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Abstract

Producers are interested in growing cover crops and reducing fallow. Growing a crop during the fallow period would increase profitability if crop benefits exceeded expenses. Benefits of growing a cover crop were shown in high rainfall areas, but limited information is available on growing cover crops in place of fallow in the semiarid Great Plains. A study was done from 2007–2016 that evaluated cover crops, annual forages, and short season grain crops grown in place of fallow. In the first experiment (2007-2012) the rotation was no-till wheat-fallow, and in the second experiment (2012-2016) the rotation was no-till wheat-grain sorghum-fallow. This report presents results from the second experiment. The previous crop affected wheat yield; however, growing a previous crop as hay or cover did not affect wheat yield. Wheat yield following the previous crop was dependent on precipitation during fallow and the growing season. In dry years (2011-2014), growing a crop during the fallow period reduced wheat yields, while growing a crop during the fallow period had little impact on wheat yield in wet years (2008-2010). The length of the fallow period also affected yields of the following wheat crop. Growing a cover or hay crop until June 1 affected wheat less than if a winter or spring crop were grown for grain, which was approximately the first week of July. Cover crops did not improve wheat or grain sorghum yields compared to fallow. To be successful, the benefits of growing a cover crop during the fallow period must be greater than the expense of growing it; plus compensate for any negative yield impacts on the subsequent crop. Cover crops always resulted in less profit than fallow, while annual forages often increased profit compared to fallow. The negative effects on wheat yields might be minimized with flex-fallow, which is the concept of only growing a crop in place of fallow in years when soil moisture at planting and precipitation outlook are favorable at the time of making the decision to plant.

Keywords

cover crops, annual forages, short-season grain crops, wheat, grain sorghum, yields, fallow replacement crops, sweet clover, hairy vetch, lentil, Austrian winter forage pea, Austrian winter grain pea, triticale

Fallow Replacement Crop (Cover Crops, Annual Forages, and Short-Season Grain Crops) Effects on Wheat and Grain Sorghum Yields

J. Holman, T. Roberts, and S. Maxwell

Summary

Producers are interested in growing cover crops and reducing fallow. Growing a crop during the fallow period would increase profitability if crop benefits exceeded expenses. Benefits of growing a cover crop were shown in high rainfall areas, but limited information is available on growing cover crops in place of fallow in the semiarid Great Plains. A study was done from 2007–2016 that evaluated cover crops, annual forages, and short season grain crops grown in place of fallow. In the first experiment (2007-2012) the rotation was no-till wheat-fallow, and in the second experiment (2012-2016) the rotation was no-till wheat-grain sorghum-fallow. This report presents results from the second experiment. The previous crop affected wheat yield; however, growing a previous crop as hay or cover did not affect wheat yield. Wheat yield following the previous crop was dependent on precipitation during fallow and the growing season. In dry years (2011-2014), growing a crop during the fallow period reduced wheat yields, while growing a crop during the fallow period had little impact on wheat yield in wet years (2008-2010). The length of the fallow period also affected yields of the following wheat crop. Growing a cover or hay crop until June 1 affected wheat less than if a winter or spring crop were grown for grain, which was approximately the first week of July. Cover crops did not improve wheat or grain sorghum yields compared to fallow. To be successful, the benefits of growing a cover crop during the fallow period must be greater than the expense of growing it; plus compensate for any negative yield impacts on the subsequent crop. Cover crops always resulted in less profit than fallow, while annual forages often increased profit compared to fallow. The negative effects on wheat yields might be minimized with flex-fallow, which is the concept of only growing a crop in place of fallow in years when soil moisture at planting and precipitation outlook are favorable at the time of making the decision to plant.

Introduction

Interest in replacing fallow with a cash crop or cover crop has necessitated research on soil water and wheat yields following a shortened fallow period. Fallow stores moisture, which helps stabilize crop yields and reduces the risk of crop failure; however, only 25 to 30% of the precipitation received during the fallow period of a no-till wheat-fallow rotation is stored. The remaining 85 to 70% of precipitation is lost, primarily due to evaporation. Moisture storage in fallow is more efficient earlier in the fallow period, when the soil is dry, and during the winter months when the evaporation rate is lower. It may be possible to increase cropping intensity without reducing winter wheat yield. This study evaluated replacing part of the fallow period with a cover, annual forage, or short-season grain crop on plant-available water at wheat planting and winter wheat yield.

Procedures

A study from 2007–2014 evaluated cover crops, annual forages, and spring grain crops (peas, oat, or triticale) grown in place of fallow in a no-till wheat-fallow rotation. This first experiment was modified beginning in 2012 to a wheat-grain sorghum-fallow rotation. Treatments that stayed the same between experiments 1 and 2 were maintained in the same plots so that long-term treatment impacts could be determined. Fallow replacement crops (cover crop, annual forage, or short-season grain crop) were either grown as standing cover, harvested for forage (annual forage crop), or harvested for grain.

In experiment 1 (2007-2012) both winter and spring crop species were evaluated. Winter species included yellow sweet clover (*Melilotus officinalis* (L.) Lam.), hairy vetch (*Vicia villosa* Roth ssp.), lentil (*Lens culinaris* Medik.), Austrian winter forage pea (*Pisum sativum* L. ssp.), Austrian winter grain pea (*Pisum sativum* L. ssp.), and triticale (×*Triticosecale* Wittm.). Spring species included lentil (*Lens culinaris* Medik.), forage pea (*Pisum sativum* L. ssp.), grain pea (*Pisum sativum* L. ssp.), and triticale (×*Triticosecale* Wittm.). Crops were grown in monoculture and in two-species mixtures of each legume plus triticale. Crops grown for grain were grown in monoculture only. Winter lentil was grown in place of yellow sweet clover beginning in 2008. Crops grown in place of fallow were compared with a wheat-fallow and continuous wheat rotation for a total of 16 treatments. The study design was a split-split-plot randomized complete block design with four replications; crop phase (wheat-fallow) was the main plot, fallow replacement was the split-plot, and fallow replacement method (forage, grain, or cover) was the split-split-plot. The main plot was 480 ft wide and 120 ft long, the split-plot was 30 ft wide and 120 ft long, and the split-split plot was 15 ft wide and 120 ft long.

In experiment 2 (2012-2014) spring crops were grown the year following grain sorghum. Grain sorghum is harvested late in the year and in most years does not enable growing a winter crop during the fallow period. Spring planted treatments included spring grain pea; spring pea plus spring oat (*Avena sativa* L.); spring pea plus spring triticale; spring oat; spring triticale; and a six species "cocktail" mixture of spring oat, spring triticale, spring pea, buckwheat var. Mancan (*Fagopyrum esculentum* Moench), purple top turnip (*Brassica campestris* L.), and forage radish (*Raphanus sativus* L.). In addition, spring grain pea, spring oat, and safflower (*Carthamus tinctorius* L.) were grown for grain. Safflower was only grown in 2012, and that treatment was replaced with spring oat grown for grain beginning in 2013. Additional treatments initiated in 2013 were yellow sweetclover planted with grain sorghum and allowed to grow into the fallow year, daikon radish (*Brassica rapa* L.) planted with winter wheat in a wheat-grain sorghum-fallow rotation, shogoin turnip (*Raphanus sativus* L.) planted with winter wheat in a wheat-grain sorghum-fallow rotation, and spring oats or a cocktail planted in a "flex-fallow" system (Table 1). The flex-fallow treatment was planted when a minimum of (12" in 2013) 14" of plant available water (PAW) was determined using a Paul Brown moisture probe at spring planting; otherwise the treatment was left fallow. The flex-fallow treatment was intended to take advantage of growing a crop during the fallow period in wet years and fallowing in dry years. Crops grown for grain were grain peas, spring oat, and triticale. Crops grown in place of fallow were compared with a wheat-grain sorghum-fallow rotation for a total of 16 treatments (Table 1). The study design was a split-split-plot randomized complete block design with four replications; crop phase (wheat-grain sorghum-fallow) was the main plot, fallow replacement was the split-plot, and fallow replacement method (forage, grain, or cover) was the split-split-plot. The main plot was 330 ft wide and 120 ft long, the split-plot was 30 ft wide and 120 ft long, and the split-split plot was 15 ft wide and 120 ft long.

Winter wheat was planted approximately October 1. Spring crops were planted as early as soil conditions allowed, ranging from the end of February through the middle of March. Spring cover and forage crops were chemically terminated or forage-harvested approximately June 1. Biomass yields for both cover crops and forage crops were determined from a 3-ft × 120-ft area cut 3 in. high using a small plot Carter forage harvester from within the split-split-plot managed for forage. Winter and spring grain peas and winter wheat were harvested with a small plot Wintersteiger combine from a 6.5-ft × 120-ft area at grain maturity, which occurred approximately the first week of July.

Volumetric soil moisture content was measured at planting and harvest of winter wheat, grain sorghum, and fallow using a Giddings soil probe by 1-foot increments to a 6-ft soil depth. In addition, volumetric soil content was measured in the 0-3-in. soil depth at wheat planting to quantify moisture in the seed planting depth. Grain yield was adjusted to 13.5% moisture content, and test weight was measured using a grain analysis computer. Grain samples were analyzed for nitrogen content.

Results and Discussion

Winter Wheat Yield in Wheat-Grain Sorghum-Fallow

In 2013, 6.25 inches of precipitation occurred during the winter wheat growing season between planting and harvest. This was about 50% of normal (12.5 inches) for this time period, and was the third consecutive year of drought. The 30-year average precipitation during the fallow period (November-October) of a wheat-grain sorghum-fallow rotation averaged 18.03 inches, and 12.88 inches of precipitation occurred during fallow between November 1, 2011 and October 1, 2012. Below normal precipitation during fallow and the winter wheat growing season resulted in any treatment other than fallow significantly reducing wheat yield 50% or more. The cover crop cocktail treatment yielded 79% less than fallow. Wheat following fallow yielded 19 bu/a and all other treatments yielded between 3 to 9 bu/a (Figure 1).

In 2014, 14.57 inches of precipitation occurred during the winter wheat growing season between planting and harvest. This was above average, but most of the rain came in June (10.5 inches), which was too late to benefit the wheat crop. Therefore wheat yields were significantly reduced by 40-80% by any treatment other than fallow and fallow only yielded 6 bu/a (Figure 2).

In 2015, 12.18 inches of precipitation occurred during the winter wheat growing season between planting and harvest, with most of this occurring in May (6.38 inches). Were it not for the rainfall received in May, yields would have been likely less than 10 bu/a in fallow. Precipitation received in the previous fallow period (between grain sorghum harvest and wheat planting) from November 2013 to October 2015 was 18.87 inches and 30-yr average for this period was 18.03 inches. The early season moisture stress and late season precipitation minimized yield differences between treatments and fallow (Figure 3). Only oats for grain, oat and pea/triticale yielded less than fallow (15 bu/a).

Grain Sorghum Yield in Wheat-Grain Sorghum-Fallow

2015 was the first year grain sorghum was in-phase with a cover crop grown in 2013 ahead of wheat prior to planting grain sorghum. In 2015, 12 inches of precipitation occurred during the growing season between planting and harvest. The 30-year average precipitation during this time period (June-November) averaged 11.06 inches. The above normal rainfall in 2015, particularly early in the growing season (5.36 inches in July and 3.24 inches in August) resulted in above normal sorghum yields ranging from 84 to 109 bu/a (Figure 4). Despite the above normal rainfall and yields there was still a correlation with 2015 grain sorghum and 2014 winter wheat yields, thus the impact of growing a cover crop was evident two years later.

Cover vs. Annual Forage

Similar to the first experiment, there was no difference in wheat or grain sorghum yields whether the previous crop was left as cover or harvested for forage. Despite slightly more plant available water following cover than forage harvest, this indicates the previous crop can be harvested for forage rather than left standing as a cover crop without negatively affecting wheat or grain sorghum yields.

Conclusions

Fallow helps stabilize crop yields in dry years. Annual precipitation in this study ranged from 12.1 to 23.3 inches. The 30-year average precipitation was 19.24 inches. In dry years (2011-2015), growing a crop during the fallow period reduced wheat yields, but in wet years (2008-2010), growing a crop during the fallow period had little impact on wheat yield. The length of the fallow period also affected yields of the following wheat crop. Growing a cover or hay crop until June 1 affected wheat less than if winter wheat or spring crops were grown for grain production, which was approximately the first week of July.

Forages can be profitable to grow in place of fallow in favorable moisture years. However, cover crops were always an expense to grow. The cropping system can be intensified by replacing part of the fallow period with annual forages or spring grain crops to increase profit and improve soil quality; however, in semiarid environments, wheat yields will be reduced in years with below normal precipitation. There was a trend that when wheat yield potential following fallow was less than 50 bu/a reducing fallow reduced wheat yields, but in years where yield potential was greater than 50 bu/a, growing a crop in place of fallow did not reduce wheat yields. Some yield reduction can be offset by the value of a forage or grain crop, but never with a cover crop. The negative impacts on wheat yields might be minimized with "flex-fallow." Flex-fallow is the concept of only planting forage or spring grain crop when soil moisture levels are adequate and the precipitation outlook is favorable. Under drought conditions such as 2011-2014, using flex-fallow, a crop would have not been grown in place of fallow. Implementing flex-fallow may minimize the negative impacts of reduced fallow. However flex-fallow will not prevent reduced yield in years that growing season precipitation levels are below normal. Additional years of data are required to determine the feasibility of flex-fallow and the effects of replacing fallow in a wheat-summer crop-fallow rotation.

Table 1. Fallow treatments 2007-2016.

				Year produced									
Crop	Cover	Hay	Grain	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Fallow				x	x	x	x	x	x	x	x	x	x
Cocktail mix†	x	x							x	x	x	x	x
Cocktail mix† (flex)††		x								-	-	N	Y
Spring oat (flex)		x								Y	N	N	Y
Spring oat		x							x	x	x	x	x
Spring oat (grain)			x						-	x	x	x	x
Spring pea	x	x		x	x	x	x	x	x	-	-	-	-
Spring pea (grain)			x				x	x	x	x	x	x	x
Spring pea/spring oat	x	x							x	x	x	-	-
Spring pea/spring triticale	x	x							x	x	x	-	-
Spring triticale	x	x							x	x	x	-	-
Spring triticale		x		-	x	x	x	x		-	-	x	x
Spring triticale (grain)			x							-	-	x	x
Spring oat/triticale/pea	x	x								x	x	x	x
Spring triticale/oat	x	x								-	-	x	x
Spring triticale/pea		x		-	x	x	x	x	x	-	-	-	-
Spring triticale/lentil					x	x	x	x	-	-	-	-	-
Spring lentil				x	x	x	x	x	-	-	-	-	-

† Oat, triticale, pea, buckwheat, forage brassica and forage radish.
†† Flex: Plant when soil moisture is 14” (12” in 2013) or > and precipitation outlook is neutral or favorable.

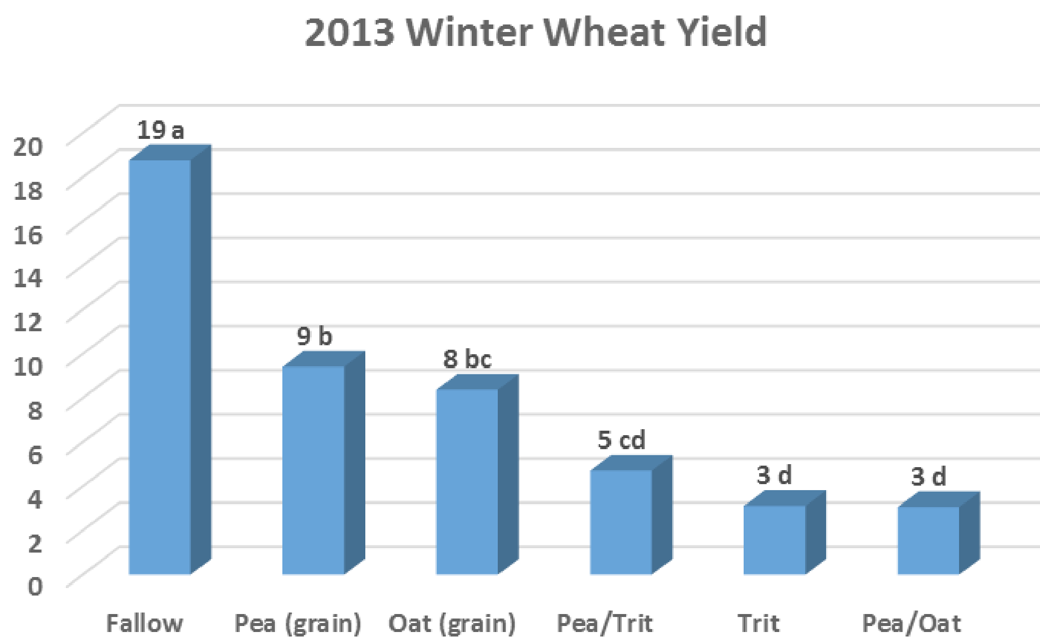

Figure 1. 2013 Winter wheat yield (bu/a). Mean values followed by different letters are statistically different at $P \leq 0.05$.

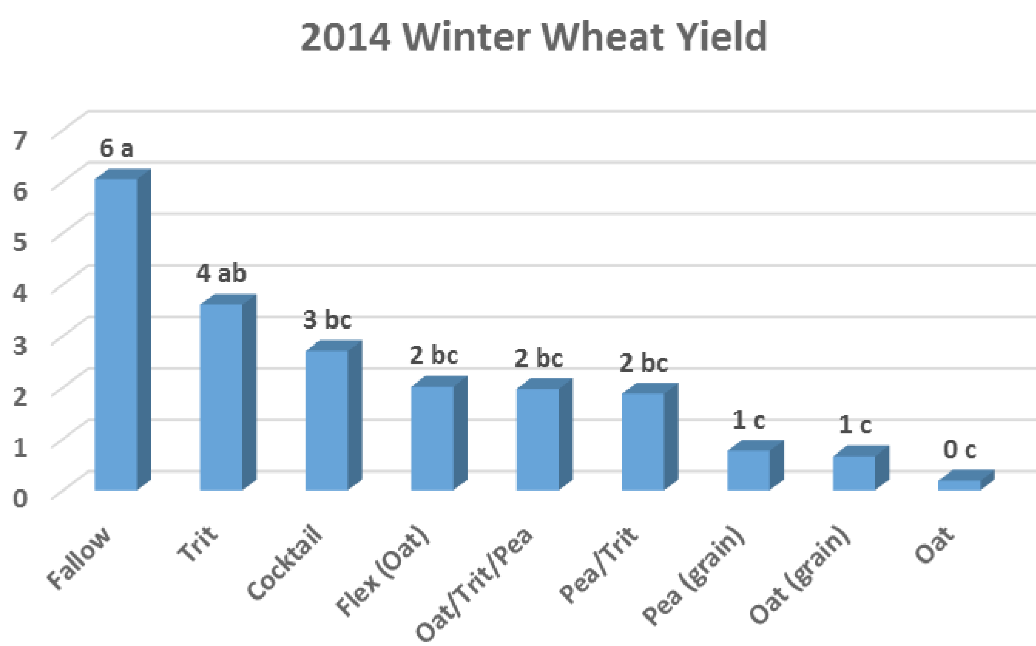

Figure 2. 2014 Winter wheat yield (bu/a). Mean values followed by different letters are statistically different at $P \leq 0.05$.

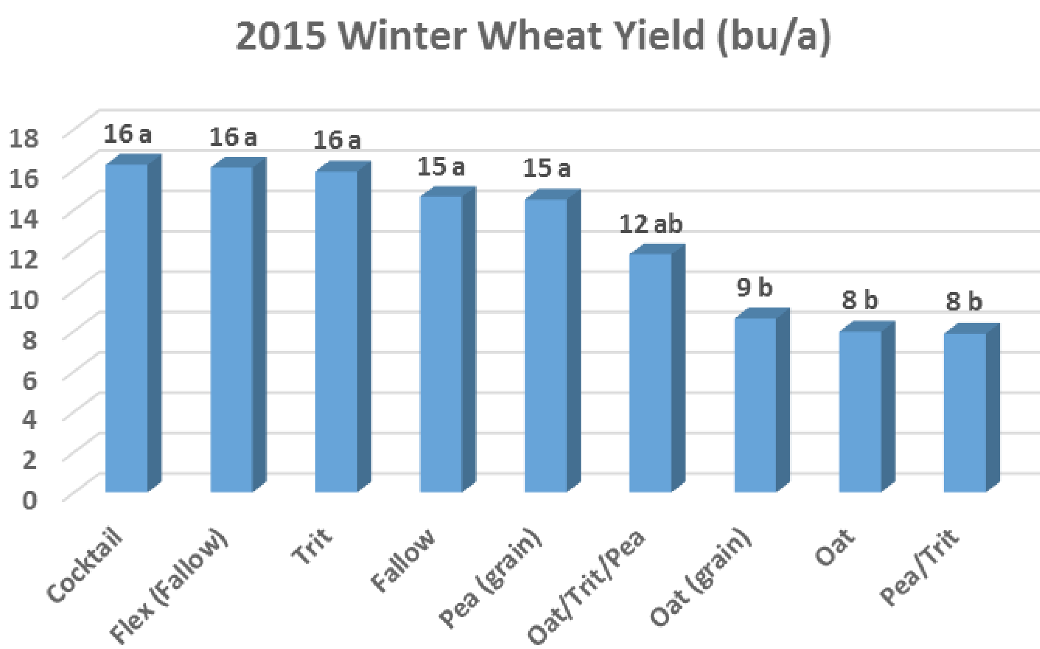

Figure 3. 2015 Winter wheat yield (bu/a). Mean values followed by different letters are statistically different at P ≤ 0.05.

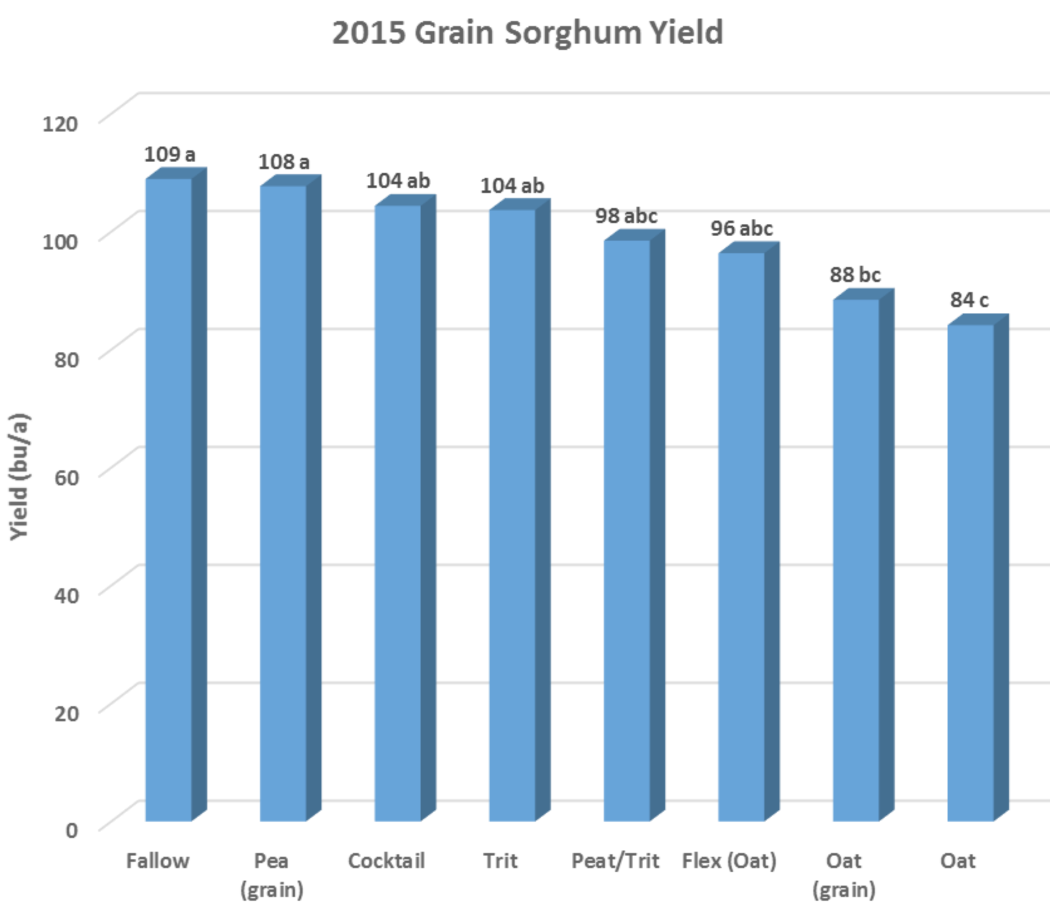

Figure 4. 2015 grain sorghum yield (bu/a). Mean values followed by different letters are statistically different at P ≤ 0.05.