AMERICAN JOURNAL OF ANIMAL AND VETERINARY SCIENCES

RESEARCH ARTICLE

Performance of Stocker Cattle Managed On Pastures Over-Seeded With Annual Forages

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Abstract: The goal of this study was to determine the performance of stocker calves managed on permanent pastures over-seeded with winter and summer annuals. Twenty-one 7-month-old Angus calves (BW = 263 ± 24 kg) sourced from the university farm, were randomly assigned to three treatments. The treatments were: i) Grass Hay Only (GHO; Control; 5 calves), ii) Permanent Pasture Only (PPO; 8 calves), or iii) Permanent Pasture + Winter Annual (PPW; 8 calves). The same calves were later randomly assigned to the summer treatments: i) Grass Hay Only (GHO; Control; 5 calves), ii) Permanent Pasture Only (PPO; 8 calves), and iii) Permanent Pasture + Summer Annual (PPS; 8 calves). The annual forages used in this study were: Barley (*Hordeum vulgare* L.) in winter and pearl millet (*Pennisetum glaucum* L.) in summer. The winter trial lasted for 58 days whereas the summer trial lasted for 42 days. The GHO calves had better (p=0.02) average daily gain (ADG; 0.69 kg/day) compared to the PPO (0.47 kg/day) and PPW calves (0.44 kg/day). There was no statistical difference (p=0.24) between the PPO and PPW calves. The PPS calves had better (p=0.01) ADG followed by the GHO and PPO calves (1.20, 1.15, 0.38 kg/day, respectively). In conclusion, over-seeding summer annuals onto existing permanent pastures is likely a good management practice for stocker cattle vs. conventional hay feeding. Whereas Over-seeding winter annuals on to permanent pastures may be beneficial, the timing of grazing should match optimal forage growth. The lack of effect seen in the winter trial can be attributed to grazing the annual forage at a mature growth stage typically accompanied by reduced nutrient availability. Future studies may determine the economic benefits of Over-seeding permanent pastures with annual forages in southern California, a region with similar weather conditions to tropical or mediterranean climate.

Keywords: Annual Forages, Stocker Cattle, Grazing

Received: 13-06-2025 | **Revised:** 22-12-2025 | **Accepted:** 01-04-2026 | **DOI:** 10.3844/ajavsp.2026.21.02.012

Introduction

The United States (US) beef industry is comprised of many segments that play an important role in beef production. The yearling-stocker phase is the middle phase between the cow-calf segments (involves cows and heifers raised to produce calves that will enter the stocker cattle phase) and the finishing segment. The finishing phase in the US is a confinement feeding operation in which a concentrate (high energy) diet is fed for the purpose of reaching the desired market weight at the age of 20-22 months [1]. The primary goal during the yearling-stocker (backgrounding) phase is to add weight to post weaned calves that

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are lightweight, by placing them on forage-based diets to prepare them for feedlot finishing [1]. In general, this goal is reached by maintaining ADG at minimum 0.68 kg/head per day so that the animal's weight stays appropriate for its age [2].

Under ideal conditions, calves that require backgrounding will be weaned from the dam and graze on available forages for further growth. However, environmental factors, such as temperature and precipitation, heavily impact the quality and quantity of forage material available to cattle throughout the year [3]. These changes in pasture conditions are mostly seen during the winter and summer periods and lead to periods of low forage growth. During periods of low forage growth beef producers must adjust and the most common practice is feeding conventional hay or concentrate supplement. However, feeding hay or concentrate supplements can be costly due to the fluctuating prices in feed, shipping and other costs including machinery and storage if harvested on the farm [1].

Other challenges that come with beef production are often uncontrollable and volatile, such as the commercial cattle market price [4]. As a result, focusing on methods to minimize husbandry costs is important and in beef management the most costly expense is nutrition. Estimates indicate that feed may make up 40 to 60 percent of costs for cow-calf operations [5]. By focusing on nutrition, it allows for beef producers to maximize animal productivity at a low cost and also contributes to a sustainable method of beef production to satisfy the demand for beef production [6]. Minimizing feed costs can be very advantageous for cattle operations and has the potential to increase overall profits [7].

Therefore, focusing on feeding strategies that minimize the use of supplemental feed during the winter and summer period, with the purpose of lowering feed-related costs and improving animal performance is a topic that requires further investigation. One technique is the introduction of temperate and drought resistant forage species to unimproved pastures. Many cool and warm season annual crops have the ability to tolerate the extreme weather conditions observed during the winter and summer periods [3]. Incorporating winter and summer annuals to established pastures during periods of low forage availability has the potential to be an efficient manner for feeding cattle.

Stocker-yearling operations produce a replacement heifer for the herd or feeder cattle for the feedlot and do so economically using inexpensive feeding strategies [8]. Forage management is necessary and can be achieved by placing cattle on pasture at optimum stage of forage growth to obtain the highest nutrient content by including a mixture of legumes and grasses [9]. Improving pastures by incorporating annual forages has the potential to improve pasture production and quality during winter and summer periods. [10] reported that grazing seasons can be extended by up to 300 plus days per year when adopting management techniques that combine perennial forages with complementary annual forages and stockpiled forages. In similar work [11] cool season annual forages combined with perennial warm-season grass pastures extended the grazing season by providing an additional 60 to 120 days of grazing.

There are many benefits to introducing annual legumes such as berseem clover **(***Trifolium alexandrinum*) to pastures. Intercropping berseem clover **(***Trifolium alexandrinum*) can increase total dry matter yields, improve forage quality, reduce fertilizer needs, and increase subsequent crop yield [12-14]. The use of cool season annual legumes instead of, or in addition to, cool season annual grasses can also extend the grazing season [15], reduce hay feeding [16] and provide a more sustained supply of high-quality forages [17, 18]. Berseem clover (*Trifolium alexandrinum L.)* is an excellent choice for a cover crop due to its vigorous warm season growth and good nitrogen-fixing potential [19]. Studies of [20] concluded that interseeding hairy vetch (*Vicia villosa* L.) into existing tall wheat pastures improved the nutritional value of the wheat regrowth [20].

The winter and summer annuals used in this study were selected because of some advantages. Pearl millet (*Pennisetum glaucum L.*) was selected because it has a higher concentration of CP and fatty acids, and a lower concentration of NDF and ADF when compared to select warm-season perennial forages [21]. Barley *(Hordeum vulgare* L.*)* provides an opportunity for early season grazing and is a valuable annual forage during drought because it is known to use water more efficiently than other small grains [22]. Consequently, we hypothesize that performance of weanling calves grazing improved pastures (overseeded with cool season and warm season annuals) will perform better than calves grazing unimproved permanent pastures and those kept in dry lot and fed oat hay.

Materials and Methods

Pasture Management

The study was conducted on the irrigated pastures and the dry lots located at the California State Polytechnic University, Pomona. Soils in the experimental area were deep and poorly drained with a fine-loamy texture. The topography is level to

gentle slope 0 to 2%. Cool season annuals, barley (*Hordeum vulgare* L.) and hairy vetch (*Vicia villosa* L.) were over-seeded onto existing permanent pastures in November 2020 and grazed in May 2021. The permanent pastures comprised of mixed grasses, primarily tall fescue (*Festuca arundinacea* L.) and bermudagrass (*Cynodon dactylon* L.). In the summer period, pearl millet (*Pennisetum glaucum* L.) and berseem clover (*Trifolium alexandrinum* L.) were established on the same pastures in July 2021 and grazed in August 2021.

To minimize competition between existing and new forages at establishment, permanent forages on experimental pastures were grazed low or mowed down using a rotary mower (pulled by a tractor) to approximately 3 cm before over-seeding with cool season/warm season annuals. Figure 1 shows the pasture management plan from establishment to utilization by season. Forages were sampled at the start and end of each experiment to determine the botanical and chemical composition, and forage yield.

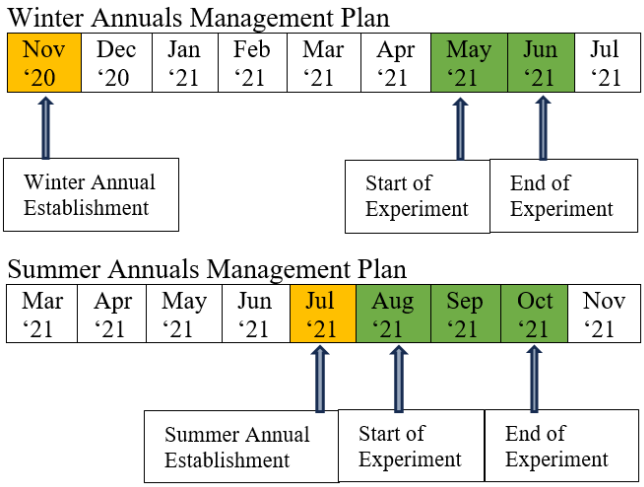

Fig. 1: Pasture managements in winter and summer periods

Experiment 1. Winter Annuals

Nitrogen fertilizer in the form of urea (46-0-0) was applied to experimental pastures at the rate of 18.2 kg/acre. The seeding rate for barley was 40.9 kg/acre whereas that of hairy vetch was 18.2 kg/acre. Hairy vetch established poorly and will not be discussed further. To obtain optimal forage growth, pastures were irrigated overnight once a week. The treatments are as follows:

1) Grass Hay Only (GHO; Control)

2) Permanent Pasture Only (PPO)

3) Permanent Pasture + Winter Annual (PPW)

The calves were put on the experimental pastures on May 21, 2021, when cool season annual forages were at an advanced or mature stage of growth. The late start can be attributed to COVID-19 related restrictions that minimized field activities on university premises, including this study. We acknowledge that the delayed placement of animals on pasture affected the results as the forages were more mature and past the nutritively most productive stage. Animal performance can be affected when energy is expended to move more frequently to search and selectively graze suitable plant material if a field is dominated by mature forage [23]. At the end of the winter experiment, cattle were removed from the pastures to enable the establishment of summer annuals.

Experiment 2. Summer Annuals

Pastures vacated by the calves were established with summer annuals in mid-July. Nine-month-old fall-born calves were placed on experimental pastures on August 24, 2021, and removed October 5, 2021 (Figure 1). Nitrogen fertilizer in the form of urea (46-0-0) was applied to experimental pastures at the rate of 18.2 kg/acre. The seeding rate for both pearl millet and berseem clover was 11.4 kg/acre. Berseem clover established poorly and will not be discussed further. To account for evaporative water loss due to intense summer heat in southern California, pastures were irrigated overnight twice a week.

Forage samples were collected at the start and end of the summer experiment, to determine the botanical and chemical composition, and available forage mass. The treatments were as follows:

1) Grass hay only (GHO; Control)

2) Permanent pasture only (PPO)

3) Permanent pasture + pearl millet (PPS)

The calves were put on the experimental pastures on August 24, 2021, when warm season annual forages were at their optimal growth phase and nutritively most productive for grazing cattle.

Animals

This study was completed at California State Polytechnic University, Pomona, and followed the approved guidelines and recommendations of the Institutional Animal Care and Use Committee (IACUC protocol #21.008). Twenty-one 7-month-old calves of Angus breeding weighing 263 ± 24 kg were used in this study. For the pasture treatments, an experimental unit comprised of two calves replicated 4 times (8 animals per treatment group) whereas the control group comprised of 5 calves housed together in one pen. Animals were dewormed, ear tagged, and vaccinated before being placed on experimental plots or pens. Trace mineralized salt block and water were provided free choice throughout the experimental period. Animals were weighed at the start and end of each period using a Flying W. Inc. squeeze chute model DVM (Watonga, OK) equipped with a balanced scale from LBS Inc. model GSE 350 (Garden City, KS) designed for safe handling of animals. Animals utilized for this study were on the experiment for a total of 100 days, 58 days in the winter period and 42 days in the summer period. In between the experimental periods, grazing cattle were put on pastures similar to the permanent pasture (PPO) treatment whereas cattle in the dry lot were fed the same grass hay. The GHO animals were housed in the beef unit dry lots, California State Polytechnic University, Pomona, and fed oat hay throughout the 153-day span (100 days on experiment and 53 days off experiment). Animal variables measured included body weight gain and Average Daily Gain (ADG) of the calves.

Statistical Analysis

Botanical and chemical composition variables for the forages and hay were averaged within period and analyzed using the GLM procedure of SAS [24], using a randomized complete block design with replicate x treatment as the error term. Pasture within treatment was the error term used to test forage type (PPO, PPW or PPS) whereas residual error tested all other independent variables. Animal variables were analyzed using least square means of SAS and ANOVA based on a randomized complete block design with pasture treatment as the main plot. Fisher's test (LSD) was used to make multiple comparisons. Treatment differences were separated at significant level of $p<0.05$.

Results

Experiment 1. Winter Grazing

The available forage yield at the start and end of the experiment was greater ($p = 0.001$) for the PPW treatment vs the PPO treatment (Table 1). The PPW pasture contained more ($p = 0.01$) grass and less ($p = 0.02$) weeds, proportion of dead material was similar ($p = 0.46$) between pasture treatments (Table 3). Both pastures contained no legume. The ADG of GHO animals (0.69 kg/d) was greater ($p = 0.02$) than PPW and PPO animals (0.44 vs. 0.47 kg/d; Table 6). The results for the winter grazing period were not expected. It was expected that the PPW animals would perform at par with the GHO group, with the PPO group being the least. However, the GHO calves had better gains than both WGL and PPO (Table 3).

Experiment 2. Summer Grazing

Available forage yield at start of experiment was similar ($p = 0.126$) between the PPO and PPS, however, PPS pasture had a greater ($p = 0.001$) amount of available forage at end of the experiment probably because summer annuals had a greater growth rate vs. permanent pasture (Table 2). Compared to PPO, the PPS pasture comprised of more ($p = 0.05$) grass and tended ($p = 0.08$) to have less weeds; the proportion of dead material was not ($p = 0.24$) different among pasture treatments (Table 4). The PPS calves had the best ADG ($p = 0.01$) followed by the GHO calves and PPO calves (1.20, 1.15, 0.38 kg/d, respectively; Table 7).

DOI: 10.3844/ajavsp.2026.21.02.012

Table 1: Forage yield of Permanent Pastures Only (PPO) and winter annual (PPW) at start and end of experiment for winter annual grazing period

	PPO	PPW	P Value
Forage yield at the start, kg DM/acre	725±184	1597±242	0.001
Forage yield at the end, kg DM/acre	276±46	854±138	0.0001

Data are means ± S.E

Table 2: Forage yield of Permanent Pastures Only (PPO) and summer annual (PPS) at start and end of experiment for summer annual grazing period

	PPO	PPS	P Value
Forage yield at the start, kg DM/acre	1885±283	1808±147	0.126
Forage yield at the end, kg DM/acre	287±48	872±72	0.0001

Data are means ± S.E

Table 3: Distribution of available forage of Permanent Pastures Only (PPO) and winter annual (PPW) during the winter annual grazing period and pasture composition

	PPO	PPW	P Value
Grass, %	39.8±8.4	61.1±1.7	0.01
Weeds, %	31.2±6.7	15.3±1.8	0.02
Legume, %	00.0	00.0	
Dead Material, %	29.0±8.7	23.6±2.1	0.46

Data are means ± S.E

Table 4: Distribution of available of Permanent Pastures Only (PPO) and summer annual (PPS) forage during the summer annual grazing period and pasture composition

	PPO	PPS	P Value
Grass, %	56.2±2.5	62.4±4.6	0.05
Weeds, %	33.7±3.2	27.8±2.7	0.08
Legume, %	00.0	0.00	
Dead Material, %	10.1±1.0	09.8±1.9	0.24

Data are means ± S.E

Table 5a: Chemical content of GHO, PPO, and PPW forages

Item	GHO	PPO	PPW
aNDF, %	62.0	61.5	63.9
ADF, %	36.0	45.0	39.9
TDN, %	55.0	48.7	51.9
ME, Mcal/kg	1.99	1.7	1.9
NEM, Mcal/kg	1.14	0.9	1.0
NEG, Mcal/kg	0.58	0.3	0.5
CP, %	9.3	12.0	12.0
Ca, %	0.2	1.4	0.5
P, %	0.2	0.4	0.4
Mg, %	0.3	0.3	0.2
K, %	1.5	3.3	2.5
Fe, μg/g	155	199	168
Mn, μg/g	64	73	33

Zn, μg/g	39	35	22
Cu, μg/g	15	7	8

Table 5b: Chemical content of GHO, PPO, and PPS forages

Item	GHO	PPO	PPS
aNDF, %	62	59.9	42.4
ADF, %	36	42.1	37.7
TDN, %	55	47.6	49.9
ME, Mcal/kg	1.99	1.7	1.8
NEM, Mcal/kg	1.14	0.8	0.9
NEG, Mcal/kg	0.58	0.3	0.4
CP, %	9.3	11.8	17.9
Ca, %	0.2	0.9	1.1
P, %	0.2	0.4	0.8
Mg, %	0.3	0.3	0.4
K, %	1.5	2.9	5.2
Fe, μg/g	155	1034.0	858.0
Mn, μg/g	64	68.0	48.0
Zn, μg/g	39	45.0	49.0
Cu, μg/g	15	8.0	10.0

Table 6: Initial body weight, final body weight, and Average Daily Gain (ADG) of Grass Hay Only (GHO), Permanent Pasture Only (PPO) and winter annual (PPW) cattle during the winter annual grazing period

	Treatment			
	GHO	PPO	PPW	P Value
BW at the start, kg	260.2±18.4	266.8±8.1	261.6±4.7	0.81
BW at the end, kg	300.3±19.3	293.9±7.7	287.2±6.3	0.64
ADG, kg/day	0.69±0.05	0.47±0.07	0.44±0.05	0.02

Data are means ± S.E

Table 7: Initial body weight, final body weight, and Average Daily Gain (ADG) of Grass Hay Only (GHO), Permanent Pasture Only (PPO) and summer annual (PPS) cattle during the summer annual grazing period

	Treatment			
	GHO	PPO	PPS	P Value
BW at the start, kg	293.2±19.8	293.8±5.5	296.3±4.9	0.60
BW at the end, kg	341.6±21.8	309.6±4.1	346.6±4.8	0.46
ADG, kg/day	1.15±0.12	0.38±0.09	1.20±0.10	0.01

Data are means ± S.E

Discussion

Studies of [25] involving early weaned calves grazing winter annuals, did not (p>0.05) find a difference between calves fed grass hay in the dry lot and calves grazing permanent or pastures over-seeded with winter annuals. One reason for this difference is that [25] studies were conducted early in spring when the cool season annual grasses were at their optimal growth stage [15]. In this study, however, animals grazed the lower quality and more mature barley, and this may explain the better (p = 0.02) ADG for the GHO group compared to PPO and PPW groups. The late start for the winter experiment affected PPW cattle more than PPO as barley was grazed at its late or mature growth stage and this compromised forage quality and

utilization [22]. This outcome was unexpected and may be attributed to greater energy expenditures for animals on pasture compared to those managed under confinement conditions. Differences in energy expenditures of both management systems, and not forage quality (Table 5), probably contributed most to this lower-than-expected animal response. Cattle on mature pasture usually walk long distances daily search-grazing for suitable forage compared to confined animals [23, 26]. Stocker or yearling cattle producers should aim for ADG of at least 0.68 kilograms per head per day so that animal body weight stays appropriate for the corresponding phase of growth [2]. In the better ADG for the PPS calves vs. PPO and GHO may be attributed to the higher quality (e.g., CP content) forage (Table 5b). Over-seeding permanent pastures with pearl millet and grazed on a timely manner can increase stocker cattle performance and probably increase the pasture carrying capacity. The pastures over-seeded with summer annuals (PPS) had four times as much residual forage vs. permanent pastures (PPO). The greater residual forage in PPS vs. PPO can be attributed to the rapid daily regrowth of pearl millet and this may explain the greater ADG of PPS vs. PPO groups.

Conclusion

The purpose of this study was to determine if yearling calves managed on pastures overseeded with annual forages during periods of low forage growth in winter and summer periods will perform better than animals fed a conventional hay diet. Over-seeding annual forages onto established pastures is a promising management system that can extend the grazing season and minimize the use of costly conserved forages (hay or silage). However, economic analysis to compare improved pasture systems vs. conventional systems require further investigation. Moreover, similar studies performed in southern California should consider different strategies to optimize grazing e.g., practice rotational grazing may increase forage use, thus, increasing the carrying capacity of the pastures and resulting in increased profits for producers. Evaluation of other annual forages for their suitability in this region may offer alternatives for producers seeking to diversify the forage species that may work best in southern California. In addition, animal grazing behavior relative to available forage may provide important information to determine if grazing cattle during periods of adverse environmental conditions e.g., when heat stress is a factor may have a negative effect on animal performance. Consequently, future studies should also investigate animal behavior to determine if animals grazing on improved pastures are provided with greater enrichment compared to animals feeding in a confined environment where animal movement is restricted and feed and water are stationed in close proximity.

Acknowledgment

Research reported in this publication was supported by funds made available through California State University – Agricultural Research Institute project #008740 (20-04-126): Determine the effect of annual grass/legume mixtures on performance of weanling calves.

Authors Contributions

Michael Martinez: Majority of the field work and data collection and processing.
Daniela Brown and Sidney Garrison: Prepared the manuscript (original draft preparation, review and editing).
Hyungchul Han: Assisted to collect and process animal data.
Ondieki Gekara: Had overall project management responsibilities.

Ethics

No ethical issues are expected after this work is published because all the authors reviewed and approved their role and listing order on the manuscript. In addition, the handling and welfare of the animals used in this study was approved by the Institutional Care and Use Committee protocol #21.008. Thus, no ethical issues arose and related to the use of animals under the described research conditions.

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