S	SOUTHWIND	ML	TAN	3571		0.761
1	3	MAN	3	331	88P68	S	EVEREST	E	RED	4327		0.809
1	3	MAN	3	332	85G03	S	EVEREST	ML	RED	4337		0.812
1	3	MAN	3	333	86G32	S	EVEREST	M	RED	4331		0.798
1	3	MAN	3	334	DKC63-84	C	EVEREST	L	C	4488		0.826
1	3	MAN	3	335	SP3303	S	EVEREST	E	TAN	4036		0.808
1	3	MAN	3	336	4525	S	EVEREST	ML	TAN	4729		0.796
1	3	MAN	4	401	85G03	S	BILLINGS	ML	RED	.		.
1	3	MAN	4	402	DKC63-84	C	BILLINGS	L	C	.		.
1	3	MAN	4	403	SP3303	S	BILLINGS	E	TAN	.		.
1	3	MAN	4	404	88P68	S	T-154	E	RED	4483		0.815
1	3	MAN	4	405	86G32	S	SOUTHWIND	M	RED	3496		0.708
1	3	MAN	4	406	4525	S	FULLER	ML	TAN	3943		0.777
1	3	MAN	4	407	85G03	S	FULLER	ML	RED	3577		0.761
1	3	MAN	4	408	DKC63-84	C	FULLER	L	C	3666		0.838
1	3	MAN	4	409	SP3303	S	FULLER	E	TAN	4045		0.810
1	3	MAN	4	410	88P68	S	DUSTER	E	RED	2641		0.755
1	3	MAN	4	411	86G32	S	FULLER	M	RED	4106		0.721
1	3	MAN	4	412	4525	S	BILLINGS	ML	TAN	3583		0.844
1	3	MAN	4	413	85G03	S	SOUTHWIND	ML	RED	3240		0.766
1	3	MAN	4	414	DKC63-84	C	SOUTHWIND	L	C	2219		0.749
1	3	MAN	4	415	SP3303	S	SOUTHWIND	E	TAN	1350		0.520
1	3	MAN	4	416	88P68	S	BILLINGS	E	RED	3149		0.799
1	3	MAN	4	417	86G32	S	DUSTER	M	RED	2136		0.779
1	3	MAN	4	418	4525	S	T-154	ML	TAN	.		0.632
1	3	MAN	4	419	85G03	S	T-154	ML	RED	3359		0.744

1	3	MAN	4	420	DKC63-84	C	T-154	L	C	4404		0.833
1	3	MAN	4	421	SP3303	S	T-154	E	TAN	4365		0.763
1	3	MAN	4	422	88P68	S	FULLER	E	RED	4097		0.800
1	3	MAN	4	423	86G32	S	BILLINGS	M	RED	3078		0.751
1	3	MAN	4	424	4525	S	EVEREST	ML	TAN	4559		0.793
1	3	MAN	4	425	85G03	S	EVEREST	ML	RED	3763		0.708
1	3	MAN	4	426	DKC63-84	C	EVEREST	L	C	4102		0.805
1	3	MAN	4	427	SP3303	S	EVEREST	E	TAN	3506		0.708
1	3	MAN	4	428	88P68	S	SOUTHWIND	E	RED	3025		0.813
1	3	MAN	4	429	86G32	S	EVEREST	M	RED	3980		0.793
1	3	MAN	4	430	4525	S	DUSTER	ML	TAN	3905		0.798
1	3	MAN	4	431	85G03	S	DUSTER	ML	RED	2025		0.704
1	3	MAN	4	432	DKC63-84	C	DUSTER	L	C	1865		0.674
1	3	MAN	4	433	SP3303	S	DUSTER	E	TAN	896		0.367
1	3	MAN	4	434	88P68	S	EVEREST	E	RED	3712		0.834
1	3	MAN	4	435	86G32	S	T-154	M	RED	2639		0.575
1	3	MAN	4	436	4525	S	SOUTHWIND	ML	TAN	3998		0.737
2	4	MAN	1	101	85G03	S	EVEREST	ML	RED	2514	0.392	0.653
2	4	MAN	1	102	4525	S	EVEREST	ML	TAN	3301	0.492	0.669
2	4	MAN	1	103	SP3303	S	EVEREST	E	TAN	3234	0.381	0.666
2	4	MAN	1	104	86G32	S	EVEREST	M	RED	3164	0.477	0.662
2	4	MAN	1	105	88P68	S	EVEREST	E	RED	3078	0.430	0.659
2	4	MAN	1	106	DKC63-84	C	EVEREST	L	C	2776	0.396	0.605
2	4	MAN	1	107	DKC63-84	C	DUSTER	L	C	1238	0.295	0.520
2	4	MAN	1	108	88P68	S	DUSTER	E	RED	1207	0.267	0.536
2	4	MAN	1	109	86G32	S	DUSTER	M	RED	1453	0.296	0.615
2	4	MAN	1	110	SP3303	S	DUSTER	E	TAN	1219	0.217	0.513
2	4	MAN	1	111	4525	S	DUSTER	ML	TAN	1377	0.197	0.489
2	4	MAN	1	112	85G03	S	DUSTER	ML	RED	1185	0.203	0.445
2	4	MAN	1	113	85G03	S	T-154	ML	RED	2133	0.261	0.497
2	4	MAN	1	114	4525	S	T-154	ML	TAN	1907	0.218	0.465
2	4	MAN	1	115	SP3303	S	T-154	E	TAN	1193	0.237	0.487
2	4	MAN	1	116	86G32	S	T-154	M	RED	2025	0.267	0.492
2	4	MAN	1	117	88P68	S	T-154	E	RED	1740	0.311	0.585
2	4	MAN	1	118	DKC63-84	C	T-154	L	C	1574	0.274	0.517

2	4	MAN	1	119	DKC63-84	C	SOUTHWIND	L	C	1689	0.288	0.556
2	4	MAN	1	120	88P68	S	SOUTHWIND	E	RED	1625	0.266	0.517
2	4	MAN	1	121	86G32	S	SOUTHWIND	M	RED	2341	0.243	0.465
2	4	MAN	1	122	SP3303	S	SOUTHWIND	E	TAN	2240	0.215	0.518
2	4	MAN	1	123	4525	S	SOUTHWIND	ML	TAN	2800	0.241	0.508
2	4	MAN	1	124	85G03	S	SOUTHWIND	ML	RED	2683	0.247	0.456
2	4	MAN	1	125	85G03	S	FULLER	ML	RED	1725	0.198	0.433
2	4	MAN	1	126	4525	S	FULLER	ML	TAN	1724	0.199	0.475
2	4	MAN	1	127	SP3303	S	FULLER	E	TAN	1372	0.186	0.450
2	4	MAN	1	128	86G32	S	FULLER	M	RED	1442	0.220	0.507
2	4	MAN	1	129	88P68	S	FULLER	E	RED	1212	0.259	0.624
2	4	MAN	1	130	DKC63-84	C	FULLER	L	C	963	0.246	0.510
2	4	MAN	1	131	DKC63-84	C	BILLINGS	L	C	1622	0.277	0.535
2	4	MAN	1	132	88P68	S	BILLINGS	E	RED	1625	0.326	0.639
2	4	MAN	1	133	86G32	S	BILLINGS	M	RED	537	0.217	0.453
2	4	MAN	1	134	SP3303	S	BILLINGS	E	TAN	363	0.189	0.395
2	4	MAN	1	135	4525	S	BILLINGS	ML	TAN	269	0.178	0.375
2	4	MAN	1	136	85G03	S	BILLINGS	ML	RED	904	0.221	0.507
2	4	MAN	2	201	88P68	S	FULLER	E	RED	1066	0.241	0.472
2	4	MAN	2	202	86G32	S	FULLER	M	RED	993	0.265	0.521
2	4	MAN	2	203	DKC63-84	C	FULLER	L	C	1217	0.262	0.565
2	4	MAN	2	204	4525	S	FULLER	ML	TAN	1820	0.179	0.489
2	4	MAN	2	205	SP3303	S	FULLER	E	TAN	1923	0.197	0.583
2	4	MAN	2	206	85G03	S	FULLER	ML	RED	2127	0.214	0.414
2	4	MAN	2	207	85G03	S	T-154	ML	RED	2338	0.297	0.452
2	4	MAN	2	208	SP3303	S	T-154	E	TAN	2479	0.229	0.492
2	4	MAN	2	209	4525	S	T-154	ML	TAN	2121	0.217	0.510
2	4	MAN	2	210	DKC63-84	C	T-154	L	C	1620	0.252	0.531
2	4	MAN	2	211	86G32	S	T-154	M	RED	1773	0.271	0.490
2	4	MAN	2	212	88P68	S	T-154	E	RED	1672	0.265	0.479
2	4	MAN	2	213	88P68	S	SOUTHWIND	E	RED	1584	0.238	0.483
2	4	MAN	2	214	86G32	S	SOUTHWIND	M	RED	2262	0.281	0.444
2	4	MAN	2	215	DKC63-84	C	SOUTHWIND	L	C	1635	0.311	0.510
2	4	MAN	2	216	4525	S	SOUTHWIND	ML	TAN	2420	0.246	0.405
2	4	MAN	2	217	SP3303	S	SOUTHWIND	E	TAN	2481	0.361	0.448

2	4	MAN	2	218	85G03	S	SOUTHWIND	ML	RED	2713	0.329	0.441
2	4	MAN	2	219	85G03	S	DUSTER	ML	RED	2037	0.270	0.494
2	4	MAN	2	220	SP3303	S	DUSTER	E	TAN	1746	0.220	0.471
2	4	MAN	2	221	4525	S	DUSTER	ML	TAN	1562	0.192	0.463
2	4	MAN	2	222	DKC63-84	C	DUSTER	L	C	1323	0.284	0.553
2	4	MAN	2	223	86G32	S	DUSTER	M	RED	1242	0.287	0.528
2	4	MAN	2	224	88P68	S	DUSTER	E	RED	1674	0.270	0.500
2	4	MAN	2	225	88P68	S	EVEREST	E	RED	2385	0.446	0.643
2	4	MAN	2	226	86G32	S	EVEREST	M	RED	2910	0.392	0.634
2	4	MAN	2	227	DKC63-84	C	EVEREST	L	C	2443	0.371	0.589
2	4	MAN	2	228	4525	S	EVEREST	ML	TAN	2860	0.366	0.572
2	4	MAN	2	229	SP3303	S	EVEREST	E	TAN	2681	0.336	0.562
2	4	MAN	2	230	85G03	S	EVEREST	ML	RED	2552	0.433	0.541
2	4	MAN	2	231	85G03	S	BILLINGS	ML	RED	1651	0.330	0.619
2	4	MAN	2	232	SP3303	S	BILLINGS	E	TAN	1225	0.216	0.562
2	4	MAN	2	233	4525	S	BILLINGS	ML	TAN	1171	0.244	0.482
2	4	MAN	2	234	DKC63-84	C	BILLINGS	L	C	1180	0.277	0.586
2	4	MAN	2	235	86G32	S	BILLINGS	M	RED	1041	0.312	0.616
2	4	MAN	2	236	88P68	S	BILLINGS	E	RED	1317	0.260	0.534
2	4	MAN	3	301	SP3303	S	T-154	E	TAN	2649	0.289	0.510
2	4	MAN	3	302	85G03	S	T-154	ML	RED	3061	0.394	0.575
2	4	MAN	3	303	4525	S	T-154	ML	TAN	2136	0.279	0.536
2	4	MAN	3	304	88P68	S	T-154	E	RED	2974	0.352	0.566
2	4	MAN	3	305	DKC63-84	C	T-154	L	C	2661	0.334	0.523
2	4	MAN	3	306	86G32	S	T-154	M	RED	2425	0.336	0.476
2	4	MAN	3	307	86G32	S	DUSTER	M	RED	1646	0.231	0.499
2	4	MAN	3	308	DKC63-84	C	DUSTER	L	C	1980	0.271	0.516
2	4	MAN	3	309	88P68	S	DUSTER	E	RED	2122	0.367	0.572
2	4	MAN	3	310	4525	S	DUSTER	ML	TAN	2166	0.322	0.529
2	4	MAN	3	311	85G03	S	DUSTER	ML	RED	2373	0.441	0.549
2	4	MAN	3	312	SP3303	S	DUSTER	E	TAN	2505	0.421	0.602
2	4	MAN	3	313	SP3303	S	FULLER	E	TAN	2145	0.250	0.533
2	4	MAN	3	314	85G03	S	FULLER	ML	RED	2658	0.386	0.549
2	4	MAN	3	315	4525	S	FULLER	ML	TAN	2522	0.299	0.532
2	4	MAN	3	316	88P68	S	FULLER	E	RED	2555	0.262	0.437

2	4	MAN	3	317	DKC63-84	C	FULLER	L	C	2151	0.251	0.523
2	4	MAN	3	318	86G32	S	FULLER	M	RED	2310	0.268	0.542
2	4	MAN	3	319	86G32	S	BILLINGS	M	RED	2103	0.271	0.490
2	4	MAN	3	320	DKC63-84	C	BILLINGS	L	C	2399	0.257	0.513
2	4	MAN	3	321	88P68	S	BILLINGS	E	RED	2508	0.293	0.561
2	4	MAN	3	322	4525	S	BILLINGS	ML	TAN	2663	0.317	0.562
2	4	MAN	3	323	85G03	S	BILLINGS	ML	RED	2955	0.468	0.572
2	4	MAN	3	324	SP3303	S	BILLINGS	E	TAN	2472	0.287	0.559
2	4	MAN	3	325	SP3303	S	EVEREST	E	TAN	2620	0.351	0.607
2	4	MAN	3	326	85G03	S	EVEREST	ML	RED	3085	0.475	0.640
2	4	MAN	3	327	4525	S	EVEREST	ML	TAN	2805	0.417	0.627
2	4	MAN	3	328	88P68	S	EVEREST	E	RED	2918	0.427	0.572
2	4	MAN	3	329	DKC63-84	C	EVEREST	L	C	2785	0.381	0.616
2	4	MAN	3	330	86G32	S	EVEREST	M	RED	2916	0.411	0.621
2	4	MAN	3	331	86G32	S	SOUTHWIND	M	RED	2617	0.342	0.494
2	4	MAN	3	332	DKC63-84	C	SOUTHWIND	L	C	2528	0.394	0.521
2	4	MAN	3	333	88P68	S	SOUTHWIND	E	RED	2693	0.355	0.543
2	4	MAN	3	334	4525	S	SOUTHWIND	ML	TAN	2874	0.319	0.497
2	4	MAN	3	335	85G03	S	SOUTHWIND	ML	RED	2714	0.440	0.558
2	4	MAN	3	336	SP3303	S	SOUTHWIND	E	TAN	2578	0.336	0.589
2	4	MAN	4	401	DKC63-84	C	FULLER	L	C	2469	0.322	0.616
2	4	MAN	4	402	88P68	S	FULLER	E	RED	2859	0.421	0.630
2	4	MAN	4	403	85G03	S	FULLER	ML	RED	2909	0.334	0.594
2	4	MAN	4	404	SP3303	S	FULLER	E	TAN	2770	0.314	0.586
2	4	MAN	4	405	86G32	S	FULLER	M	RED	2590	0.296	0.564
2	4	MAN	4	406	4525	S	FULLER	ML	TAN	2767	0.321	0.576
2	4	MAN	4	407	4525	S	DUSTER	ML	TAN	2528	0.453	0.533
2	4	MAN	4	408	86G32	S	DUSTER	M	RED	2239	0.435	0.584
2	4	MAN	4	409	SP3303	S	DUSTER	E	TAN	2461	0.384	0.554
2	4	MAN	4	410	85G03	S	DUSTER	ML	RED	2540	0.429	0.601
2	4	MAN	4	411	88P68	S	DUSTER	E	RED	2900	0.523	0.654
2	4	MAN	4	412	DKC63-84	C	DUSTER	L	C	2302	0.416	0.585
2	4	MAN	4	413	DKC63-84	C	BILLINGS	L	C	1705	0.350	0.655
2	4	MAN	4	414	88P68	S	BILLINGS	E	RED	2740	0.456	0.718
2	4	MAN	4	415	85G03	S	BILLINGS	ML	RED	2602	0.382	0.653

2	4	MAN	4	416	SP3303	S	BILLINGS	E	TAN	2089	0.323	0.515
2	4	MAN	4	417	86G32	S	BILLINGS	M	RED	2253	0.386	0.585
2	4	MAN	4	418	4525	S	BILLINGS	ML	TAN	1856	0.379	0.605
2	4	MAN	4	419	4525	S	EVEREST	ML	TAN	2155	0.455	0.558
2	4	MAN	4	420	86G32	S	EVEREST	M	RED	2216	0.451	0.570
2	4	MAN	4	421	SP3303	S	EVEREST	E	TAN	2263	0.378	0.546
2	4	MAN	4	422	85G03	S	EVEREST	ML	RED	2673	0.409	0.565
2	4	MAN	4	423	88P68	S	EVEREST	E	RED	2797	0.483	0.655
2	4	MAN	4	424	DKC63-84	C	EVEREST	L	C	2018	0.477	0.632
2	4	MAN	4	425	DKC63-84	C	T-154	L	C	2148	0.381	0.561
2	4	MAN	4	426	88P68	S	T-154	E	RED	2537	0.448	0.589
2	4	MAN	4	427	85G03	S	T-154	ML	RED	2531	0.371	0.531
2	4	MAN	4	428	SP3303	S	T-154	E	TAN	2016	0.284	0.489
2	4	MAN	4	429	86G32	S	T-154	M	RED	2587	0.372	0.569
2	4	MAN	4	430	4525	S	T-154	ML	TAN	2016	0.329	0.484
2	4	MAN	4	431	4525	S	SOUTHWIND	ML	TAN	2308	0.381	0.554
2	4	MAN	4	432	86G32	S	SOUTHWIND	M	RED	2390	0.360	0.593
2	4	MAN	4	433	SP3303	S	SOUTHWIND	E	TAN	2171	0.277	0.589
2	4	MAN	4	434	85G03	S	SOUTHWIND	ML	RED	2192	0.354	0.561
2	4	MAN	4	435	88P68	S	SOUTHWIND	E	RED	2534	0.398	0.594
2	4	MAN	4	436	DKC63-84	C	SOUTHWIND	L	C	2511	0.352	0.583

Table C.3 Winter wheat spike number, kernel number head^{-1}, and kernel weight data.

YR	ENV	LOC	BLOC	PLOT	HYBRID	CROP	CULTIVAR	MAT-URITY	PIG-MENT	SPIKES	KERNELS HEAD^{-1}	KERNEL WEIGHT
										m^{-2}		g 1000 seeds^{-1}
1	1	HUT	1	101	4525	S	SOUTHWIND	ML	TAN	520	19.68	21.12
1	1	HUT	1	102	86G32	S	SOUTHWIND	M	RED	500	27.64	18.69
1	1	HUT	1	103	88P68	S	SOUTHWIND	E	RED	626	19.36	20.52
1	1	HUT	1	104	DKC63-84	C	SOUTHWIND	L	C	516	.	.
1	1	HUT	1	105	SP3303	S	SOUTHWIND	E	TAN	378	43.8	23.48
1	1	HUT	1	106	85G03	S	SOUTHWIND	ML	RED	484	30.74	26.02
1	1	HUT	1	107	4525	S	DUSTER	ML	TAN	594	23.36	23.39
1	1	HUT	1	108	86G32	S	DUSTER	M	RED	713	25.78	18.94
1	1	HUT	1	109	88P68	S	DUSTER	E	RED	665	16.06	24.96
1	1	HUT	1	110	DKC63-84	C	DUSTER	L	C	650	19.38	25.11
1	1	HUT	1	111	SP3303	S	DUSTER	E	TAN	484	21.32	25.46
1	1	HUT	1	112	85G03	S	DUSTER	ML	RED	539	24.28	21.45
1	1	HUT	1	113	4525	S	BILLINGS	ML	TAN	535	21.06	26.70
1	1	HUT	1	114	86G32	S	BILLINGS	M	RED	346	26.68	28.69
1	1	HUT	1	115	88P68	S	BILLINGS	E	RED	531	27.26	24.48
1	1	HUT	1	116	DKC63-84	C	BILLINGS	L	C	484	26.56	28.44
1	1	HUT	1	117	SP3303	S	BILLINGS	E	TAN	492	16.72	27.56
1	1	HUT	1	118	85G03	S	BILLINGS	ML	RED	327	29.66	22.10
1	1	HUT	1	119	4525	S	FULLER	ML	TAN	441	21.66	26.31
1	1	HUT	1	120	86G32	S	FULLER	M	RED	500	19.1	24.62
1	1	HUT	1	121	88P68	S	FULLER	E	RED	409	26.52	23.54
1	1	HUT	1	122	DKC63-84	C	FULLER	L	C	472	21.28	26.71
1	1	HUT	1	123	SP3303	S	FULLER	E	TAN	488	24.86	26.72
1	1	HUT	1	124	85G03	S	FULLER	ML	RED	500	19.7	22.03
1	1	HUT	1	125	4525	S	EVEREST	ML	TAN	441	25.16	25.24
1	1	HUT	1	126	86G32	S	EVEREST	M	RED	555	24.32	20.30
1	1	HUT	1	127	88P68	S	EVEREST	E	RED	626	24.14	23.87
1	1	HUT	1	128	DKC63-84	C	EVEREST	L	C	622	22.18	25.88
1	1	HUT	1	129	SP3303	S	EVEREST	E	TAN	622	20.46	25.28

1	1	HUT	1	130	85G03	S	EVEREST	ML	RED	642	26.82	21.41
1	1	HUT	1	131	4525	S	T-154	ML	TAN	646	18.16	23.03
1	1	HUT	1	132	86G32	S	T-154	M	RED	492	23.5	22.11
1	1	HUT	1	133	88P68	S	T-154	E	RED	799	22.54	21.56
1	1	HUT	1	134	DKC63-84	C	T-154	L	C	630	18.3	24.46
1	1	HUT	1	135	SP3303	S	T-154	E	TAN	551	15.96	25.11
1	1	HUT	1	136	85G03	S	T-154	ML	RED	398	22.38	21.05
1	1	HUT	2	201	85G03	S	BILLINGS	ML	RED	382	24.86	30.13
1	1	HUT	2	202	86G32	S	BILLINGS	M	RED	421	32.56	24.10
1	1	HUT	2	203	88P68	S	BILLINGS	E	RED	433	29.18	27.42
1	1	HUT	2	204	SP3303	S	BILLINGS	E	TAN	429	16.38	25.31
1	1	HUT	2	205	DKC63-84	C	BILLINGS	L	C	409	25.98	26.87
1	1	HUT	2	206	4525	S	BILLINGS	ML	TAN	449	25.66	26.64
1	1	HUT	2	207	85G03	S	FULLER	ML	RED	622	24.8	26.14
1	1	HUT	2	208	86G32	S	FULLER	M	RED	543	22.16	24.06
1	1	HUT	2	209	88P68	S	FULLER	E	RED	500	12.5	24.43
1	1	HUT	2	210	SP3303	S	FULLER	E	TAN	504	28.82	21.92
1	1	HUT	2	211	DKC63-84	C	FULLER	L	C	539	31.32	21.93
1	1	HUT	2	212	4525	S	FULLER	ML	TAN	500	26.16	21.63
1	1	HUT	2	213	85G03	S	EVEREST	ML	RED	610	24.62	26.80
1	1	HUT	2	214	86G32	S	EVEREST	M	RED	563	23.8	24.34
1	1	HUT	2	215	88P68	S	EVEREST	E	RED	646	20.64	25.65
1	1	HUT	2	216	SP3303	S	EVEREST	E	TAN	870	23	20.42
1	1	HUT	2	217	DKC63-84	C	EVEREST	L	C	705	21.86	26.02
1	1	HUT	2	218	4525	S	EVEREST	ML	TAN	488	20.22	26.63
1	1	HUT	2	219	85G03	S	T-154	ML	RED	776	14.28	26.26
1	1	HUT	2	220	86G32	S	T-154	M	RED	740	28.6	18.98
1	1	HUT	2	221	88P68	S	T-154	E	RED	787	11.94	22.58
1	1	HUT	2	222	SP3303	S	T-154	E	TAN	685	21.96	23.43
1	1	HUT	2	223	DKC63-84	C	T-154	L	C	681	27.58	20.65
1	1	HUT	2	224	4525	S	T-154	ML	TAN	657	25.28	20.42
1	1	HUT	2	225	85G03	S	DUSTER	ML	RED	630	24.62	23.23
1	1	HUT	2	226	86G32	S	DUSTER	M	RED	780	24.1	18.78
1	1	HUT	2	227	88P68	S	DUSTER	E	RED	709	22.62	21.96
1	1	HUT	2	228	SP3303	S	DUSTER	E	TAN	827	11.48	21.17

1	1	HUT	2	229	DKC63-84	C	DUSTER	L	C	598	23.06	23.13
1	1	HUT	2	230	4525	S	DUSTER	ML	TAN	528	22.56	22.36
1	1	HUT	2	231	85G03	S	SOUTHWIND	ML	RED	571	38.42	20.85
1	1	HUT	2	232	86G32	S	SOUTHWIND	M	RED	492	29.8	20.18
1	1	HUT	2	233	88P68	S	SOUTHWIND	E	RED	528	15.38	21.72
1	1	HUT	2	234	SP3303	S	SOUTHWIND	E	TAN	539	21.34	20.02
1	1	HUT	2	235	DKC63-84	C	SOUTHWIND	L	C	524	17.9	23.44
1	1	HUT	2	236	4525	S	SOUTHWIND	ML	TAN	429	16.64	21.85
1	1	HUT	3	301	SP3303	S	EVEREST	E	TAN	728	23.66	26.84
1	1	HUT	3	302	DKC63-84	C	EVEREST	L	C	661	21.24	25.16
1	1	HUT	3	303	88P68	S	EVEREST	E	RED	740	22	25.42
1	1	HUT	3	304	85G03	S	EVEREST	ML	RED	732	20.86	21.30
1	1	HUT	3	305	86G32	S	EVEREST	M	RED	500	18.7	26.19
1	1	HUT	3	306	4525	S	EVEREST	ML	TAN	543	17.72	24.70
1	1	HUT	3	307	SP3303	S	FULLER	E	TAN	654	26.62	22.22
1	1	HUT	3	308	DKC63-84	C	FULLER	L	C	673	24.76	23.14
1	1	HUT	3	309	88P68	S	FULLER	E	RED	587	27.36	20.64
1	1	HUT	3	310	85G03	S	FULLER	ML	RED	654	23.62	20.36
1	1	HUT	3	311	86G32	S	FULLER	M	RED	488	25.36	23.79
1	1	HUT	3	312	4525	S	FULLER	ML	TAN	343	27.22	20.87
1	1	HUT	3	313	SP3303	S	BILLINGS	E	TAN	669	25.54	26.77
1	1	HUT	3	314	DKC63-84	C	BILLINGS	L	C	713	27.42	23.16
1	1	HUT	3	315	88P68	S	BILLINGS	E	RED	520	22.88	31.51
1	1	HUT	3	316	85G03	S	BILLINGS	ML	RED	469	24.02	26.67
1	1	HUT	3	317	86G32	S	BILLINGS	M	RED	453	25.2	24.22
1	1	HUT	3	318	4525	S	BILLINGS	ML	TAN	449	22.74	26.09
1	1	HUT	3	319	SP3303	S	T-154	E	TAN	768	26.02	20.44
1	1	HUT	3	320	DKC63-84	C	T-154	L	C	732	20.42	20.62
1	1	HUT	3	321	88P68	S	T-154	E	RED	531	22.48	19.66
1	1	HUT	3	322	85G03	S	T-154	ML	RED	602	30.52	16.80
1	1	HUT	3	323	86G32	S	T-154	M	RED	579	15.24	24.57
1	1	HUT	3	324	4525	S	T-154	ML	TAN	693	22.56	21.45
1	1	HUT	3	325	SP3303	S	SOUTHWIND	E	TAN	693	23.92	20.60
1	1	HUT	3	326	DKC63-84	C	SOUTHWIND	L	C	559	22.12	18.42
1	1	HUT	3	327	88P68	S	SOUTHWIND	E	RED	583	26.28	19.82

1	1	HUT	3	328	85G03	S	SOUTHWIND	ML	RED	.	.	.
1	1	HUT	3	329	86G32	S	SOUTHWIND	M	RED	587	17	20.86
1	1	HUT	3	330	4525	S	SOUTHWIND	ML	TAN	303	17.18	22.27
1	1	HUT	3	331	SP3303	S	DUSTER	E	TAN	764	26.52	21.63
1	1	HUT	3	332	DKC63-84	C	DUSTER	L	C	598	15.94	22.97
1	1	HUT	3	333	88P68	S	DUSTER	E	RED	472	27.64	18.62
1	1	HUT	3	334	85G03	S	DUSTER	ML	RED	555	18.92	24.53
1	1	HUT	3	335	86G32	S	DUSTER	M	RED	622	24.12	20.88
1	1	HUT	3	336	4525	S	DUSTER	ML	TAN	528	22.38	22.87
1	1	HUT	4	401	86G32	S	BILLINGS	M	RED	488	23.8	26.96
1	1	HUT	4	402	85G03	S	BILLINGS	ML	RED	638	24.94	25.32
1	1	HUT	4	403	4525	S	BILLINGS	ML	TAN	539	28.34	21.43
1	1	HUT	4	404	88P68	S	BILLINGS	E	RED	543	27.8	26.62
1	1	HUT	4	405	DKC63-84	C	BILLINGS	L	C	453	25.12	28.50
1	1	HUT	4	406	SP3303	S	BILLINGS	E	TAN	461	27.72	25.84
1	1	HUT	4	407	86G32	S	FULLER	M	RED	480	32.3	23.53
1	1	HUT	4	408	85G03	S	FULLER	ML	RED	484	19	24.26
1	1	HUT	4	409	4525	S	FULLER	ML	TAN	528	6.6	25.30
1	1	HUT	4	410	88P68	S	FULLER	E	RED	575	21.7	22.08
1	1	HUT	4	411	DKC63-84	C	FULLER	L	C	496	23.48	26.20
1	1	HUT	4	412	SP3303	S	FULLER	E	TAN	709	12.96	22.11
1	1	HUT	4	413	86G32	S	SOUTHWIND	M	RED	531	32.02	19.49
1	1	HUT	4	414	85G03	S	SOUTHWIND	ML	RED	720	37.42	21.64
1	1	HUT	4	415	4525	S	SOUTHWIND	ML	TAN	598	27.2	18.80
1	1	HUT	4	416	88P68	S	SOUTHWIND	E	RED	665	22.12	21.06
1	1	HUT	4	417	DKC63-84	C	SOUTHWIND	L	C	461	26.16	22.25
1	1	HUT	4	418	SP3303	S	SOUTHWIND	E	TAN	642	24.38	19.93
1	1	HUT	4	419	86G32	S	EVEREST	M	RED	575	22.62	25.72
1	1	HUT	4	420	85G03	S	EVEREST	ML	RED	748	22.44	23.80
1	1	HUT	4	421	4525	S	EVEREST	ML	TAN	413	55.7	26.33
1	1	HUT	4	422	88P68	S	EVEREST	E	RED	732	18.14	23.48
1	1	HUT	4	423	DKC63-84	C	EVEREST	L	C	717	18.62	25.67
1	1	HUT	4	424	SP3303	S	EVEREST	E	TAN	634	24.08	21.31
1	1	HUT	4	425	86G32	S	T-154	M	RED	701	19.2	25.52
1	1	HUT	4	426	85G03	S	T-154	ML	RED	728	17.62	24.55

1	1	HUT	4	427	4525	S	T-154	ML	TAN	701	21.62	21.20
1	1	HUT	4	428	88P68	S	T-154	E	RED	669	24.04	27.66
1	1	HUT	4	429	DKC63-84	C	T-154	L	C	807	20.64	23.04
1	1	HUT	4	430	SP3303	S	T-154	E	TAN	642	27.52	21.69
1	1	HUT	4	431	86G32	S	DUSTER	M	RED	681	24.54	19.71
1	1	HUT	4	432	85G03	S	DUSTER	ML	RED	543	26.26	19.99
1	1	HUT	4	433	4525	S	DUSTER	ML	TAN	606	25.32	18.84
1	1	HUT	4	434	88P68	S	DUSTER	E	RED	634	13.88	21.74
1	1	HUT	4	435	DKC63-84	C	DUSTER	L	C	768	25.48	21.75
1	1	HUT	4	436	SP3303	S	DUSTER	E	TAN	634	17.48	24.26
2	2	HUT	1	101	85G03	S	T-154	ML	RED	323	15.56	24.0
2	2	HUT	1	102	SP3303	S	T-154	E	TAN	295	12.70	23.3
2	2	HUT	1	103	4525	S	T-154	ML	TAN	346	13.22	27.8
2	2	HUT	1	104	DKC63-84	C	T-154	L	C	291	20.38	25.4
2	2	HUT	1	105	86G32	S	T-154	M	RED	362	12.62	22.4
2	2	HUT	1	106	88P68	S	T-154	E	RED	264	20.86	15.1
2	2	HUT	1	107	88P68	S	SOUTHWIND	E	RED	457	11.56	24.8
2	2	HUT	1	108	86G32	S	SOUTHWIND	M	RED	268	19.12	16.9
2	2	HUT	1	109	DKC63-84	C	SOUTHWIND	L	C	224	14.48	27.3
2	2	HUT	1	110	4525	S	SOUTHWIND	ML	TAN	291	20.22	26.2
2	2	HUT	1	111	SP3303	S	SOUTHWIND	E	TAN	299	26.76	24.8
2	2	HUT	1	112	85G03	S	SOUTHWIND	ML	RED	402	22.56	25.3
2	2	HUT	1	113	85G03	S	DUSTER	ML	RED	346	9.58	27.1
2	2	HUT	1	114	SP3303	S	DUSTER	E	TAN	386	31.22	15.4
2	2	HUT	1	115	4525	S	DUSTER	ML	TAN	378	16.92	23.3
2	2	HUT	1	116	DKC63-84	C	DUSTER	L	C	260	15.50	26.5
2	2	HUT	1	117	86G32	S	DUSTER	M	RED	260	12.96	24.5
2	2	HUT	1	118	88P68	S	DUSTER	E	RED	382	37.04	14.6
2	2	HUT	1	119	88P68	S	FULLER	E	RED	291	12.84	32.7
2	2	HUT	1	120	86G32	S	FULLER	M	RED	260	18.66	24.3
2	2	HUT	1	121	DKC63-84	C	FULLER	L	C	665	16.70	28.4
2	2	HUT	1	122	4525	S	FULLER	ML	TAN	272	23.20	29.3
2	2	HUT	1	123	SP3303	S	FULLER	E	TAN	217	14.40	26.4
2	2	HUT	1	124	85G03	S	FULLER	ML	RED	260	14.20	28.1
2	2	HUT	1	125	85G03	S	BILLINGS	ML	RED	299	23.64	34.4

2	2	HUT	1	126	SP3303	S	BILLINGS	E	TAN	335	16.30	31.1
2	2	HUT	1	127	4525	S	BILLINGS	ML	TAN	240	21.36	32.2
2	2	HUT	1	128	DKC63-84	C	BILLINGS	L	C	307	23.24	33.2
2	2	HUT	1	129	86G32	S	BILLINGS	M	RED	.	12.66	31.6
2	2	HUT	1	130	88P68	S	BILLINGS	E	RED	307	16.60	24.8
2	2	HUT	1	131	88P68	S	EVEREST	E	RED	319	13.82	28.4
2	2	HUT	1	132	86G32	S	EVEREST	M	RED	276	14.10	22.4
2	2	HUT	1	133	DKC63-84	C	EVEREST	L	C	307	7.64	27.7
2	2	HUT	1	134	4525	S	EVEREST	ML	TAN	287	15.52	26.5
2	2	HUT	1	135	SP3303	S	EVEREST	E	TAN	343	14.22	24.8
2	2	HUT	1	136	85G03	S	EVEREST	ML	RED	354	10.98	31.1
2	2	HUT	2	201	86G32	S	T-154	M	RED	386	11.52	21.2
2	2	HUT	2	202	DKC63-84	C	T-154	L	C	240	13.88	24.5
2	2	HUT	2	203	88P68	S	T-154	E	RED	252	15.96	20.1
2	2	HUT	2	204	SP3303	S	T-154	E	TAN	413	19.54	26.1
2	2	HUT	2	205	4525	S	T-154	ML	TAN	291	12.44	22.0
2	2	HUT	2	206	85G03	S	T-154	ML	RED	354	7.08	20.2
2	2	HUT	2	207	85G03	S	SOUTHWIND	ML	RED	295	6.50	24.9
2	2	HUT	2	208	4525	S	SOUTHWIND	ML	TAN	358	19.20	23.0
2	2	HUT	2	209	SP3303	S	SOUTHWIND	E	TAN	311	18.54	25.7
2	2	HUT	2	210	88P68	S	SOUTHWIND	E	RED	299	13.22	16.1
2	2	HUT	2	211	DKC63-84	C	SOUTHWIND	L	C	307	9.00	24.4
2	2	HUT	2	212	86G32	S	SOUTHWIND	M	RED	264	22.68	25.6
2	2	HUT	2	213	86G32	S	BILLINGS	M	RED	295	10.68	33.9
2	2	HUT	2	214	DKC63-84	C	BILLINGS	L	C	319	17.76	30.1
2	2	HUT	2	215	88P68	S	BILLINGS	E	RED	252	13.34	33.5
2	2	HUT	2	216	SP3303	S	BILLINGS	E	TAN	307	17.16	32.9
2	2	HUT	2	217	4525	S	BILLINGS	ML	TAN	240	24.86	16.4
2	2	HUT	2	218	85G03	S	BILLINGS	ML	RED	299	9.56	25.5
2	2	HUT	2	219	85G03	S	EVEREST	ML	RED	362	11.68	21.7
2	2	HUT	2	220	4525	S	EVEREST	ML	TAN	386	13.04	21.9
2	2	HUT	2	221	SP3303	S	EVEREST	E	TAN	504	8.28	27.5
2	2	HUT	2	222	88P68	S	EVEREST	E	RED	374	9.32	26.4
2	2	HUT	2	223	DKC63-84	C	EVEREST	L	C	291	10.10	30.5
2	2	HUT	2	224	86G32	S	EVEREST	M	RED	374	8.48	28.5

2	2	HUT	2	225	86G32	S	DUSTER	M	RED	362	10.06	27.0
2	2	HUT	2	226	DKC63-84	C	DUSTER	L	C	350	14.18	25.4
2	2	HUT	2	227	88P68	S	DUSTER	E	RED	299	15.44	26.7
2	2	HUT	2	228	SP3303	S	DUSTER	E	TAN	382	13.02	26.8
2	2	HUT	2	229	4525	S	DUSTER	ML	TAN	378	13.94	24.3
2	2	HUT	2	230	85G03	S	DUSTER	ML	RED	496	9.28	25.9
2	2	HUT	2	231	85G03	S	FULLER	ML	RED	248	20.60	26.9
2	2	HUT	2	232	4525	S	FULLER	ML	TAN	240	14.26	24.9
2	2	HUT	2	233	SP3303	S	FULLER	E	TAN	217	13.14	26.3
2	2	HUT	2	234	88P68	S	FULLER	E	RED	213	20.22	29.0
2	2	HUT	2	235	DKC63-84	C	FULLER	L	C	236	14.92	18.3
2	2	HUT	2	236	86G32	S	FULLER	M	RED	220	19.40	28.0
2	2	HUT	3	301	4525	S	EVEREST	ML	TAN	327	9.58	30.2
2	2	HUT	3	302	85G03	S	EVEREST	ML	RED	327	17.84	27.4
2	2	HUT	3	303	SP3303	S	EVEREST	E	TAN	280	14.74	29.1
2	2	HUT	3	304	86G32	S	EVEREST	M	RED	291	9.62	24.5
2	2	HUT	3	305	88P68	S	EVEREST	E	RED	181	10.34	35.0
2	2	HUT	3	306	DKC63-84	C	EVEREST	L	C	433	11.38	30.9
2	2	HUT	3	307	DKC63-84	C	DUSTER	L	C	354	22.86	27.3
2	2	HUT	3	308	88P68	S	DUSTER	E	RED	406	14.96	25.9
2	2	HUT	3	309	86G32	S	DUSTER	M	RED	256	16.48	19.5
2	2	HUT	3	310	SP3303	S	DUSTER	E	TAN	354	7.84	27.1
2	2	HUT	3	311	85G03	S	DUSTER	ML	RED	224	17.82	21.3
2	2	HUT	3	312	4525	S	DUSTER	ML	TAN	339	16.22	22.9
2	2	HUT	3	313	4525	S	SOUTHWIND	ML	TAN	346	16.06	23.6
2	2	HUT	3	314	85G03	S	SOUTHWIND	ML	RED	276	33.26	15.5
2	2	HUT	3	315	SP3303	S	SOUTHWIND	E	TAN	343	15.44	27.1
2	2	HUT	3	316	86G32	S	SOUTHWIND	M	RED	264	20.74	16.2
2	2	HUT	3	317	88P68	S	SOUTHWIND	E	RED	268	7.84	25.3
2	2	HUT	3	318	DKC63-84	C	SOUTHWIND	L	C	272	18.90	26.4
2	2	HUT	3	319	DKC63-84	C	BILLINGS	L	C	303	9.58	33.1
2	2	HUT	3	320	88P68	S	BILLINGS	E	RED	323	14.14	29.3
2	2	HUT	3	321	86G32	S	BILLINGS	M	RED	287	12.52	29.5
2	2	HUT	3	322	SP3303	S	BILLINGS	E	TAN	252	14.76	35.9
2	2	HUT	3	323	85G03	S	BILLINGS	ML	RED	248	35.64	10.0

2	2	HUT	3	324	4525	S	BILLINGS	ML	TAN	244	12.80	30.4
2	2	HUT	3	325	4525	S	T-154	ML	TAN	236	18.60	24.8
2	2	HUT	3	326	85G03	S	T-154	ML	RED	303	19.52	24.7
2	2	HUT	3	327	SP3303	S	T-154	E	TAN	307	25.98	25.1
2	2	HUT	3	328	86G32	S	T-154	M	RED	402	18.46	25.2
2	2	HUT	3	329	88P68	S	T-154	E	RED	315	9.86	24.7
2	2	HUT	3	330	DKC63-84	C	T-154	L	C	299	6.70	21.7
2	2	HUT	3	331	DKC63-84	C	FULLER	L	C	283	18.76	28.3
2	2	HUT	3	332	88P68	S	FULLER	E	RED	362	19.44	19.0
2	2	HUT	3	333	86G32	S	FULLER	M	RED	244	22.06	25.3
2	2	HUT	3	334	SP3303	S	FULLER	E	TAN	315	18.64	27.7
2	2	HUT	3	335	85G03	S	FULLER	ML	RED	280	18.72	26.4
2	2	HUT	3	336	4525	S	FULLER	ML	TAN	287	22.76	25.2
2	2	HUT	4	401	88P68	S	FULLER	E	RED	146	14.14	25.1
2	2	HUT	4	402	86G32	S	FULLER	M	RED	276	16.04	26.7
2	2	HUT	4	403	85G03	S	FULLER	ML	RED	217	19.26	27.0
2	2	HUT	4	404	4525	S	FULLER	ML	TAN	350	15.34	29.5
2	2	HUT	4	405	DKC63-84	C	FULLER	L	C	260	16.72	30.4
2	2	HUT	4	406	SP3303	S	FULLER	E	TAN	283	15.80	32.0
2	2	HUT	4	407	SP3303	S	EVEREST	E	TAN	370	11.16	31.5
2	2	HUT	4	408	DKC63-84	C	EVEREST	L	C	327	17.38	26.3
2	2	HUT	4	409	4525	S	EVEREST	ML	TAN	390	14.90	28.4
2	2	HUT	4	410	85G03	S	EVEREST	ML	RED	429	12.84	28.7
2	2	HUT	4	411	86G32	S	EVEREST	M	RED	232	5.54	25.8
2	2	HUT	4	412	88P68	S	EVEREST	E	RED	287	13.30	27.2
2	2	HUT	4	413	88P68	S	BILLINGS	E	RED	228	12.98	24.9
2	2	HUT	4	414	86G32	S	BILLINGS	M	RED	295	18.00	26.6
2	2	HUT	4	415	85G03	S	BILLINGS	ML	RED	228	25.34	28.2
2	2	HUT	4	416	4525	S	BILLINGS	ML	TAN	236	22.12	18.6
2	2	HUT	4	417	DKC63-84	C	BILLINGS	L	C	276	22.46	32.1
2	2	HUT	4	418	SP3303	S	BILLINGS	E	TAN	173	16.14	33.6
2	2	HUT	4	419	SP3303	S	T-154	E	TAN	319	17.76	29.4
2	2	HUT	4	420	DKC63-84	C	T-154	L	C	350	16.62	23.2
2	2	HUT	4	421	4525	S	T-154	ML	TAN	358	28.78	16.4
2	2	HUT	4	422	85G03	S	T-154	ML	RED	335	26.46	25.4

2	2	HUT	4	423	86G32	S	T-154	M	RED	295	18.22	24.7
2	2	HUT	4	424	88P68	S	T-154	E	RED	295	9.46	27.0
2	2	HUT	4	425	88P68	S	DUSTER	E	RED	228	26.94	15.3
2	2	HUT	4	426	86G32	S	DUSTER	M	RED	201	24.94	16.0
2	2	HUT	4	427	85G03	S	DUSTER	ML	RED	327	17.50	26.3
2	2	HUT	4	428	4525	S	DUSTER	ML	TAN	252	18.16	24.0
2	2	HUT	4	429	DKC63-84	C	DUSTER	L	C	311	17.78	27.6
2	2	HUT	4	430	SP3303	S	DUSTER	E	TAN	311	16.30	23.9
2	2	HUT	4	431	SP3303	S	SOUTHWIND	E	TAN	319	50.72	15.8
2	2	HUT	4	432	DKC63-84	C	SOUTHWIND	L	C	323	29.78	16.5
2	2	HUT	4	433	4525	S	SOUTHWIND	ML	TAN	382	26.86	25.6
2	2	HUT	4	434	85G03	S	SOUTHWIND	ML	RED	311	31.98	25.1
2	2	HUT	4	435	86G32	S	SOUTHWIND	M	RED	.	.	.
2	2	HUT	4	436	88P68	S	SOUTHWIND	E	RED	.	.	.
1	3	MAN	1	101	SP3303	S	FULLER	E	TAN	1008	24.9	18.82
1	3	MAN	1	102	86G32	S	FULLER	M	RED	520	21.8	19.53
1	3	MAN	1	103	88P68	S	FULLER	E	RED	656	26.2	23.17
1	3	MAN	1	104	DKC63-84	C	FULLER	L	C	1181	25.2	22.62
1	3	MAN	1	105	85G03	S	FULLER	ML	RED	1108	22.3	24.82
1	3	MAN	1	106	4525	S	FULLER	ML	TAN	388	27.4	21.47
1	3	MAN	1	107	SP3303	S	BILLINGS	E	TAN	772	29.3	26.73
1	3	MAN	1	108	86G32	S	BILLINGS	M	RED	693	23.6	22.38
1	3	MAN	1	109	88P68	S	BILLINGS	S	RED	682	27.9	24.36
1	3	MAN	1	110	DKC63-84	C	BILLINGS	L	C	730	27.4	24.38
1	3	MAN	1	111	85G03	S	BILLINGS	ML	RED	588	24.8	20.98
1	3	MAN	1	112	4525	S	BILLINGS	ML	TAN	541	28.7	21.97
1	3	MAN	1	113	SP3303	S	T-154	E	TAN	367	20.8	19.77
1	3	MAN	1	114	86G32	S	T-154	M	RED	.	.	.
1	3	MAN	1	115	88P68	S	T-154	E	RED	415	31.3	23.37
1	3	MAN	1	116	DKC63-84	C	T-154	L	C	310	29.7	21.67
1	3	MAN	1	117	85G03	S	T-154	ML	RED	378	33.3	20.31
1	3	MAN	1	118	4525	S	T-154	ML	TAN	.	.	.
1	3	MAN	1	119	SP3303	S	EVEREST	E	TAN	1097	25.4	23.58
1	3	MAN	1	120	86G32	S	EVEREST	M	RED	1071	24.5	23.78
1	3	MAN	1	121	88P68	S	EVEREST	E	RED	735	23.5	20.62

1	3	MAN	1	122	DKC63-84	C	EVEREST	L	C	892	22.1	21.81
1	3	MAN	1	123	85G03	S	EVEREST	ML	RED	824	27.1	22.66
1	3	MAN	1	124	4525	S	EVEREST	ML	TAN	619	24.3	24.23
1	3	MAN	1	125	SP3303	S	DUSTER	E	TAN	1333	23.7	21.13
1	3	MAN	1	126	86G32	S	DUSTER	M	RED	840	25.6	20.63
1	3	MAN	1	127	88P68	S	DUSTER	S	RED	567	26.5	22.98
1	3	MAN	1	128	DKC63-84	C	DUSTER	L	C	887	24.3	19.63
1	3	MAN	1	129	85G03	S	DUSTER	ML	RED	814	25.8	21.88
1	3	MAN	1	130	4525	S	DUSTER	ML	TAN	520	25.7	20.86
1	3	MAN	1	131	SP3303	S	SOUTHWIND	S	TAN	877	27.6	17.61
1	3	MAN	1	132	86G32	S	SOUTHWIND	M	RED	924	21.1	18.59
1	3	MAN	1	133	88P68	S	SOUTHWIND	E	RED	430	22.4	19.14
1	3	MAN	1	134	DKC63-84	C	SOUTHWIND	L	C	898	28.9	17.78
1	3	MAN	1	135	85G03	S	SOUTHWIND	ML	RED	546	34.8	16.00
1	3	MAN	1	136	4525	S	SOUTHWIND	ML	TAN	651	20.6	19.91
1	3	MAN	2	201	SP3303	S	SOUTHWIND	E	TAN	992	19.1	20.25
1	3	MAN	2	202	DKC63-84	C	SOUTHWIND	L	C	772	18.2	17.91
1	3	MAN	2	203	4525	S	SOUTHWIND	ML	TAN	966	22.1	19.82
1	3	MAN	2	204	85G03	S	SOUTHWIND	ML	RED	961	24.8	17.30
1	3	MAN	2	205	88P68	S	SOUTHWIND	E	RED	856	16.3	22.38
1	3	MAN	2	206	86G32	S	SOUTHWIND	M	RED	.	.	.
1	3	MAN	2	207	SP3303	S	FULLER	E	TAN	982	17.0	23.42
1	3	MAN	2	208	DKC63-84	C	FULLER	L	C	966	13.5	22.77
1	3	MAN	2	209	4525	S	FULLER	ML	TAN	877	16.3	22.91
1	3	MAN	2	210	85G03	S	FULLER	ML	RED	908	17.0	24.58
1	3	MAN	2	211	88P68	S	FULLER	E	RED	1060	22.1	21.53
1	3	MAN	2	212	86G32	S	FULLER	M	RED	714	18.6	21.94
1	3	MAN	2	213	SP3303	S	DUSTER	E	TAN	667	23.2	21.93
1	3	MAN	2	214	DKC63-84	C	DUSTER	L	C	719	18.9	21.19
1	3	MAN	2	215	4525	S	DUSTER	ML	TAN	.	.	.
1	3	MAN	2	216	85G03	S	DUSTER	ML	RED	378	28.9	22.21
1	3	MAN	2	217	88P68	S	DUSTER	E	RED	777	26.1	21.35
1	3	MAN	2	218	86G32	S	DUSTER	M	RED	168	14.9	20.59
1	3	MAN	2	219	SP3303	S	BILLINGS	E	TAN	814	24.9	28.66
1	3	MAN	2	220	DKC63-84	C	BILLINGS	L	C	677	17.8	26.00

1	3	MAN	2	221	4525	S	BILLINGS	ML	TAN	903	22.8	27.96
1	3	MAN	2	222	85G03	S	BILLINGS	ML	RED	898	25.5	26.08
1	3	MAN	2	223	88P68	S	BILLINGS	E	RED	.	.	.
1	3	MAN	2	224	86G32	S	BILLINGS	M	RED	1060	21.4	22.53
1	3	MAN	2	225	SP3303	S	EVEREST	E	TAN	604	18.4	24.16
1	3	MAN	2	226	DKC63-84	C	EVEREST	L	C	556	23.9	26.24
1	3	MAN	2	227	4525	S	EVEREST	ML	TAN	656	23.4	23.27
1	3	MAN	2	228	85G03	S	EVEREST	ML	RED	661	21.0	23.08
1	3	MAN	2	229	88P68	S	EVEREST	E	RED	619	23.6	20.66
1	3	MAN	2	230	86G32	S	EVEREST	M	RED	467	23.1	23.82
1	3	MAN	2	231	SP3303	S	T-154	E	TAN	1113	21.2	25.48
1	3	MAN	2	232	DKC63-84	C	T-154	L	C	814	15.8	23.06
1	3	MAN	2	233	4525	S	T-154	ML	TAN	940	22.5	22.78
1	3	MAN	2	234	85G03	S	T-154	ML	RED	577	25.2	24.77
1	3	MAN	2	235	88P68	S	T-154	E	RED	961	23.4	21.86
1	3	MAN	2	236	86G32	S	T-154	M	RED	609	32.4	22.64
1	3	MAN	3	301	88P68	S	T-154	E	RED	966	21.6	22.81
1	3	MAN	3	302	85G03	S	T-154	ML	RED	572	17.9	23.05
1	3	MAN	3	303	86G32	S	T-154	M	RED	1060	18.9	20.57
1	3	MAN	3	304	DKC63-84	C	T-154	L	C	1097	18.2	20.04
1	3	MAN	3	305	SP3303	S	T-154	E	TAN	740	19.6	22.58
1	3	MAN	3	306	4525	S	T-154	ML	TAN	856	18.8	23.02
1	3	MAN	3	307	88P68	S	DUSTER	E	RED	740	32.4	22.32
1	3	MAN	3	308	85G03	S	DUSTER	ML	RED	268	20.0	19.08
1	3	MAN	3	309	86G32	S	DUSTER	M	RED	336	24.4	21.83
1	3	MAN	3	310	DKC63-84	C	DUSTER	L	C	.	.	.
1	3	MAN	3	311	SP3303	S	DUSTER	S	TAN	378	18.5	21.67
1	3	MAN	3	312	4525	S	DUSTER	ML	TAN	184	12.8	23.90
1	3	MAN	3	313	88P68	S	BILLINGS	E	RED	68	34.0	30.25
1	3	MAN	3	314	85G03	S	BILLINGS	ML	RED	52	27.2	27.72
1	3	MAN	3	315	86G32	S	BILLINGS	M	RED	268	24.5	25.82
1	3	MAN	3	316	DKC63-84	C	BILLINGS	L	C	646	31.3	24.17
1	3	MAN	3	317	SP3303	S	BILLINGS	E	TAN	220	32.3	28.99
1	3	MAN	3	318	4525	S	BILLINGS	ML	TAN	89	9.8	25.93
1	3	MAN	3	319	88P68	S	FULLER	E	RED	924	13.5	23.93

1	3	MAN	3	320	85G03	S	FULLER	ML	RED	577	9.2	25.23
1	3	MAN	3	321	86G32	S	FULLER	M	RED	609	22.0	22.60
1	3	MAN	3	322	DKC63-84	C	FULLER	L	C	1008	16.3	19.34
1	3	MAN	3	323	SP3303	S	FULLER	E	TAN	646	25.4	22.37
1	3	MAN	3	324	4525	S	FULLER	ML	TAN	562	24.3	20.34
1	3	MAN	3	325	88P68	S	SOUTHWIND	L	RED	.	.	.
1	3	MAN	3	326	85G03	S	SOUTHWIND	ML	RED	383	16.8	18.38
1	3	MAN	3	327	86G32	S	SOUTHWIND	M	RED	.	.	.
1	3	MAN	3	328	DKC63-84	C	SOUTHWIND	L	C	614	25.6	14.61
1	3	MAN	3	329	SP3303	S	SOUTHWIND	E	TAN	903	27.2	16.50
1	3	MAN	3	330	4525	S	SOUTHWIND	ML	TAN	336	25.6	15.89
1	3	MAN	3	331	88P68	S	EVEREST	E	RED	530	18.1	22.85
1	3	MAN	3	332	85G03	S	EVEREST	ML	RED	735	14.0	22.50
1	3	MAN	3	333	86G32	S	EVEREST	M	RED	656	23.1	22.73
1	3	MAN	3	334	DKC63-84	C	EVEREST	L	C	651	21.0	24.55
1	3	MAN	3	335	SP3303	S	EVEREST	E	TAN	903	20.2	23.84
1	3	MAN	3	336	4525	S	EVEREST	ML	TAN	525	22.8	24.52
1	3	MAN	4	401	85G03	S	BILLINGS	ML	RED	.	.	.
1	3	MAN	4	402	DKC63-84	C	BILLINGS	L	C	.	.	.
1	3	MAN	4	403	SP3303	S	BILLINGS	E	TAN	.	.	.
1	3	MAN	4	404	88P68	S	T-154	E	RED	577	28.8	18.57
1	3	MAN	4	405	86G32	S	SOUTHWIND	M	RED	220	27.4	15.82
1	3	MAN	4	406	4525	S	FULLER	ML	TAN	404	20.4	25.19
1	3	MAN	4	407	85G03	S	FULLER	ML	RED	614	26.3	19.76
1	3	MAN	4	408	DKC63-84	C	FULLER	L	C	640	19.7	19.82
1	3	MAN	4	409	SP3303	S	FULLER	E	TAN	383	29.1	20.60
1	3	MAN	4	410	88P68	S	DUSTER	E	RED	299	27.9	20.79
1	3	MAN	4	411	86G32	S	FULLER	M	RED	714	27.4	22.30
1	3	MAN	4	412	4525	S	BILLINGS	ML	TAN	740	29.7	26.74
1	3	MAN	4	413	85G03	S	SOUTHWIND	ML	RED	352	36.0	17.76
1	3	MAN	4	414	DKC63-84	C	SOUTHWIND	L	C	514	27.1	14.49
1	3	MAN	4	415	SP3303	S	SOUTHWIND	E	TAN	.	.	.
1	3	MAN	4	416	88P68	S	BILLINGS	E	RED	882	27.9	23.50
1	3	MAN	4	417	86G32	S	DUSTER	M	RED	294	35.8	21.11
1	3	MAN	4	418	4525	S	T-154	ML	TAN	1165	34.8	24.58

1	3	MAN	4	419	85G03	S	T-154	ML	RED	656	20.9	25.97
1	3	MAN	4	420	DKC63-84	C	T-154	L	C	950	21.2	19.90
1	3	MAN	4	421	SP3303	S	T-154	E	TAN	714	24.9	19.85
1	3	MAN	4	422	88P68	S	FULLER	E	RED	488	28.3	19.57
1	3	MAN	4	423	86G32	S	BILLINGS	M	RED	378	28.7	25.24
1	3	MAN	4	424	4525	S	EVEREST	ML	TAN	819	22.8	23.15
1	3	MAN	4	425	85G03	S	EVEREST	ML	RED	436	21.0	25.08
1	3	MAN	4	426	DKC63-84	C	EVEREST	L	C	703	22.3	21.23
1	3	MAN	4	427	SP3303	S	EVEREST	E	TAN	420	20.3	24.25
1	3	MAN	4	428	88P68	S	SOUTHWIND	E	RED	976	22.3	16.11
1	3	MAN	4	429	86G32	S	EVEREST	M	RED	798	25.0	21.60
1	3	MAN	4	430	4525	S	DUSTER	ML	TAN	220	29.4	20.91
1	3	MAN	4	431	85G03	S	DUSTER	ML	RED	220	28.5	19.45
1	3	MAN	4	432	DKC63-84	C	DUSTER	L	C	26	45.8	20.57
1	3	MAN	4	433	SP3303	S	DUSTER	E	TAN	68	9.6	10.88
1	3	MAN	4	434	88P68	S	EVEREST	E	RED	903	16.0	21.52
1	3	MAN	4	435	86G32	S	T-154	M	RED	373	30.2	21.24
1	3	MAN	4	436	4525	S	SOUTHWIND	ML	TAN	1045	24.2	17.43
2	4	MAN	1	101	85G03	S	EVEREST	ML	RED	661	20.7	33.81
2	4	MAN	1	102	4525	S	EVEREST	ML	TAN	488	24.2	31.75
2	4	MAN	1	103	SP3303	S	EVEREST	E	TAN	514	21.0	33.85
2	4	MAN	1	104	86G32	S	EVEREST	M	RED	467	21.1	33.65
2	4	MAN	1	105	88P68	S	EVEREST	E	RED	399	22.6	34.56
2	4	MAN	1	106	DKC63-84	C	EVEREST	L	C	588	24.7	31.58
2	4	MAN	1	107	DKC63-84	C	DUSTER	L	C	105	29.0	28.29
2	4	MAN	1	108	88P68	S	DUSTER	E	RED	173	54.2	28.28
2	4	MAN	1	109	86G32	S	DUSTER	M	RED	441	23.1	30.94
2	4	MAN	1	110	SP3303	S	DUSTER	E	TAN	362	28.9	27.83
2	4	MAN	1	111	4525	S	DUSTER	ML	TAN	52	21.1	21.99
2	4	MAN	1	112	85G03	S	DUSTER	ML	RED	157	19.6	19.95
2	4	MAN	1	113	85G03	S	T-154	ML	RED	609	32.2	28.03
2	4	MAN	1	114	4525	S	T-154	ML	TAN	415	40.1	28.20
2	4	MAN	1	115	SP3303	S	T-154	E	TAN	535	36.4	30.09
2	4	MAN	1	116	86G32	S	T-154	M	RED	394	25.7	30.68
2	4	MAN	1	117	88P68	S	T-154	E	RED	436	36.4	25.00

2	4	MAN	1	118	DKC63-84	C	T-154	L	C	399	29.8	32.11
2	4	MAN	1	119	DKC63-84	C	SOUTHWIND	L	C	205	33.9	30.03
2	4	MAN	1	120	88P68	S	SOUTHWIND	E	RED	73	30.5	31.66
2	4	MAN	1	121	86G32	S	SOUTHWIND	M	RED	299	23.6	29.26
2	4	MAN	1	122	SP3303	S	SOUTHWIND	E	TAN	415	38.5	27.57
2	4	MAN	1	123	4525	S	SOUTHWIND	ML	TAN	294	27.1	29.42
2	4	MAN	1	124	85G03	S	SOUTHWIND	ML	RED	205	31.2	24.91
2	4	MAN	1	125	85G03	S	FULLER	ML	RED	436	26.3	32.46
2	4	MAN	1	126	4525	S	FULLER	ML	TAN	352	30.0	30.29
2	4	MAN	1	127	SP3303	S	FULLER	E	TAN	37	30.9	33.06
2	4	MAN	1	128	86G32	S	FULLER	M	RED	404	28.3	31.88
2	4	MAN	1	129	88P68	S	FULLER	E	RED	94	25.3	31.30
2	4	MAN	1	130	DKC63-84	C	FULLER	L	C	79	13.2	26.36
2	4	MAN	1	131	DKC63-84	C	BILLINGS	L	C	0	0.0	.
2	4	MAN	1	132	88P68	S	BILLINGS	E	RED	147	16.6	30.86
2	4	MAN	1	133	86G32	S	BILLINGS	M	RED	121	28.0	37.30
2	4	MAN	1	134	SP3303	S	BILLINGS	E	TAN	0	0.0	.
2	4	MAN	1	135	4525	S	BILLINGS	ML	TAN	121	29.0	27.95
2	4	MAN	1	136	85G03	S	BILLINGS	ML	RED	37	39.1	31.09
2	4	MAN	2	201	88P68	S	FULLER	E	RED	63	11.3	18.67
2	4	MAN	2	202	86G32	S	FULLER	M	RED	0	0.0	.
2	4	MAN	2	203	DKC63-84	C	FULLER	L	C	126	24.3	30.14
2	4	MAN	2	204	4525	S	FULLER	ML	TAN	226	26.3	32.83
2	4	MAN	2	205	SP3303	S	FULLER	E	TAN	0	0.0	.
2	4	MAN	2	206	85G03	S	FULLER	ML	RED	147	23.4	35.03
2	4	MAN	2	207	85G03	S	T-154	ML	RED	646	30.3	31.44
2	4	MAN	2	208	SP3303	S	T-154	E	TAN	530	31.2	31.42
2	4	MAN	2	209	4525	S	T-154	ML	TAN	740	30.6	27.92
2	4	MAN	2	210	DKC63-84	C	T-154	L	C	478	26.5	32.25
2	4	MAN	2	211	86G32	S	T-154	M	RED	84	23.9	30.47
2	4	MAN	2	212	88P68	S	T-154	E	RED	205	26.1	30.76
2	4	MAN	2	213	88P68	S	SOUTHWIND	E	RED	194	30.6	28.11
2	4	MAN	2	214	86G32	S	SOUTHWIND	M	RED	168	31.2	29.20
2	4	MAN	2	215	DKC63-84	C	SOUTHWIND	L	C	42	38.8	31.58
2	4	MAN	2	216	4525	S	SOUTHWIND	ML	TAN	310	28.5	30.42

2	4	MAN	2	217	SP3303	S	SOUTHWIND	E	TAN	604	27.7	26.89
2	4	MAN	2	218	85G03	S	SOUTHWIND	ML	RED	357	27.9	31.21
2	4	MAN	2	219	85G03	S	DUSTER	ML	RED	667	26.3	33.42
2	4	MAN	2	220	SP3303	S	DUSTER	E	TAN	383	30.4	29.64
2	4	MAN	2	221	4525	S	DUSTER	ML	TAN	0	0.0	.
2	4	MAN	2	222	DKC63-84	C	DUSTER	L	C	210	0.1	25.00
2	4	MAN	2	223	86G32	S	DUSTER	M	RED	394	27.5	27.00
2	4	MAN	2	224	88P68	S	DUSTER	E	RED	320	23.9	25.64
2	4	MAN	2	225	88P68	S	EVEREST	E	RED	567	19.7	34.11
2	4	MAN	2	226	86G32	S	EVEREST	M	RED	331	21.1	33.53
2	4	MAN	2	227	DKC63-84	C	EVEREST	L	C	567	15.8	32.63
2	4	MAN	2	228	4525	S	EVEREST	ML	TAN	394	23.4	34.88
2	4	MAN	2	229	SP3303	S	EVEREST	E	TAN	415	19.0	34.35
2	4	MAN	2	230	85G03	S	EVEREST	ML	RED	530	21.7	31.89
2	4	MAN	2	231	85G03	S	BILLINGS	ML	RED	415	29.2	40.17
2	4	MAN	2	232	SP3303	S	BILLINGS	E	TAN	283	31.5	35.77
2	4	MAN	2	233	4525	S	BILLINGS	ML	TAN	105	25.6	31.86
2	4	MAN	2	234	DKC63-84	C	BILLINGS	L	C	0	0.0	.
2	4	MAN	2	235	86G32	S	BILLINGS	M	RED	0	0.0	.
2	4	MAN	2	236	88P68	S	BILLINGS	E	RED	142	24.8	30.63
2	4	MAN	3	301	SP3303	S	T-154	E	TAN	525	33.6	30.70
2	4	MAN	3	302	85G03	S	T-154	ML	RED	462	27.6	30.38
2	4	MAN	3	303	4525	S	T-154	ML	TAN	982	23.7	31.56
2	4	MAN	3	304	88P68	S	T-154	E	RED	551	27.8	30.03
2	4	MAN	3	305	DKC63-84	C	T-154	L	C	509	25.6	30.32
2	4	MAN	3	306	86G32	S	T-154	M	RED	399	22.1	30.51
2	4	MAN	3	307	86G32	S	DUSTER	M	RED	142	27.2	28.24
2	4	MAN	3	308	DKC63-84	C	DUSTER	L	C	194	21.0	28.60
2	4	MAN	3	309	88P68	S	DUSTER	E	RED	719	25.6	27.53
2	4	MAN	3	310	4525	S	DUSTER	ML	TAN	446	22.0	28.37
2	4	MAN	3	311	85G03	S	DUSTER	ML	RED	483	19.5	29.74
2	4	MAN	3	312	SP3303	S	DUSTER	E	TAN	646	25.8	27.90
2	4	MAN	3	313	SP3303	S	FULLER	E	TAN	399	25.1	32.62
2	4	MAN	3	314	85G03	S	FULLER	ML	RED	698	28.4	33.54
2	4	MAN	3	315	4525	S	FULLER	ML	TAN	394	29.4	32.49

2	4	MAN	3	316	88P68	S	FULLER	E	RED	373	28.6	36.19
2	4	MAN	3	317	DKC63-84	C	FULLER	L	C	504	24.0	35.80
2	4	MAN	3	318	86G32	S	FULLER	M	RED	0	0.0	.
2	4	MAN	3	319	86G32	S	BILLINGS	M	RED	194	17.2	31.45
2	4	MAN	3	320	DKC63-84	C	BILLINGS	L	C	394	28.9	37.61
2	4	MAN	3	321	88P68	S	BILLINGS	E	RED	499	27.1	39.94
2	4	MAN	3	322	4525	S	BILLINGS	ML	TAN	514	23.1	39.60
2	4	MAN	3	323	85G03	S	BILLINGS	ML	RED	210	18.6	38.45
2	4	MAN	3	324	SP3303	S	BILLINGS	E	TAN	273	30.7	36.86
2	4	MAN	3	325	SP3303	S	EVEREST	E	TAN	688	19.1	33.18
2	4	MAN	3	326	85G03	S	EVEREST	ML	RED	462	17.4	34.26
2	4	MAN	3	327	4525	S	EVEREST	ML	TAN	556	23.8	31.08
2	4	MAN	3	328	88P68	S	EVEREST	E	RED	567	19.3	33.31
2	4	MAN	3	329	DKC63-84	C	EVEREST	L	C	499	24.9	31.80
2	4	MAN	3	330	86G32	S	EVEREST	M	RED	493	18.9	32.04
2	4	MAN	3	331	86G32	S	SOUTHWIND	M	RED	257	26.1	27.28
2	4	MAN	3	332	DKC63-84	C	SOUTHWIND	L	C	341	23.0	29.39
2	4	MAN	3	333	88P68	S	SOUTHWIND	E	RED	583	25.1	31.25
2	4	MAN	3	334	4525	S	SOUTHWIND	ML	TAN	835	26.2	28.14
2	4	MAN	3	335	85G03	S	SOUTHWIND	ML	RED	504	26.0	31.78
2	4	MAN	3	336	SP3303	S	SOUTHWIND	E	TAN	262	27.2	30.32
2	4	MAN	4	401	DKC63-84	C	FULLER	L	C	451	23.4	34.92
2	4	MAN	4	402	88P68	S	FULLER	E	RED	478	22.8	37.25
2	4	MAN	4	403	85G03	S	FULLER	ML	RED	257	23.6	36.74
2	4	MAN	4	404	SP3303	S	FULLER	E	TAN	336	25.3	37.25
2	4	MAN	4	405	86G32	S	FULLER	M	RED	388	25.9	36.91
2	4	MAN	4	406	4525	S	FULLER	ML	TAN	556	23.4	32.74
2	4	MAN	4	407	4525	S	DUSTER	ML	TAN	399	19.1	29.81
2	4	MAN	4	408	86G32	S	DUSTER	M	RED	462	22.3	29.75
2	4	MAN	4	409	SP3303	S	DUSTER	E	TAN	598	25.7	31.21
2	4	MAN	4	410	85G03	S	DUSTER	ML	RED	955	16.6	28.69
2	4	MAN	4	411	88P68	S	DUSTER	E	RED	698	17.8	28.75
2	4	MAN	4	412	DKC63-84	C	DUSTER	L	C	630	25.3	27.46
2	4	MAN	4	413	DKC63-84	C	BILLINGS	L	C	535	24.1	37.12
2	4	MAN	4	414	88P68	S	BILLINGS	E	RED	247	22.2	39.79

2	4	MAN	4	415	85G03	S	BILLINGS	ML	RED	499	23.9	38.44
2	4	MAN	4	416	SP3303	S	BILLINGS	E	TAN	383	25.7	37.21
2	4	MAN	4	417	86G32	S	BILLINGS	M	RED	388	19.7	37.77
2	4	MAN	4	418	4525	S	BILLINGS	ML	TAN	509	24.0	37.26
2	4	MAN	4	419	4525	S	EVEREST	ML	TAN	672	19.7	32.67
2	4	MAN	4	420	86G32	S	EVEREST	M	RED	488	20.1	31.67
2	4	MAN	4	421	SP3303	S	EVEREST	E	TAN	462	19.6	32.78
2	4	MAN	4	422	85G03	S	EVEREST	ML	RED	367	21.1	32.82
2	4	MAN	4	423	88P68	S	EVEREST	E	RED	577	19.8	31.30
2	4	MAN	4	424	DKC63-84	C	EVEREST	L	C	514	19.5	32.77
2	4	MAN	4	425	DKC63-84	C	T-154	L	C	.	24.5	29.71
2	4	MAN	4	426	88P68	S	T-154	E	RED	467	25.0	29.47
2	4	MAN	4	427	85G03	S	T-154	ML	RED	535	29.9	28.68
2	4	MAN	4	428	SP3303	S	T-154	E	TAN	672	23.5	30.14
2	4	MAN	4	429	86G32	S	T-154	M	RED	572	22.6	32.77
2	4	MAN	4	430	4525	S	T-154	ML	TAN	583	29.7	29.68
2	4	MAN	4	431	4525	S	SOUTHWIND	ML	TAN	462	24.2	30.41
2	4	MAN	4	432	86G32	S	SOUTHWIND	M	RED	677	25.8	31.19
2	4	MAN	4	433	SP3303	S	SOUTHWIND	E	TAN	462	24.7	30.32
2	4	MAN	4	434	85G03	S	SOUTHWIND	ML	RED	530	24.1	31.59
2	4	MAN	4	435	88P68	S	SOUTHWIND	E	RED	735	22.9	31.41
2	4	MAN	4	436	DKC63-84	C	SOUTHWIND	L	C	352	19.8	32.20

Appendix D - Raw Data: Chapter 3 "Effects of Hybrid Characteristics and Environment on Phenolic Acid Content in Grain Sorghum and Corn Residue"

Table D.1 Vanillic, *p*-coumaric, and ferulic acid concentration data.

YR	ENV	LOC	PLOT	BLOC	HYBRID	CROP	MAT-URITY	PIG-MENT	SAMPLE TIME	RES-IDUE DRY WT.	VA	PCA	FA	TOTAL
										g	———— mg g^{-1} ————			
1	1	MAN	101	1	SP3303	S	E	TAN	1	241	0.132	10.438	3.313	13.883
1	1	MAN	101	1	SP3303	S	E	TAN	2	153	0.108	11.913	3.096	15.117
1	1	MAN	101	1	SP3303	S	E	TAN	3	147	0.097	13.941	3.039	17.078
1	1	MAN	102	1	86G32	S	M	RED	1	184	0.127	13.040	3.371	16.539
1	1	MAN	102	1	86G32	S	M	RED	2	226	0.128	8.584	2.446	11.159
1	1	MAN	102	1	86G32	S	M	RED	3	198	0.121	13.792	2.523	16.435
1	1	MAN	103	1	88P68	S	E	RED	1	241	0.118	11.112	2.962	14.192
1	1	MAN	103	1	88P68	S	E	RED	2	176	0.129	9.100	2.659	11.888
1	1	MAN	103	1	88P68	S	E	RED	3	181	0.094	17.617	2.644	20.355
1	1	MAN	104	1	DKC63-84	C	L	C	1	320	0.165	15.610	2.933	18.708
1	1	MAN	104	1	DKC63-84	C	L	C	2	315	0.156	24.415	3.586	28.157
1	1	MAN	104	1	DKC63-84	C	L	C	3	300	0.114	17.413	2.349	19.876
1	1	MAN	105	1	85G03	S	ML	RED	1	270	0.104	9.609	2.704	12.417
1	1	MAN	105	1	85G03	S	ML	RED	2	207	0.153	11.662	3.369	15.183
1	1	MAN	105	1	85G03	S	ML	RED	3	182	0.094	14.470	2.403	16.967
1	1	MAN	106	1	4525	S	ML	TAN	1	258	0.119	9.653	2.762	12.534
1	1	MAN	106	1	4525	S	ML	TAN	2	213	0.114	16.578	3.023	19.715
1	1	MAN	106	1	4525	S	ML	TAN	3	201	0.085	14.306	2.284	16.674
1	1	MAN	201	2	SP3303	S	E	TAN	1	233	0.135	9.638	3.041	12.814

1	1	MAN	201	2	SP3303	S	E	TAN	2	137	0.129	12.536	3.169	15.834
1	1	MAN	201	2	SP3303	S	E	TAN	3	151	0.109	14.997	2.882	17.988
1	1	MAN	202	2	DKC63-84	C	L	C	1	299	0.149	16.065	3.327	19.542
1	1	MAN	202	2	DKC63-84	C	L	C	2	270	0.159	24.569	3.566	28.293
1	1	MAN	202	2	DKC63-84	C	L	C	3	273	0.130	21.907	2.877	24.914
1	1	MAN	203	2	4525	S	ML	TAN	1	224	0.128	9.123	2.620	11.871
1	1	MAN	203	2	4525	S	ML	TAN	2	193	0.111	15.371	2.709	18.192
1	1	MAN	203	2	4525	S	ML	TAN	3	189	0.082	12.235	2.172	14.489
1	1	MAN	204	2	85G03	S	ML	RED	1	265	0.106	9.688	2.749	12.543
1	1	MAN	204	2	85G03	S	ML	RED	2	184	0.118	10.998	3.217	14.332
1	1	MAN	204	2	85G03	S	ML	RED	3	173	0.106	14.788	2.441	17.335
1	1	MAN	205	2	88P68	S	E	RED	1	208	0.135	10.580	2.928	13.643
1	1	MAN	205	2	88P68	S	E	RED	2	144	0.147	9.848	2.836	12.831
1	1	MAN	205	2	88P68	S	E	RED	3	135	0.088	15.059	2.309	17.457
1	1	MAN	206	2	86G32	S	M	RED	1	163	0.121	12.023	3.169	15.313
1	1	MAN	206	2	86G32	S	M	RED	2	203	0.124	8.698	2.471	11.293
1	1	MAN	206	2	86G32	S	M	RED	3	137	0.116	13.534	2.439	16.089
1	1	MAN	301	3	88P68	S	E	RED	1	230	0.128	11.002	3.014	14.144
1	1	MAN	301	3	88P68	S	E	RED	2	156	0.133	9.237	2.735	12.105
1	1	MAN	301	3	88P68	S	E	RED	3	151	0.084	15.028	2.219	17.331
1	1	MAN	302	3	85G03	S	ML	RED	1	250	0.117	9.424	2.746	12.287
1	1	MAN	302	3	85G03	S	ML	RED	2	191	0.122	11.549	3.182	14.853
1	1	MAN	302	3	85G03	S	ML	RED	3	175	0.104	14.743	2.436	17.283
1	1	MAN	303	3	86G32	S	M	RED	1	171	0.126	12.131	3.177	15.434
1	1	MAN	303	3	86G32	S	M	RED	2	211	0.117	8.606	2.420	11.143
1	1	MAN	303	3	86G32	S	M	RED	3	96	0.119	13.908	2.526	16.553
1	1	MAN	304	3	DKC63-84	C	L	C	1	280	0.184	19.479	3.557	23.220
1	1	MAN	304	3	DKC63-84	C	L	C	2	290	0.181	26.112	3.815	30.109
1	1	MAN	304	3	DKC63-84	C	L	C	3	260	0.126	21.454	2.857	24.437
1	1	MAN	305	3	SP3303	S	E	TAN	1	231	0.136	9.695	3.175	13.006

1	1	MAN	305	3	SP3303	S	E	TAN	2	145	0.113	10.453	2.953	13.519
1	1	MAN	305	3	SP3303	S	E	TAN	3	129	0.103	14.394	2.762	17.259
1	1	MAN	306	3	4525	S	ML	TAN	1	230	0.120	9.274	2.607	12.001
1	1	MAN	306	3	4525	S	ML	TAN	2	180	0.116	14.519	2.620	17.255
1	1	MAN	306	3	4525	S	ML	TAN	3	161	0.092	14.418	2.337	16.848
1	1	MAN	401	4	85G03	S	ML	RED	1	234	0.121	9.532	2.752	12.405
1	1	MAN	401	4	85G03	S	ML	RED	2	183	0.102	9.945	2.806	12.853
1	1	MAN	401	4	85G03	S	ML	RED	3	162	0.103	15.244	2.503	17.850
1	1	MAN	402	4	DKC63-84	C	L	C	1	198	0.142	15.430	2.898	18.470
1	1	MAN	402	4	DKC63-84	C	L	C	2	231	0.183	25.355	3.731	29.269
1	1	MAN	402	4	DKC63-84	C	L	C	3	218	0.136	21.934	2.848	24.918
1	1	MAN	403	4	SP3303	S	E	TAN	1	223	0.144	10.575	3.368	14.087
1	1	MAN	403	4	SP3303	S	E	TAN	2	121	0.115	11.655	3.034	14.804
1	1	MAN	403	4	SP3303	S	E	TAN	3	127	0.086	14.558	2.292	16.937
1	1	MAN	404	4	88P68	S	E	RED	1	165	0.133	11.069	3.004	14.206
1	1	MAN	404	4	88P68	S	E	RED	2	142	0.128	9.418	2.778	12.324
1	1	MAN	404	4	88P68	S	E	RED	3	142	0.085	16.761	2.429	19.275
1	1	MAN	405	4	86G32	S	M	RED	1	183	0.122	12.284	3.215	15.621
1	1	MAN	405	4	86G32	S	M	RED	2	239	0.137	10.222	2.919	13.278
1	1	MAN	405	4	86G32	S	M	RED	3	183	0.120	14.141	2.493	16.753
1	1	MAN	406	4	4525	S	ML	TAN	1	215	0.134	9.748	2.762	12.644
1	1	MAN	406	4	4525	S	ML	TAN	2	185	0.103	13.913	2.505	16.521
1	1	MAN	406	4	4525	S	ML	TAN	3	196	0.114	15.531	2.967	18.612
2	2	MAN	101	1	85G03	S	ML	RED	3	491	0.089	20.550	2.922	23.562
2	2	MAN	101	1	85G03	S	ML	RED	2	503	0.070	20.313	3.380	23.764
2	2	MAN	101	1	85G03	S	ML	RED	1	644	0.112	15.872	3.238	19.222
2	2	MAN	102	1	4525	S	ML	TAN	3	413	0.121	18.249	2.876	21.246
2	2	MAN	102	1	4525	S	ML	TAN	2	534	0.073	15.606	2.749	18.428
2	2	MAN	102	1	4525	S	ML	TAN	1	768	0.117	17.722	3.564	21.403
2	2	MAN	103	1	SP3303	S	E	TAN	3	598	0.115	18.045	3.529	21.689

2	2	MAN	103	1	SP3303	S	E	TAN	2	454	0.133	19.673	3.766	23.572
2	2	MAN	103	1	SP3303	S	E	TAN	1	582	0.156	14.841	4.024	19.020
2	2	MAN	104	1	86G32	S	M	RED	3	371	0.106	13.941	2.868	16.916
2	2	MAN	104	1	86G32	S	M	RED	2	600	0.140	13.749	2.845	16.734
2	2	MAN	104	1	86G32	S	M	RED	1	502	0.098	14.298	3.297	17.694
2	2	MAN	105	1	88P68	S	E	RED	3	557	0.127	13.713	2.518	16.358
2	2	MAN	105	1	88P68	S	E	RED	2	399	0.094	15.204	2.697	17.996
2	2	MAN	105	1	88P68	S	E	RED	1	500	0.118	14.100	3.315	17.532
2	2	MAN	106	1	DKC63-84	C	L	C	3	476	0.176	22.356	3.712	26.243
2	2	MAN	106	1	DKC63-84	C	L	C	2	478	0.207	20.052	3.292	23.551
2	2	MAN	106	1	DKC63-84	C	L	C	1	.	.	.	.	.
2	2	MAN	201	2	88P68	S	E	RED	3	437	0.133	13.817	2.147	16.097
2	2	MAN	201	2	88P68	S	E	RED	2	401	0.124	17.224	3.190	20.537
2	2	MAN	201	2	88P68	S	E	RED	1	602	0.106	12.910	3.103	16.119
2	2	MAN	202	2	86G32	S	M	RED	3	487	0.119	14.358	2.506	16.983
2	2	MAN	202	2	86G32	S	M	RED	2	.	.	.	.	.
2	2	MAN	202	2	86G32	S	M	RED	1	546	0.107	13.762	2.974	16.844
2	2	MAN	203	2	DKC63-84	C	L	C	3	380	0.192	17.319	3.664	21.175
2	2	MAN	203	2	DKC63-84	C	L	C	2	540	0.204	25.857	4.190	30.252
2	2	MAN	203	2	DKC63-84	C	L	C	1	642	0.224	16.621	4.186	21.031
2	2	MAN	204	2	4525	S	ML	TAN	3	525	0.091	17.160	2.481	19.732
2	2	MAN	204	2	4525	S	ML	TAN	2	565	0.099	12.076	2.507	14.682
2	2	MAN	204	2	4525	S	ML	TAN	1	658	0.100	14.521	3.272	17.892
2	2	MAN	205	2	SP3303	S	E	TAN	3	514	0.107	14.124	2.821	17.052
2	2	MAN	205	2	SP3303	S	E	TAN	2	506	0.116	13.307	3.095	16.518
2	2	MAN	205	2	SP3303	S	E	TAN	1	572	0.138	11.548	3.725	15.411
2	2	MAN	206	2	85G03	S	ML	RED	3	438	0.121	20.647	3.487	24.255
2	2	MAN	206	2	85G03	S	ML	RED	2	410	0.091	16.532	2.809	19.431
2	2	MAN	206	2	85G03	S	ML	RED	1	738	0.112	15.477	3.233	18.822
2	2	MAN	301	3	SP3303	S	E	TAN	3	588	0.125	16.775	3.193	20.092

2	2	MAN	301	3	SP3303	S	E	TAN	2	498	0.115	20.873	4.565	25.553
2	2	MAN	301	3	SP3303	S	E	TAN	1	534	0.202	14.147	3.990	18.338
2	2	MAN	302	3	85G03	S	ML	RED	3	495	0.119	24.633	3.330	28.082
2	2	MAN	302	3	85G03	S	ML	RED	2	631	0.159	18.555	3.477	22.191
2	2	MAN	302	3	85G03	S	ML	RED	1	644	0.104	16.030	3.117	19.252
2	2	MAN	303	3	4525	S	ML	TAN	3	422	0.110	18.185	2.681	20.976
2	2	MAN	303	3	4525	S	ML	TAN	2	626	0.117	15.358	3.004	18.479
2	2	MAN	303	3	4525	S	ML	TAN	1	794	0.097	15.548	3.121	18.766
2	2	MAN	304	3	88P68	S	E	RED	3	471	0.146	14.286	2.695	17.127
2	2	MAN	304	3	88P68	S	E	RED	2	393	0.136	17.869	2.907	20.912
2	2	MAN	304	3	88P68	S	E	RED	1	554	0.132	14.837	3.323	18.292
2	2	MAN	305	3	DKC63-84	C	L	C	3	438	0.234	21.676	3.982	25.891
2	2	MAN	305	3	DKC63-84	C	L	C	2	450	0.210	15.557	3.986	19.753
2	2	MAN	305	3	DKC63-84	C	L	C	1	528	0.235	19.779	3.988	24.002
2	2	MAN	306	3	86G32	S	M	RED	3	462	0.098	15.257	2.714	18.069
2	2	MAN	306	3	86G32	S	M	RED	2	441	0.099	13.374	2.696	16.169
2	2	MAN	306	3	86G32	S	M	RED	1	596	0.109	13.154	3.042	16.305
2	2	MAN	401	4	DKC63-84	C	L	C	3	522	0.203	32.544	4.443	37.189
2	2	MAN	401	4	DKC63-84	C	L	C	2	506	0.235	29.322	4.480	34.037
2	2	MAN	401	4	DKC63-84	C	L	C	1	726	0.209	22.291	4.746	27.246
2	2	MAN	402	4	88P68	S	E	RED	3	436	0.122	15.879	2.781	18.782
2	2	MAN	402	4	88P68	S	E	RED	2	520	0.103	13.006	2.473	15.581
2	2	MAN	402	4	88P68	S	E	RED	1	546	0.133	15.343	3.444	18.919
2	2	MAN	403	4	85G03	S	ML	RED	3	408	0.107	18.898	2.878	21.883
2	2	MAN	403	4	85G03	S	ML	RED	2	451	0.112	17.175	3.024	20.312
2	2	MAN	403	4	85G03	S	ML	RED	1	680	0.166	13.639	3.599	17.405
2	2	MAN	404	4	SP3303	S	E	TAN	3	548	0.100	16.862	3.244	20.207
2	2	MAN	404	4	SP3303	S	E	TAN	2	532	0.127	11.166	2.684	13.978
2	2	MAN	404	4	SP3303	S	E	TAN	1	648	0.163	13.061	4.189	17.412
2	2	MAN	405	4	86G32	S	M	RED	3	487	0.118	14.400	2.806	17.324

2	2	MAN	405	4	86G32	S	M	RED	2	454	0.118	16.745	3.047	19.911
2	2	MAN	405	4	86G32	S	M	RED	1	552	0.098	16.691	4.540	21.330
2	2	MAN	406	4	4525	S	ML	TAN	3	688	0.114	19.825	3.066	23.005
2	2	MAN	406	4	4525	S	ML	TAN	2	450	0.103	22.149	3.459	25.711
2	2	MAN	406	4	4525	S	ML	TAN	1	854	0.113	18.106	4.086	22.305
2	3	HUT	101	1	85G03	S	ML	RED	3	393	0.165	15.608	3.328	19.101
2	3	HUT	101	1	85G03	S	ML	RED	2	384	0.147	9.238	2.584	11.969
2	3	HUT	101	1	85G03	S	ML	RED	1	399	0.178	13.170	3.370	16.717
2	3	HUT	102	1	SP3303	S	E	TAN	3	296	0.185	12.778	3.353	16.316
2	3	HUT	102	1	SP3303	S	E	TAN	2	278	0.193	17.125	4.146	21.464
2	3	HUT	102	1	SP3303	S	E	TAN	1	266	0.212	13.429	4.221	17.862
2	3	HUT	103	1	4525	S	ML	TAN	3	282	0.153	17.973	3.782	21.908
2	3	HUT	103	1	4525	S	ML	TAN	2	316	0.129	14.902	3.074	18.105
2	3	HUT	103	1	4525	S	ML	TAN	1	325	0.153	16.578	3.928	20.658
2	3	HUT	104	1	DKC63-84	C	L	C	3	230	0.261	13.344	4.920	18.525
2	3	HUT	104	1	DKC63-84	C	L	C	2	253	0.323	14.535	4.755	19.613
2	3	HUT	104	1	DKC63-84	C	L	C	1	211	0.318	14.677	5.665	20.661
2	3	HUT	105	1	86G32	S	M	RED	3	287	0.173	10.107	2.666	12.947
2	3	HUT	105	1	86G32	S	M	RED	2	281	0.169	15.747	3.637	19.553
2	3	HUT	105	1	86G32	S	M	RED	1	307	0.158	10.576	3.078	13.813
2	3	HUT	106	1	88P68	S	E	RED	3	226	0.170	11.781	3.178	15.129
2	3	HUT	106	1	88P68	S	E	RED	2	236	0.172	15.937	3.588	19.697
2	3	HUT	106	1	88P68	S	E	RED	1	242	0.196	11.462	3.279	14.938
2	3	HUT	201	2	86G32	S	M	RED	3	354	0.161	12.274	3.560	15.995
2	3	HUT	201	2	86G32	S	M	RED	2	345	0.161	11.720	3.262	15.143
2	3	HUT	201	2	86G32	S	M	RED	1	378	0.147	11.545	3.502	15.193
2	3	HUT	202	2	DKC63-84	C	L	C	3	225	0.339	21.235	5.933	27.507
2	3	HUT	202	2	DKC63-84	C	L	C	2	206	0.258	12.927	5.675	18.860
2	3	HUT	202	2	DKC63-84	C	L	C	1	205	0.322	15.517	5.037	20.875
2	3	HUT	203	2	88P68	S	E	RED	3	178	0.173	10.394	2.830	13.397

2	3	HUT	203	2	88P68	S	E	RED	2	182	0.150	8.169	2.465	10.784
2	3	HUT	203	2	88P68	S	E	RED	1	198	0.158	10.035	2.937	13.130
2	3	HUT	204	2	SP3303	S	E	TAN	3	.	.	.	.	.
2	3	HUT	204	2	SP3303	S	E	TAN	2	276	.	.	.	.
2	3	HUT	204	2	SP3303	S	E	TAN	1	227	0.263	10.467	3.132	13.862
2	3	HUT	205	2	4525	S	ML	TAN	3	305	0.132	13.590	2.777	16.499
2	3	HUT	205	2	4525	S	ML	TAN	2	301	0.128	12.088	2.488	14.704
2	3	HUT	205	2	4525	S	ML	TAN	1	304	0.124	13.533	3.143	16.799
2	3	HUT	206	2	85G03	S	ML	RED	3	318	0.156	13.915	2.906	16.978
2	3	HUT	206	2	85G03	S	ML	RED	2	337	0.126	10.420	2.252	12.798
2	3	HUT	206	2	85G03	S	ML	RED	1	331	0.184	12.901	3.547	16.632
2	3	HUT	301	3	4525	S	ML	TAN	3	342	0.123	14.081	2.981	17.185
2	3	HUT	301	3	4525	S	ML	TAN	2	343	0.120	12.976	2.627	15.723
2	3	HUT	301	3	4525	S	ML	TAN	1	356	0.213	11.248	2.977	14.437
2	3	HUT	302	3	85G03	S	ML	RED	3	315	0.201	10.000	2.235	12.435
2	3	HUT	302	3	85G03	S	ML	RED	2	340	0.229	12.324	2.868	15.421
2	3	HUT	302	3	85G03	S	ML	RED	1	316	0.186	8.245	2.738	11.170
2	3	HUT	303	3	SP3303	S	E	TAN	3	249	0.278	9.234	2.469	11.981
2	3	HUT	303	3	SP3303	S	E	TAN	2	217	0.339	12.069	2.999	15.407
2	3	HUT	303	3	SP3303	S	E	TAN	1	265	0.308	9.071	2.748	12.127
2	3	HUT	304	3	86G32	S	M	RED	3	250	0.224	9.946	2.815	12.985
2	3	HUT	304	3	86G32	S	M	RED	2	237	0.165	9.117	2.355	11.637
2	3	HUT	304	3	86G32	S	M	RED	1	254	0.160	10.396	3.052	13.608
2	3	HUT	305	3	88P68	S	E	RED	3	281	0.127	12.055	3.108	15.290
2	3	HUT	305	3	88P68	S	E	RED	2	289	0.223	9.797	2.505	12.525
2	3	HUT	305	3	88P68	S	E	RED	1	290	0.206	8.503	2.608	11.318
2	3	HUT	306	3	DKC63-84	C	L	C	3	249	0.409	11.714	3.687	15.810
2	3	HUT	306	3	DKC63-84	C	L	C	2	232	0.363	12.031	3.308	15.702
2	3	HUT	306	3	DKC63-84	C	L	C	1	246	0.347	19.539	5.213	25.100
2	3	HUT	401	4	88P68	S	E	RED	3	170	0.218	9.777	2.466	12.461

2	3	HUT	401	4	88P68	S	E	RED	2	172	0.141	12.234	2.975	15.351
2	3	HUT	401	4	88P68	S	E	RED	1	179	0.180	9.405	2.615	12.201
2	3	HUT	402	4	86G32	S	M	RED	3	231	0.193	9.188	2.227	11.607
2	3	HUT	402	4	86G32	S	M	RED	2	252	0.183	9.125	2.341	11.649
2	3	HUT	402	4	86G32	S	M	RED	1	247	0.197	9.733	2.683	12.613
2	3	HUT	403	4	85G03	S	ML	RED	3	228	0.207	12.295	2.399	14.901
2	3	HUT	403	4	85G03	S	ML	RED	2	270	0.182	12.015	2.617	14.814
2	3	HUT	403	4	85G03	S	ML	RED	1	259	0.203	10.670	2.558	13.431
2	3	HUT	404	4	4525	S	ML	TAN	3	324	0.152	11.947	2.423	14.523
2	3	HUT	404	4	4525	S	ML	TAN	2	370	0.157	9.854	2.299	12.311
2	3	HUT	404	4	4525	S	ML	TAN	1	370	0.190	11.619	2.791	14.601
2	3	HUT	405	4	DKC63-84	C	L	C	3	229	0.399	23.021	5.161	28.580
2	3	HUT	405	4	DKC63-84	C	L	C	2	217	0.285	11.959	4.617	16.862
2	3	HUT	405	4	DKC63-84	C	L	C	1	248	0.409	15.049	4.945	20.404
2	3	HUT	406	4	SP3303	S	E	TAN	3	260	0.194	13.653	3.370	17.217
2	3	HUT	406	4	SP3303	S	E	TAN	2	273	0.255	8.988	2.911	12.154
2	3	HUT	406	4	SP3303	S	E	TAN	1	274	0.224	12.060	3.825	16.109

Table D.2 Vanillic, *p*-coumaric, and ferulic acid quantity data.

YR	ENV	LOC	PLOT	BLOC	HYBRID	CROP	MAT-URITY	PIG-MENT	SAMPLE TIME	RES-IDUE DRY WT.	VA	PCA	FA	TOTAL
										g	$g\ m^{-2}$			
1	1	MAN	101	1	SP3303	S	E	TAN	1	241	0.064	5.031	1.597	6.691
1	1	MAN	101	1	SP3303	S	E	TAN	2	153	0.033	3.645	0.947	4.626
1	1	MAN	101	1	SP3303	S	E	TAN	3	147	0.029	4.099	0.894	5.021
1	1	MAN	102	1	86G32	S	M	RED	1	184	0.047	4.799	1.241	6.086
1	1	MAN	102	1	86G32	S	M	RED	2	226	0.058	3.880	1.106	5.044
1	1	MAN	102	1	86G32	S	M	RED	3	198	0.048	5.462	0.999	6.508
1	1	MAN	103	1	88P68	S	E	RED	1	241	0.057	5.356	1.428	6.840
1	1	MAN	103	1	88P68	S	E	RED	2	176	0.046	3.203	0.936	4.185
1	1	MAN	103	1	88P68	S	E	RED	3	181	0.034	6.377	0.957	7.368
1	1	MAN	104	1	DKC63-84	C	L	C	1	320	0.105	9.991	1.877	11.973
1	1	MAN	104	1	DKC63-84	C	L	C	2	315	0.098	15.381	2.259	17.739
1	1	MAN	104	1	DKC63-84	C	L	C	3	300	0.068	10.448	1.409	11.925
1	1	MAN	105	1	85G03	S	ML	RED	1	270	0.056	5.189	1.460	6.705
1	1	MAN	105	1	85G03	S	ML	RED	2	207	0.063	4.828	1.395	6.286
1	1	MAN	105	1	85G03	S	ML	RED	3	182	0.034	5.267	0.875	6.176
1	1	MAN	106	1	4525	S	ML	TAN	1	258	0.061	4.981	1.425	6.468
1	1	MAN	106	1	4525	S	ML	TAN	2	213	0.048	7.062	1.288	8.398
1	1	MAN	106	1	4525	S	ML	TAN	3	201	0.034	5.751	0.918	6.703
1	1	MAN	201	2	SP3303	S	E	TAN	1	233	0.063	4.491	1.417	5.971
1	1	MAN	201	2	SP3303	S	E	TAN	2	137	0.035	3.435	0.868	4.339
1	1	MAN	201	2	SP3303	S	E	TAN	3	151	0.033	4.529	0.870	5.432
1	1	MAN	202	2	DKC63-84	C	L	C	1	299	0.089	9.607	1.990	11.686
1	1	MAN	202	2	DKC63-84	C	L	C	2	270	0.086	13.267	1.926	15.278

1	1	MAN	202	2	DKC63-84	C	L	C	3	273	0.071	11.961	1.571	13.603
1	1	MAN	203	2	4525	S	ML	TAN	1	224	0.057	4.087	1.174	5.318
1	1	MAN	203	2	4525	S	ML	TAN	2	193	0.043	5.933	1.046	7.022
1	1	MAN	203	2	4525	S	ML	TAN	3	189	0.031	4.625	0.821	5.477
1	1	MAN	204	2	85G03	S	ML	RED	1	265	0.056	5.135	1.457	6.648
1	1	MAN	204	2	85G03	S	ML	RED	2	184	0.043	4.047	1.184	5.274
1	1	MAN	204	2	85G03	S	ML	RED	3	173	0.037	5.117	0.845	5.998
1	1	MAN	205	2	88P68	S	E	RED	1	208	0.056	4.401	1.218	5.675
1	1	MAN	205	2	88P68	S	E	RED	2	144	0.042	2.836	0.817	3.695
1	1	MAN	205	2	88P68	S	E	RED	3	135	0.024	4.066	0.623	4.713
1	1	MAN	206	2	86G32	S	M	RED	1	163	0.039	3.920	1.033	4.992
1	1	MAN	206	2	86G32	S	M	RED	2	203	0.050	3.531	1.003	4.585
1	1	MAN	206	2	86G32	S	M	RED	3	137	0.032	3.708	0.668	4.408
1	1	MAN	301	3	88P68	S	E	RED	1	230	0.059	5.061	1.386	6.506
1	1	MAN	301	3	88P68	S	E	RED	2	156	0.041	2.882	0.853	3.777
1	1	MAN	301	3	88P68	S	E	RED	3	151	0.025	4.538	0.670	5.234
1	1	MAN	302	3	85G03	S	ML	RED	1	250	0.059	4.712	1.373	6.144
1	1	MAN	302	3	85G03	S	ML	RED	2	191	0.047	4.412	1.216	5.674
1	1	MAN	302	3	85G03	S	ML	RED	3	175	0.036	5.160	0.853	6.049
1	1	MAN	303	3	86G32	S	M	RED	1	171	0.043	4.149	1.086	5.278
1	1	MAN	303	3	86G32	S	M	RED	2	211	0.050	3.632	1.021	4.703
1	1	MAN	303	3	86G32	S	M	RED	3	96	0.023	2.670	0.485	3.178
1	1	MAN	304	3	DKC63-84	C	L	C	1	280	0.103	10.908	1.992	13.003
1	1	MAN	304	3	DKC63-84	C	L	C	2	290	0.105	15.145	2.213	17.463
1	1	MAN	304	3	DKC63-84	C	L	C	3	260	0.065	11.156	1.486	12.707
1	1	MAN	305	3	SP3303	S	E	TAN	1	231	0.063	4.479	1.467	6.009
1	1	MAN	305	3	SP3303	S	E	TAN	2	145	0.033	3.031	0.857	3.921
1	1	MAN	305	3	SP3303	S	E	TAN	3	129	0.027	3.714	0.713	4.453
1	1	MAN	306	3	4525	S	ML	TAN	1	230	0.055	4.266	1.199	5.520
1	1	MAN	306	3	4525	S	ML	TAN	2	180	0.042	5.227	0.943	6.212

1	1	MAN	306	3	4525	S	ML	TAN	3	161	0.030	4.643	0.753	5.425
1	1	MAN	401	4	85G03	S	ML	RED	1	234	0.057	4.461	1.288	5.806
1	1	MAN	401	4	85G03	S	ML	RED	2	183	0.037	3.640	1.027	4.704
1	1	MAN	401	4	85G03	S	ML	RED	3	162	0.033	4.939	0.811	5.784
1	1	MAN	402	4	DKC63-84	C	L	C	1	198	0.056	6.110	1.148	7.314
1	1	MAN	402	4	DKC63-84	C	L	C	2	231	0.084	11.714	1.724	13.522
1	1	MAN	402	4	DKC63-84	C	L	C	3	218	0.059	9.563	1.242	10.864
1	1	MAN	403	4	SP3303	S	E	TAN	1	223	0.064	4.717	1.502	6.283
1	1	MAN	403	4	SP3303	S	E	TAN	2	121	0.028	2.820	0.734	3.583
1	1	MAN	403	4	SP3303	S	E	TAN	3	127	0.022	3.698	0.582	4.302
1	1	MAN	404	4	88P68	S	E	RED	1	165	0.044	3.653	0.991	4.688
1	1	MAN	404	4	88P68	S	E	RED	2	142	0.036	2.675	0.789	3.500
1	1	MAN	404	4	88P68	S	E	RED	3	142	0.024	4.760	0.690	5.474
1	1	MAN	405	4	86G32	S	M	RED	1	183	0.045	4.496	1.177	5.717
1	1	MAN	405	4	86G32	S	M	RED	2	239	0.066	4.886	1.395	6.347
1	1	MAN	405	4	86G32	S	M	RED	3	183	0.044	5.175	0.912	6.132
1	1	MAN	406	4	4525	S	ML	TAN	1	215	0.058	4.191	1.188	5.437
1	1	MAN	406	4	4525	S	ML	TAN	2	185	0.038	5.148	0.927	6.113
1	1	MAN	406	4	4525	S	ML	TAN	3	196	0.045	6.088	1.163	7.296
2	2	MAN	101	1	85G03	S	ML	RED	3	491	0.088	20.164	2.867	23.119
2	2	MAN	101	1	85G03	S	ML	RED	2	503	0.071	20.431	3.400	23.902
2	2	MAN	101	1	85G03	S	ML	RED	1	644	0.145	20.443	4.170	24.758
2	2	MAN	102	1	4525	S	ML	TAN	3	413	0.100	15.070	2.375	17.545
2	2	MAN	102	1	4525	S	ML	TAN	2	534	0.078	16.670	2.937	19.685
2	2	MAN	102	1	4525	S	ML	TAN	1	768	0.179	27.221	5.475	32.876
2	2	MAN	103	1	SP3303	S	E	TAN	3	598	0.138	21.578	4.220	25.935
2	2	MAN	103	1	SP3303	S	E	TAN	2	454	0.121	17.871	3.421	21.413
2	2	MAN	103	1	SP3303	S	E	TAN	1	582	0.181	17.275	4.684	22.140
2	2	MAN	104	1	86G32	S	M	RED	3	371	0.079	10.333	2.126	12.538
2	2	MAN	104	1	86G32	S	M	RED	2	600	0.167	16.496	3.413	20.077

2	2	MAN	104	1	86G32	S	M	RED	1	502	0.098	14.356	3.311	17.764
2	2	MAN	105	1	88P68	S	E	RED	3	557	0.141	15.282	2.806	18.229
2	2	MAN	105	1	88P68	S	E	RED	2	399	0.075	12.127	2.151	14.353
2	2	MAN	105	1	88P68	S	E	RED	1	500	0.118	14.100	3.315	17.532
2	2	MAN	106	1	DKC63-84	C	L	C	3	476	0.167	21.269	3.532	24.968
2	2	MAN	106	1	DKC63-84	C	L	C	2	478	0.198	19.182	3.149	22.529
2	2	MAN	106	1	DKC63-84	C	L	C	1	.	.	.	.	.
2	2	MAN	201	2	88P68	S	E	RED	3	437	0.116	12.076	1.877	14.069
2	2	MAN	201	2	88P68	S	E	RED	2	401	0.099	13.807	2.557	16.463
2	2	MAN	201	2	88P68	S	E	RED	1	602	0.127	15.544	3.736	19.407
2	2	MAN	202	2	86G32	S	M	RED	3	487	0.116	13.993	2.442	16.552
2	2	MAN	202	2	86G32	S	M	RED	2	.	.	.	.	.
2	2	MAN	202	2	86G32	S	M	RED	1	546	0.117	15.028	3.248	18.393
2	2	MAN	203	2	DKC63-84	C	L	C	3	380	0.146	13.156	2.783	16.084
2	2	MAN	203	2	DKC63-84	C	L	C	2	540	0.221	27.905	4.522	32.647
2	2	MAN	203	2	DKC63-84	C	L	C	1	642	0.288	21.341	5.375	27.004
2	2	MAN	204	2	4525	S	ML	TAN	3	525	0.095	18.012	2.604	20.711
2	2	MAN	204	2	4525	S	ML	TAN	2	565	0.112	13.637	2.830	16.579
2	2	MAN	204	2	4525	S	ML	TAN	1	658	0.131	19.110	4.305	23.546
2	2	MAN	205	2	SP3303	S	E	TAN	3	514	0.110	14.525	2.901	17.536
2	2	MAN	205	2	SP3303	S	E	TAN	2	506	0.117	13.478	3.135	16.729
2	2	MAN	205	2	SP3303	S	E	TAN	1	572	0.158	13.210	4.262	17.630
2	2	MAN	206	2	85G03	S	ML	RED	3	438	0.106	18.095	3.056	21.257
2	2	MAN	206	2	85G03	S	ML	RED	2	410	0.074	13.559	2.304	15.937
2	2	MAN	206	2	85G03	S	ML	RED	1	738	0.165	22.845	4.771	27.781
2	2	MAN	301	3	SP3303	S	E	TAN	3	588	0.147	19.734	3.756	23.637
2	2	MAN	301	3	SP3303	S	E	TAN	2	498	0.114	20.789	4.547	25.450
2	2	MAN	301	3	SP3303	S	E	TAN	1	534	0.216	15.109	4.261	19.585
2	2	MAN	302	3	85G03	S	ML	RED	3	495	0.118	24.367	3.294	27.779
2	2	MAN	302	3	85G03	S	ML	RED	2	631	0.200	23.409	4.386	27.996

2	2	MAN	302	3	85G03	S	ML	RED	1	644	0.134	20.647	4.015	24.796
2	2	MAN	303	3	4525	S	ML	TAN	3	422	0.093	15.352	2.263	17.708
2	2	MAN	303	3	4525	S	ML	TAN	2	626	0.146	19.219	3.760	23.125
2	2	MAN	303	3	4525	S	ML	TAN	1	794	0.155	24.689	4.956	29.800
2	2	MAN	304	3	88P68	S	E	RED	3	471	0.137	13.446	2.536	16.120
2	2	MAN	304	3	88P68	S	E	RED	2	393	0.107	14.049	2.286	16.441
2	2	MAN	304	3	88P68	S	E	RED	1	554	0.146	16.439	3.682	20.267
2	2	MAN	305	3	DKC63-84	C	L	C	3	438	0.205	18.984	3.487	22.676
2	2	MAN	305	3	DKC63-84	C	L	C	2	450	0.189	14.004	3.588	17.782
2	2	MAN	305	3	DKC63-84	C	L	C	1	528	0.248	20.887	4.211	25.346
2	2	MAN	306	3	86G32	S	M	RED	3	462	0.090	14.101	2.508	16.700
2	2	MAN	306	3	86G32	S	M	RED	2	441	0.087	11.796	2.378	14.261
2	2	MAN	306	3	86G32	S	M	RED	1	596	0.129	15.680	3.627	19.436
2	2	MAN	401	4	DKC63-84	C	L	C	3	522	0.211	33.956	4.636	38.803
2	2	MAN	401	4	DKC63-84	C	L	C	2	506	0.238	29.679	4.535	34.452
2	2	MAN	401	4	DKC63-84	C	L	C	1	726	0.303	32.367	6.891	39.561
2	2	MAN	402	4	88P68	S	E	RED	3	436	0.106	13.840	2.424	16.370
2	2	MAN	402	4	88P68	S	E	RED	2	520	0.107	13.521	2.571	16.198
2	2	MAN	402	4	88P68	S	E	RED	1	546	0.145	16.754	3.761	20.660
2	2	MAN	403	4	85G03	S	ML	RED	3	408	0.087	15.406	2.346	17.839
2	2	MAN	403	4	85G03	S	ML	RED	2	451	0.101	15.475	2.725	18.301
2	2	MAN	403	4	85G03	S	ML	RED	1	680	0.226	18.549	4.895	23.671
2	2	MAN	404	4	SP3303	S	E	TAN	3	548	0.110	18.485	3.556	22.151
2	2	MAN	404	4	SP3303	S	E	TAN	2	532	0.135	11.870	2.853	14.858
2	2	MAN	404	4	SP3303	S	E	TAN	1	648	0.211	16.926	5.428	22.566
2	2	MAN	405	4	86G32	S	M	RED	3	487	0.115	14.026	2.733	16.874
2	2	MAN	405	4	86G32	S	M	RED	2	454	0.107	15.211	2.768	18.087
2	2	MAN	405	4	86G32	S	M	RED	1	552	0.109	18.427	5.012	23.548
2	2	MAN	406	4	4525	S	ML	TAN	3	688	0.157	27.279	4.219	31.654
2	2	MAN	406	4	4525	S	ML	TAN	2	450	0.093	19.939	3.114	23.145

2	2	MAN	406	4	4525	S	ML	TAN	1	854	0.193	30.926	6.978	38.096
2	3	HUT	101	1	85G03	S	ML	RED	3	393	0.130	12.265	2.615	15.009
2	3	HUT	101	1	85G03	S	ML	RED	2	384	0.113	7.093	1.984	9.190
2	3	HUT	101	1	85G03	S	ML	RED	1	399	0.142	10.507	2.688	13.337
2	3	HUT	102	1	SP3303	S	E	TAN	3	296	0.109	7.559	1.984	9.652
2	3	HUT	102	1	SP3303	S	E	TAN	2	278	0.108	9.535	2.309	11.951
2	3	HUT	102	1	SP3303	S	E	TAN	1	266	0.112	7.134	2.242	9.488
2	3	HUT	103	1	4525	S	ML	TAN	3	282	0.086	10.119	2.129	12.334
2	3	HUT	103	1	4525	S	ML	TAN	2	316	0.081	9.430	1.945	11.457
2	3	HUT	103	1	4525	S	ML	TAN	1	325	0.099	10.766	2.551	13.415
2	3	HUT	104	1	DKC63-84	C	L	C	3	230	0.120	6.141	2.264	8.525
2	3	HUT	104	1	DKC63-84	C	L	C	2	253	0.163	7.346	2.403	9.912
2	3	HUT	104	1	DKC63-84	C	L	C	1	211	0.134	6.197	2.392	8.723
2	3	HUT	105	1	86G32	S	M	RED	3	287	0.099	5.797	1.529	7.426
2	3	HUT	105	1	86G32	S	M	RED	2	281	0.095	8.850	2.044	10.989
2	3	HUT	105	1	86G32	S	M	RED	1	307	0.097	6.485	1.888	8.470
2	3	HUT	106	1	88P68	S	E	RED	3	226	0.077	5.334	1.439	6.850
2	3	HUT	106	1	88P68	S	E	RED	2	236	0.081	7.509	1.691	9.281
2	3	HUT	106	1	88P68	S	E	RED	1	242	0.095	5.550	1.588	7.233
2	3	HUT	201	2	86G32	S	M	RED	3	354	0.114	8.697	2.522	11.334
2	3	HUT	201	2	86G32	S	M	RED	2	345	0.111	8.077	2.248	10.437
2	3	HUT	201	2	86G32	S	M	RED	1	378	0.111	8.721	2.645	11.477
2	3	HUT	202	2	DKC63-84	C	L	C	3	225	0.153	9.560	2.671	12.384
2	3	HUT	202	2	DKC63-84	C	L	C	2	206	0.106	5.321	2.336	7.763
2	3	HUT	202	2	DKC63-84	C	L	C	1	205	0.132	6.368	2.067	8.567
2	3	HUT	203	2	88P68	S	E	RED	3	178	0.062	3.698	1.007	4.767
2	3	HUT	203	2	88P68	S	E	RED	2	182	0.054	2.965	0.895	3.915
2	3	HUT	203	2	88P68	S	E	RED	1	198	0.062	3.970	1.162	5.194
2	3	HUT	204	2	SP3303	S	E	TAN	3	.	.	.	.	.
2	3	HUT	204	2	SP3303	S	E	TAN	2	276	.	.	.	.

2	3	HUT	204	2	SP3303	S	E	TAN	1	227	0.119	4.746	1.420	6.285
2	3	HUT	205	2	4525	S	ML	TAN	3	305	0.080	8.287	1.694	10.061
2	3	HUT	205	2	4525	S	ML	TAN	2	301	0.077	7.272	1.497	8.846
2	3	HUT	205	2	4525	S	ML	TAN	1	304	0.075	8.214	1.908	10.197
2	3	HUT	206	2	85G03	S	ML	RED	3	318	0.099	8.842	1.847	10.788
2	3	HUT	206	2	85G03	S	ML	RED	2	337	0.085	7.017	1.516	8.618
2	3	HUT	206	2	85G03	S	ML	RED	1	331	0.122	8.551	2.351	11.024
2	3	HUT	301	3	4525	S	ML	TAN	3	342	0.084	9.626	2.038	11.748
2	3	HUT	301	3	4525	S	ML	TAN	2	343	0.082	8.894	1.801	10.777
2	3	HUT	301	3	4525	S	ML	TAN	1	356	0.151	7.999	2.117	10.268
2	3	HUT	302	3	85G03	S	ML	RED	3	315	0.126	6.300	1.408	7.834
2	3	HUT	302	3	85G03	S	ML	RED	2	340	0.156	8.378	1.950	10.483
2	3	HUT	302	3	85G03	S	ML	RED	1	316	0.118	5.206	1.729	7.053
2	3	HUT	303	3	SP3303	S	E	TAN	3	249	0.139	4.604	1.231	5.974
2	3	HUT	303	3	SP3303	S	E	TAN	2	217	0.147	5.228	1.299	6.674
2	3	HUT	303	3	SP3303	S	E	TAN	1	265	0.163	4.801	1.454	6.418
2	3	HUT	304	3	86G32	S	M	RED	3	250	0.112	4.969	1.406	6.487
2	3	HUT	304	3	86G32	S	M	RED	2	237	0.078	4.314	1.114	5.507
2	3	HUT	304	3	86G32	S	M	RED	1	254	0.081	5.281	1.551	6.913
2	3	HUT	305	3	88P68	S	E	RED	3	281	0.072	6.779	1.748	8.599
2	3	HUT	305	3	88P68	S	E	RED	2	289	0.129	5.661	1.447	7.237
2	3	HUT	305	3	88P68	S	E	RED	1	290	0.120	4.935	1.514	6.569
2	3	HUT	306	3	DKC63-84	C	L	C	3	249	0.204	5.831	1.835	7.870
2	3	HUT	306	3	DKC63-84	C	L	C	2	232	0.168	5.575	1.533	7.276
2	3	HUT	306	3	DKC63-84	C	L	C	1	246	0.171	9.625	2.568	12.364
2	3	HUT	401	4	88P68	S	E	RED	3	170	0.074	3.314	0.836	4.224
2	3	HUT	401	4	88P68	S	E	RED	2	172	0.049	4.206	1.023	5.278
2	3	HUT	401	4	88P68	S	E	RED	1	179	0.065	3.367	0.936	4.368
2	3	HUT	402	4	86G32	S	M	RED	3	231	0.089	4.239	1.027	5.356
2	3	HUT	402	4	86G32	S	M	RED	2	252	0.092	4.595	1.179	5.866

2	3	HUT	402	4	86G32	S	M	RED	1	247	0.098	4.810	1.326	6.233
2	3	HUT	403	4	85G03	S	ML	RED	3	228	0.094	5.599	1.093	6.786
2	3	HUT	403	4	85G03	S	ML	RED	2	270	0.098	6.498	1.415	8.011
2	3	HUT	403	4	85G03	S	ML	RED	1	259	0.105	5.516	1.323	6.944
2	3	HUT	404	4	4525	S	ML	TAN	3	324	0.099	7.751	1.572	9.422
2	3	HUT	404	4	4525	S	ML	TAN	2	370	0.116	7.288	1.701	9.105
2	3	HUT	404	4	4525	S	ML	TAN	1	370	0.141	8.605	2.067	10.813
2	3	HUT	405	4	DKC63-84	C	L	C	3	229	0.182	10.530	2.361	13.073
2	3	HUT	405	4	DKC63-84	C	L	C	2	217	0.124	5.193	2.005	7.321
2	3	HUT	405	4	DKC63-84	C	L	C	1	248	0.203	7.464	2.453	10.120
2	3	HUT	406	4	SP3303	S	E	TAN	3	260	0.101	7.108	1.754	8.963
2	3	HUT	406	4	SP3303	S	E	TAN	2	273	0.139	4.898	1.587	6.624
2	3	HUT	406	4	SP3303	S	E	TAN	1	274	0.123	6.614	2.098	8.834