Annual grain legumes are important components of agricultural systems in many parts of the world (Batterham and Egan, 1986). For example, they are the sole protein source for animals and humans in the East African highlands (Campbell, 1997). Grain legumes complement cereal crops in dietary terms, with two or more times the protein and minerals found in cereals (Beebe, 2006). Therefore, legumes offer a practical means of reducing protein malnutrition in cereal-based diets in such areas as the arid Mediterranean region (Bhal, 1988), and many are included in ruminant diets.

Grain legumes other than soybean [Glycine max (L.) Merr.] have begun to receive consideration as feedstuffs in parts of the United States. Field pea (Pisum sativum L.) production in the northern Great Plains has increased in recent years. Field pea grain was found to have energy contents similar to corn (Zea mays L.), and crude protein levels ranging from 17 to 27% (Bock and Anderson, 2001; Anderson et al., 2007; Loe et al., 2004; Wang and Daun, 2004).

Livestock production in the southern Great Plains (SGP) has focused on generating weight gain by yearling stocker cattle from different regions of the United States (Peel, 2003). Stocker cattle graze forages for various periods of time to generate low cost gains, before entering the feedlot phase of growth. The primary forages used in the SGP are winter wheat (Triticum aestivum L.), or different types of warm-season perennial grasses (Phillips and Coleman, 1995; Redmon et al., 1995; Coleman and Forbes, 1998; Krenzer, 2000).

**Abstractions of Four Novel Warm-Season Legumes in the Southern Great Plains: Grain Production and Quality**

Srinivas C. Rao* and Brian K. Northup

**ABSTRACT**

Grain legumes could serve as a low cost nitrogen (N) and energy source for animal production in the southern Great Plains (SGP). This study evaluated the yield and nutritive value of grains of tropical annual legumes novel to the SGP. Included were cultivars of pigeon pea [Cajanus cajan (L.) Millsp.] (cv. GA-2), guar [Cyamopsis tetragonoloba (L.) Taub.] (cv. Kinman), cowpea [Vigna unguiculata (L.) Walp.] (cv. Chinese red), mung bean [Vigna radiata (L.) Wilcz.] (cv. Berkins), and the grain soybean [Glycine max (L.) Merr.] (cv. Hutcheson) as a control. Seeds were inoculated and planted (60-cm row spacing) annually in mid-June 2004 through 2006. Seeding rates were varied to achieve 10 seeds m⁻¹ row length. Grain was harvested at the end of growing seasons (90–120 d since planting), and grain samples were ground (1.0 mm) and analyzed for N concentration and in vitro digestible dry matter (IVDDM). Significant (P < 0.05) year × legume interactions were recorded for all characteristics, with variable legume responses among years. Guar produced both the highest (2730 kg ha⁻¹ in 2004) and lowest (897 kg ha⁻¹ in 2005) grain yields. Nitrogen concentrations were the highest in soybean grain (60.2–60.7 g kg⁻¹) and consistently the lowest in pigeon pea (33.3–34.9 g kg⁻¹). Soybean grain had the highest IVDDM (968–969 g kg⁻¹), while pigeon pea had the consistently lowest digestibility (890–894 g kg⁻¹). The four novel legumes produced grains that meet the nutritional requirements for all classes of stocker or feeder cattle.


**Abbreviations:** CSM, cottonseed meal; IVDDM, in vitro digestible dry matter; MG, maturity groups; N, nitrogen; SGP, southern Great Plains.

Annual grain legumes are important components of agricultural systems in many parts of the world (Batterham and Egan, 1986). For example, they are the sole protein source for animals and humans in the East African highlands (Campbell, 1997). Grain legumes complement cereal crops in dietary terms, with two or more times the protein and minerals found in cereals (Beebe, 2006). Therefore, legumes offer a practical means of reducing protein malnutrition in cereal-based diets in such areas as the arid Mediterranean region (Bhal, 1988), and many are included in ruminant diets. Grain legumes other than soybean [Glycine max (L.) Merr.] have begun to receive consideration as feedstuffs in parts of the United States. Field pea (Pisum sativum L.) production in the northern Great Plains has increased in recent years. Field pea grain was found to have energy contents similar to corn (Zea mays L.), and crude protein levels ranging from 17 to 27% (Bock and Anderson, 2001; Anderson et al., 2007; Loe et al., 2004; Wang and Daun, 2004).

Livestock production in the southern Great Plains (SGP) has focused on generating weight gain by yearling stocker cattle from different regions of the United States (Peel, 2003). Stocker cattle graze forages for various periods of time to generate low cost gains, before entering the feedlot phase of growth. The primary forages used in the SGP are winter wheat (Triticum aestivum L.), or different types of warm-season perennial grasses (Phillips and Coleman, 1995; Redmon et al., 1995; Coleman and Forbes, 1998; Krenzer, 2000).
Warm-season grasses produce large amounts of forage during June through October (Phillips and Coleman, 1995; Coleman and Forbes, 1998), but forage quality can be problematic for stocker cattle, with limited effective utilization due to low digestibility and N concentrations. Supplementary feeding must supply the deficient nutrients to improve stocker performance (Phillips and Horn, 1998). Producers have utilized off-farm sources of protein, such as by-products from the oil seed industry (cottonseed meal) or dehydrated forage legumes, such as alfalfa (Medicago sativa L.) pellets, to enhance livestock performance. The costs of such products are volatile and currently increasing. Further, though commercial urea and protein blocks are convenient and have been successful as supplements (Phillips and Horn, 1998), their costs are greater than high protein feed (Blackwood, 2007).

There are many subtropical and tropical grain legumes that could be used as feedstock in the SGP. The application of some species such as guar (Cyamopsis tetragonoloba [L.] Taub.) in the SGP has been investigated (Stafford, 1982), but they have not been widely incorporated into cropping systems of the SGP. Such species would be adapted to the dry, hot conditions that exist during the summer growing seasons (Garbrecht et al., 2000). Some were incorporated into cropping systems in regions of the tropics and subtropics to diversify agricultural production (Pandy et al., 1983; Senthong and Pandey, 1989; Mandal et al., 1990). Though most are used for human consumption, they have potential as high-protein animal feed (National Academy of Sciences, 1979). Studies have compared cultivar responses for some species (Rao et al., 2003; Rao et al., 2005), but there is little information on direct comparisons of grain production among species in the SGP. This study described the grain yield of four warm-season grain legumes not regularly grown in the SGP and their potential nutritive value as a feed supplement.

### MATERIALS AND METHODS

This study was conducted at the USDA-ARS Grazinglands Research laboratory (35°40′ N, 98° 0′ W, elevation 414 m) near El Reno, OK. Experiments were undertaken during the summer fallow periods (June through October) of 2004 through 2006 within a production system of continuous no-till winter wheat. Soils at the experimental site (USDA-NRCS, 1999) were described as Brewer silty clay loams (fine, mixed, superactive, thermic Udertic Argiustolls). Average maximum and minimum temperatures during June through October were 29°C and 15°C, respectively. Long-term (1971–2000) average precipitation during this period was 425 mm.

Cultivars of four grain legumes were included in the study; pigeon pea [Cajanus cajan (L.) Millsp.] (cv. GA-2), guar (cv. Kinman), cowpea [Vigna unguiculata (L.) Walp.] (cv. Chinese red), and mung bean [Vigna radiata (L.) Wilcz.] (cv. Berkins). A common grain soybean (cv. Hutcheson) was included as a control. The legumes varied in length of growing season and maturity groups (MG). Cowpea and mung bean were short season types, while the guar and pigeon pea were longer season types. Hutcheson soybean has been defined as belonging to MG V. Phosphorus (26 kg ha⁻¹) was applied to the plots following grain harvest of no-till winter wheat (15–20 June). Type of fertilizer changed during the study; P was applied as 0–46–0 in 2004 and as 18–46–0 in 2005 and 2006, because the initial fertilizer was no longer available. Seeds of each cultivar were treated with the proper inoculum and planted 2 cm deep at 60-cm row spacing in three replicate, 3 × 20 m plots on 17 June ± 2 d. The cultivars were repeatedly planted on the same plots throughout the study (treatments fixed in space). Seeding rates were varied for the different legumes to achieve a uniform rate of 10 seeds per meter of row length.

Grain harvest was undertaken at the end of the growing season of each species, which ranged from 90 to 120 d since planting, and occurred in late–September through mid–October. Plots planted to mung bean and cowpea were generally harvested 15 d earlier than the other legumes. Three randomly selected 0.5-m row lengths were clipped 2.5 cm above ground from each plot and seeds were separated from herbage. Grain samples were dried (60°C) in a forced-draft oven to a consistent weight to calculate seed yield. Grain samples were then ground to 1.0 mm particle size for laboratory analyses. Samples were analyzed for N concentration with a complete-combustion N analyzer (Leco 1000, Leco Corp., St. Joseph, MI). In vitro digestible dry matter (IVDDM) was determined by the two-stage technique of Tilley and Terry (1963), as modified by Monson et al. (1969).

Logarithmic transformations of grain biomass and N concentration, and arc sin ½ of proportion (converted from g kg⁻¹) of IVDDM were analyzed by mixed model procedures in longitudinal (repeated measures) analyses (Littell et al., 1996). Tests for compound symmetry during the exploratory phase of analyses indicated autocorrelation among years was not significant for grain production ($W' = 0.98; \chi^2 = 0.17; P = 0.92$) and N concentration ($W' = 0.69; \chi^2 = 3.2; P = 0.20$), and marginal for IVDDM ($W' = 0.51; \chi^2 = 6.1; P = 0.06$). Species were analyzed as the main fixed effect, and years were the longitudinal effect. Analyses utilized compound symmetry variance/covariance matrices (Littell et al., 1996; Patetta, 2005), due to the form of covariance among years, and lack of observations required to utilize more complex forms of matrices. Mean (±1 SE) N and IVDDM accumulated (kg ha⁻¹) across years were calculated to compare nutritional yields of the different species. Significant main and interaction effects were tested by LSMEANS procedures. Tested means and errors were back-transformed and reported in their original scales. Level of significance for these tests was $P = 0.05$. Simple correlations (Statsoft, 1995) determined if grain biomass generated by the legumes were influenced by monthly or total growing season precipitation during the three years of the study ($n = 9$ d.f. per comparison). Level of significance for correlations was $P = 0.10$.

### RESULTS

#### Environmental Conditions

Amount and distribution of precipitation during the study varied among years (Table 1), and segments of all three growing seasons were definable as drought-affected. Growing season precipitation in 2004, 2005, and 2006 was 89, 114, and 43%, respectively, of the long-
Accumulated N and IVDDM

Mean (across years) species-level responses showed the novel legumes did not exceed kg N ha$^{-1}$ accumulated in soybean grain (Table 2). Mung bean, guar, and pigeon pea grains had similar amounts (70–78 kg N ha$^{-1}$), but were 30 kg N ha$^{-1}$ below levels recorded for soybean (107 ± 10 kg ha$^{-1}$), and cowpea grain accumulated only 50% of the N accumulated in soybean. In contrast, accumulated kg IVDDM ha$^{-1}$ was more consistent across species. Mung bean, guar, and soybean accumulated similar amounts of digestible dry matter in grain, while pigeon pea accumulated the highest amounts.

**Grain Production**

Year × species interactions in grain production (Fig. 1A) were significant ($F_{8, 20} = 6.7; P < 0.01$). Guar produced the greatest amounts of grain (LSD = 266 kg ha$^{-1}$) in 2004 (2730 kg ha$^{-1}$), and a group with the second-highest amounts included mung bean in 2004 (2287 kg ha$^{-1}$), and pigeon pea in 2004 and 2006 (2265 and 2206 kg ha$^{-1}$, respectively). Guar also generated the lowest level of grain (897 kg ha$^{-1}$ in 2005). All species except soybean were least productive in 2005 and most productive in 2004. The most consistent year for grain production across species occurred in 2006. Grain production by mung bean, guar, and cowpea were negatively, though weakly, correlated ($r = -0.60$ to $-0.75$) with precipitation received in June (planting and emergence), August, and September (pod formation), and production by guar was positively correlated ($r = 0.74$) with October precipitation. Grain produced by pigeon pea and soybean was uncorrelated ($r = -0.39$ to 0.36) to precipitation during individual months, or the entire growing season.

**N Concentration**

Year × species interactions in N concentrations of grain (Fig. 1B) were significant ($F_{8, 20} = 12.9; P < 0.01$). The highest concentrations (LSD = 2.1 g N kg$^{-1}$) were recorded for soybean grain in 2004 through 2006 (60.2–60.7 g N kg$^{-1}$), followed by a group including mung bean and guar in 2005 and 2006 (44.0–46.1 g N kg$^{-1}$). The lowest N concentrations were recorded in cowpea, mung bean, and pigeon pea grain during 2003 (31.1–33.2 g kg$^{-1}$). Pigeon pea grain generally had the lowest N concentrations across years. Nitrogen concentrations of cowpea and mung bean grains were higher in 2005 and 2006 than in 2004; pigeon pea and soybean grains remained constant, and varied in guar grain.

**In Vitro Digestible Dry Matter**

Year × species interactions in IVDDM of legume grains (Fig. 1C) were also significant ($F_{8, 20} = 2.5; P = 0.045$). The highest IVDDM (LSD = 15 g N kg$^{-1}$) were recorded for a group that contained soybean in all years (968–969 g kg$^{-1}$), and mung bean in 2005 (965 g kg$^{-1}$). The lowest IVDDM was recorded for pigeon pea grain in all years (890–894 g kg$^{-1}$), and cowpea in 2004 (892 g kg$^{-1}$). Digestibility of cowpea and mung bean grains were higher in 2005 and 2006 than in 2003; pigeon pea and soybean grains remained stable and varied in guar grain.

**Accumulated N and IVDDM**

Mean (across years) species-level responses showed the novel legumes did not exceed kg N ha$^{-1}$ accumulated in soybean grain (Table 2). Mung bean, guar, and pigeon pea grains had similar amounts (70–78 kg N ha$^{-1}$), but were 30 kg N ha$^{-1}$ below levels recorded for soybean (107 ± 10 kg ha$^{-1}$), and cowpea grain accumulated only 50% of the N accumulated in soybean. In contrast, accumulated kg IVDDM ha$^{-1}$ was more consistent across species. Mung bean, guar, and soybean accumulated similar amounts of digestible dry matter in grain, while pigeon pea accumulated the highest amounts.

**Table 1. Monthly precipitation records for the 2004 through 2006 summer growing seasons, and the 30-yr (1971–2000) averages.**

<table>
<thead>
<tr>
<th>Month</th>
<th>2004</th>
<th>Years</th>
<th>2006</th>
<th>30-yr avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun</td>
<td>52</td>
<td>117</td>
<td>41</td>
<td>125</td>
</tr>
<tr>
<td>Jul</td>
<td>82</td>
<td>90</td>
<td>40</td>
<td>67</td>
</tr>
<tr>
<td>Aug</td>
<td>88</td>
<td>144</td>
<td>75</td>
<td>69</td>
</tr>
<tr>
<td>Sep</td>
<td>36</td>
<td>103</td>
<td>22</td>
<td>87</td>
</tr>
<tr>
<td>Oct</td>
<td>120</td>
<td>31</td>
<td>6</td>
<td>77</td>
</tr>
<tr>
<td>Total</td>
<td>378</td>
<td>485</td>
<td>184</td>
<td>425</td>
</tr>
</tbody>
</table>
Table 2. Mean (± 1 s.e.) accumulation of N and IVDDM in grain of annual warm-season legumes during the 2004–2006 growing seasons.

<table>
<thead>
<tr>
<th>Species</th>
<th>Variables</th>
<th>N (kg ha⁻¹)</th>
<th>IVDDM (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow Pea</td>
<td>N</td>
<td>53 (4)</td>
<td>1347 (103)</td>
</tr>
<tr>
<td></td>
<td>IVDDM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mung Bean</td>
<td>N</td>
<td>70 (4)</td>
<td>1681 (133)</td>
</tr>
<tr>
<td></td>
<td>IVDDM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guar</td>
<td>N</td>
<td>78 (11)</td>
<td>1651 (238)</td>
</tr>
<tr>
<td></td>
<td>IVDDM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigeon Pea</td>
<td>N</td>
<td>70 (4)</td>
<td>1830 (118)</td>
</tr>
<tr>
<td></td>
<td>IVDDM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>N</td>
<td>107 (10)</td>
<td>1706 (153)</td>
</tr>
<tr>
<td></td>
<td>IVDDM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1830 ± 118 kg ha⁻¹). As with N, cowpea accumulated the lowest kg IVDDM ha⁻¹ during the study.

DISCUSSION

There was no clear “best” legume species in terms of grain production in this study. Grain production was variable, and appeared to be driven mostly by timing of precipitation received and growing conditions during the three years. Most of the legumes were least productive during the wettest of the three years (2005), and most productive during the year with approximately normal precipitation (2004). Further, grain production by all species, except pigeon pea, was reduced during the driest year (2006), but generally greater than amounts recorded during the wettest year. The levels of grain biomass produced by soybean and pigeon pea were similar to earlier reports of cultivar responses in the SGP to different growing seasons; lower productivity during overly wet or dry years (Rao et al., 2003; 2005).

Guar generated the most variable response, producing both the highest and lowest grain yields during the study. A similar lack of stability in guar yields was noted over an eight-year period at 16 locations throughout Oklahoma and Texas, with a large portion of the variability attributed to environment (Stafford, 1982). Numbers of racemes, pods, and seeds per plant were considered the primary factors driving productivity of guar at a subset of these locations (Seiler and Stafford, 1985). Pod numbers and seeds per plant were also important to grain production by mung bean, cowpea, soybean, and pigeon pea, and were affected by availability of water (Senthong and Pandey, 1989). Environmental conditions during the growing seasons that correlate to critical periods of plant development can therefore have significant effects on level of grain produced by these species. Both pod numbers and seeds per pod were significantly reduced when drought coincided with the onset of the reproductive phase of growth in soybean, mung bean and cowpea, while pigeon pea was less affected (Senthong and Pandey, 1989). In contrast, the occurrence of drought during vegetative stages of growth had less affect on grain yield by cowpea (Turk et al., 1980).

The limited responses noted during 2005 were likely due to waterlogged conditions during August and September, with precipitation recorded at 20 to 50% above the long-term average. These were among the highest levels of precipitation recorded during the active growing season of the legumes. Prolonged wet periods were shown to reduce levels of rhizobia in nodules (Toomsan, 1990). Further, lack of oxygen under wet conditions limits root respiration, resulting in loss of nitrogenase activity (Sprent and Gallacher, 1976). In contrast, the lower yields in 2006 were likely related to drought conditions during the growing season. Rao and Venkateswarlu (1987) found even minor changes in plant water potential, including drought tolerant species, reduced N₂ fixation rates and translocation of fixed N to the shoots. Further, flower production can be reduced and flower abortion increased under drier growing conditions. Pandy et al. (1983) found pod numbers in mung bean, cowpea, and soybean were reduced by 63, 46, and 52%, respectively, by the driest of a set of treatments compared to the wettest treatment. The reduced effect of drought on grain production by pigeon pea may be related to osmotic adjustments (concentrate solutes) in the leaves, partially limiting rates of water loss, and maintenance of low CO₂ exchange rates under water stress (Lopez et al., 1988). Additional research is required to define how available soil moisture, and the variable environment of the SGP, can affect grain yields of these species.

Nitrogen concentrations and digestibility of grains produced by the different species were variable. However, our results were similar to those reported by Batterham and Egan (1986), who noted a range of N concentrations in different legume grains, from 32 g N kg⁻¹ for pigeon pea and chickpea, to 80 g N kg⁻¹ for peanut and soybean. None of the experimental species included in this study exceeded the N concentrations or digestibility recorded in soybean. Nitrogen concentrations in cowpea and mung bean grains increased in the last two years, but were more consistent in guar and pigeon pea grains. Further, there was a noted increase in grain digestibility of the short-season legumes and guar during the last two years of the study, compared to pigeon pea and soybean. There were few earlier reports in the Great Plains on grain quality of these species, and they focused on cultivar responses. Our N concentrations of pigeon pea grain were similar to those (27–32 g kg⁻¹) of Rao et al. (2003), while IVDDM was generally higher than the earlier study (730–775 g kg⁻¹). Rao et al. (2005) also noted similar N (33–62 g kg⁻¹) and IVDDM (825–982 g kg⁻¹) concentrations for soybean. Variations in both concentrations were related to annual growing conditions (Rao et al., 2003, 2005).

We have no clear explanation for the increased N and IVDDM of cowpea and mung bean grains during the three years of the study, or the lack of response by pigeon pea or soybean. The legumes were grown during the summer fallow periods of a continuous winter wheat system, without large N inputs. As such, carry-over
effects (accumulation of N) from continued application of the legumes to plots should be minimal. One possible (and most plausible) reason could be the change in fertilizer. The forced shift to 18–46–0 resulted in roughly 22 kg N ha$^{-1}$ enrichment of the plots, which possibly resulted in increased N of grains produced by the short-season species. However, the lack of increase in pigeon pea or soybean grains may indicate the involvement of some other unmeasured effect, correlated to N concentrations, from the repeated application of species to plots. Earlier research found residues of warm-season legumes may require several years to decompose, thereby retaining N in soil organic matter, and that decomposition rates were species-specific. Vallis and Gardener (1984) reported 17% of N from N$^{15}$–labeled Stylosanthes humilis Kunth residue was available to a grass sward within one year, and an additional 9% was available after two years. In contrast, 50 to 60% of N in Macroptilium atropurpureum (Mocino & Ses-seex DC.) Urb. residue was available to associated plants within one year (Vallis, 1983). An alternative explanation for the lack of response by pigeon pea and soybean could be slow nodulation or nodule function early in the growing season. Research is required to define N utilization, N turnover rates, and nodule function of the tested legumes within the variable environments of the SGP.

All species included in the study produced grains with potential value in livestock feeding enterprises. The combination of N concentration and digestibility were above 31 g kg$^{-1}$ (which corresponds to 19.4% crude protein) and 890 g kg$^{-1}$, respectively, across all species. Though these values were not greater than levels in soybean, they still represent a high quality feed for growing cattle. Pigeon pea serves as an example of their potential value as a feedstock. Pigeon pea grain contained 33 to 35 g N kg$^{-1}$ of seed, with 890 to 894 g IVDDM kg$^{-1}$. These N concentrations and concomitant levels of crude protein (20.6–21.9%) would be equivalent to, or in excess of, many commercial forms of protein or N supplements (National Research Council, 1995). The lower IVDDM reported for pigeon pea grain was likely related to condensed tannins, which lowers protein digestibility (Reed et al., 2000). However, recent studies found one unit of cracked pigeon pea grain (as a protein source) replaced 0.6 units of maize and 0.4 units of cottonseed meal (CSM) in lamb diets without lowering digestibility or N retention (Phillips and Rao, 2006). The N and IVDDM concentrations of mung bean, cowpea, and guar grains exceeded those of pigeon pea, indicating they could also be efficient replacements for maize or CSM in livestock diets, assuming these species could generate enough grain biomass to be cost-effective. Additional research is required to define the function of these novel legumes in diets of stocker or feeder cattle.

The relative stability and consistency (across years) of the nutritional values in pigeon pea (and soybean) grain, despite shifts in annual production, indicates reduced effects of variable growing conditions, or potential cumulative effects of management, on grain quality. This consistency in grain quality may be as important as maximum production, when considering feed sources for growing cattle. Such consistency indicates pigeon pea would be easier to utilize in livestock diets than the other novel species. Balanced diets would be easier to formulate, and rations could be standardized and applied more effectively than species with more variable N contents or digestibility.

Identifying the most-useful species among these less commonly used warm-season legumes was problematic, due to variations in response during the different years of the study. Conditions, and moisture received, during the summer growing seasons influenced performance by these grain legumes, which indicates the presence of a degree of weather-related risk in their use. Further, seasonal-scale climate forecasts for the SGP have proven unreliable (Schneider and Garbrecht, 2003), and currently lack the accuracy required for tactical planning of agricultural systems (Northup et al., 2002). Given this lack of accuracy, and the regular occurrence of dry periods in the SGP (Garbrecht et al., 2000), the wisest choice would be to utilize species that are more productive under drier growing conditions. Though mung bean, guar, and pigeon pea were not as effective as soybean, all were capable of accumulating useful levels of N and digestible dry matter under the variable growing conditions of this study. The true usefulness of these legumes to livestock producers in the SGP will depend on production costs, the potential uses and returns for such grain legumes, and potential cost savings when used to balance stocker diets, in comparison to the standard legume grain (soybean).

Acknowledgments

The authors would like to thank Delmer Shantz for his assistance with the field experiments and laboratory analysis.

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