

THE RHODES GRASS: A POTENTIAL ALTERNATIVE FORAGE CROP FOR THE LOW DESERT

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ABSTRACT

Rhodes Grass (*Chloris gayana*, Kunth), is a C₄ perennial grass native to Africa, but widespread in tropical & subtropical countries. We tested two Rhodes grass varieties; known as *Gulfcut* (GF) & *Recliner* (RL) for the first time under California's low desert condition (dry, high heat and high temperature) for adaptability, forage yield and forage nutritional quality. The research was conducted at the University of California Desert Research and Extension Center (UCDREC), Holtville, California. The crops were established by sowing 18 lbs of seeds/ac. Our results showed that both varieties germinated in 4-7 days after sowing, produced 18 - 19 t/ac (six cuttings) during its first year of establishment and 11 t / ac during the second year (5 cuttings). Feed nutrient qualities of both hybrids ranged 12-14% in Crude Protein, among many other quality measures. There were no significant differences between the two varieties in either dry biomass or nutritional qualities. Our results clearly indicate that Rhodes grass has excellent adaptability, high biomass productivity and of excellent nutritive quality if grown under low desert conditions of California. Rhodes grass biomass and nutrition comparison to other forage crops such as alfalfa and Sudan grass reveals that this grass is highly competent and may serve as an alternative forage crop for the low desert.

Keywords: Rhodes grass, forage crop, low desert, crop water use

INTRODUCTION

Rhodes Grass (*Chloris gayana* Kunth) is a C₄ perennial forage grass that originated from Africa, but widely grown and naturalized throughout the tropical and subtropical regions (Ponsens et al. 2010). Rhodes grass is valued for its (1) ability to set seeds, (2) relative ease of establishment and ability to cover ground, (3) tolerance for drought, light frost, and (4) suitability to be grown (Keftasa 2006). It is tolerant of moderately saline and alkaline soils (Waisel 1972, Naidoo and Naidoo 1998, Kobayashi et al., 2007, Takao et al., 2012) using salt glands on its leaf surfaces to secrete excess salts, a mechanism of salt tolerance (Kobayashi et al. 2007). Salt tolerance of Rhodes grass, however, is influenced by the growing conditions (Chichelli et al., 2016). Rhodes grass is very closely related to Bermuda grass (*Cynodon dactylon*) and makes heavy yield of hay of excellent quality. Stems of Rhodes grass are slender, tender, very leafy and spreads through stolons (Figure 1) with highly productive nature. The culms are tufted or creeping, erect or decumbent, sometimes rooting from the nodes. Rhodes grass seeds germinate quickly (1-7 days) depending on temperature and often achieve full ground cover within three months of sowing. Seeds can be broadcasted or shallow-drilled (5-10 mm depth) and start to germinate when soil temperatures are at least 60°F. Once seeds germinate it is critical that the roots stay wet for the next 10-12 days to ensure good crop establishment. After seedling establishment, watering is

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usually every 14 days in flood irrigation systems, depending on local climatic conditions. The stand begins to produce valuable forage within 6 months, though the highest yield is obtained during the second year of cultivation. Stands require good management and fertilizer (N) if long production (over 3 years) is intended. Highest recorded yield of about 30-40 t DM/ha and average yield of 10-16 t DM/ha has been reported. Rhodes grass can survive in areas where temperature extremes are 5°C and 50°C. Due to its deep roots that can extract water at a depth of 4.5 meters (Mazahrih 2016), Rhodes grass can also withstand long dry periods (over 6 months) and up to 50 days of flooding (Imaz et al., 2015). Rhodes grass can be harvested at about 50 days from planting for the first cutting and every 30 days for subsequent cuttings, allowing about 6 cuttings annually (Ponsens et al., 2010). While the highest biomass production is in summer, Rhodes grass could remain dormant during winter and persist for 3+ years, depending on phenotypic diversities (Ponsens et al., 2010).



Figure 1: Stolons of Rhodes grass allows it fast ground cover and weed suppression

Although, Rhodesgrass is cultivated in the US (Florida and Texas) for forage or as a cover crop, agronomic information for the low desert, particularly for the South West US is missing or very rare. However, Nadaf et al. (2014) showed that Rhodes grass varieties produced significantly higher green and dry mass yields than alfalfa cultivars under the Arabian Peninsula. This finding is indicative of the potential adaptability and high yielding capacity of Rhodes grass under the low desert conditions of California. Recognizing the potentials of Rhodes grass as a potential alternative crop, this research was conducted to evaluate forage yield and nutrition of two Rhodes grass varieties under irrigated low desert conditions. Selected Seeds of Australia states that the previous RG were wild selections & inconsistent in feed bunks. It is latter hybridized and optimized as fine stemmed leafy plant of aggressive stoloniferous growth habits, salt tolerance and high dry matter yields. The Gulfcut is improved diploid cultivar, bred for its extremely fine stem, erect growth habit, high leaf production & well suited for hay production in regions with over 60°F.

MATERIALS AND METHODS

Rhodes grass adaptation and yielding trial is the first of its kind to be conducted under the low desert condition of the US. Two varieties of Rhodes grass, (known as Reclaimer (RC) and Gulfcut (GF)) were tested at the University of California Agriculture and Natural Resources (UCANR) Desert Research and Extension Centre (DREC). Each variety were established by sowing 18 lbs of seeds/ ac on a 30 ft x 15 ft plot size with 4 replications per variety. All treatment plots were separated with a 10 ft alley. Higher seed rates were used to compensate for

the commonly known 50% germination rate of Rhodes grass and maintain uniform stand.

Desirable planting date for Rhodes grass is late August or September for establishing new crops, although, it is expected to germinate anytime during the summer and fall. For this trial, the seeds were planted in the second week of September. Seeds of Rhodes grass are small & light, with over 2 million seeds /lb and can be broadcasted or shallow-drilled (5-10 mm deep). The seeds can germinate under dry conditions provided the soil has residual moisture and germinate in 4-7 days from sowing (Figure 2), provide full groundcover within 3 months of sowing and produce valuable forage within about 6 months.



Figure 2: Newly germinating Rhodes grass trial field

Soon after sowing, all trial plots were sprinkler irrigated for stand establishment and then switched to flood or surface irrigation. While some suggested that 3 to 5 surface irrigations may be necessary to establish a stand, about 14 to 16 irrigations were needed during the season for good crop production. Fertilizers of urea, UAN32, and or anhydrous ammonia were applied at 120 kg/ac N as a pre-plant and 50 lbs /ac N at subsequent cuttings. Pre-plant PK were applied at 40-50 kg/ac. Since the crop propagates through stolons, slight differences in seeding rates may not influence Rhodes grass biomass production, although row spacings may have influences on weed control (Rasool et al., 2017). Treatment plots were laid out in a completely randomized blocks (RCBD) of 4 replications. Crops were harvested when 5 to 10% of the crop is in the boot stage or develops seed head (Figure 3).



Figure 3: Rhodes grass plants near harvest time

The first cutting was done at about 50 days (under some conditions) from planting with varied subsequent cuttings, but about every 30 to 35 days cycle. Five to 6 times cuttings per year are possible. We used a small forage harvester (Wintersteiger) for all cuttings. Under large scale mechanized conditions, Rhodes grass can be cut with regular swathes and baled, just like Bermuda or Klein grass. At every cutting, crop samples were weighed for fresh and dry biomass production and three subsequent cutting samples taken for forage nutritional analysis.

RESULTS AND DISCUSSION

1. Biomass Productivity

Both varieties germinated quickly (4-7 days) & full groundcover achieved within 3 months for the first-year establishment. With six cuttings for first year, we obtained 18 t/ac and 19 t/ac for GF and RL, respectively (Table 1).

Table 1: Rhodes grass dry biomass & t / ac) productivity at various harvesting cycles

Variety	5-May	21-Jun	28-Jul	29-Aug	10-Oct	12-Dec	Total
GF	5.4a	4.5a	3.6a	2.0a	2.0a	0.9a	18.4
RL	6.2a	4.26a	3.61a	2.0a	2.0a	0.8b	19.1
<i>Pr>F</i>	0.34	0.73	0.94	0.95	0.46	0.05	

Biomass yield from the Table 1 is extrapolated into Figure 4 for simplicity. As can be seen from the Figure, forage yield of both varieties was highest from the first cuttings and declined linearly throughout the subsequent cuttings (Figure 4).

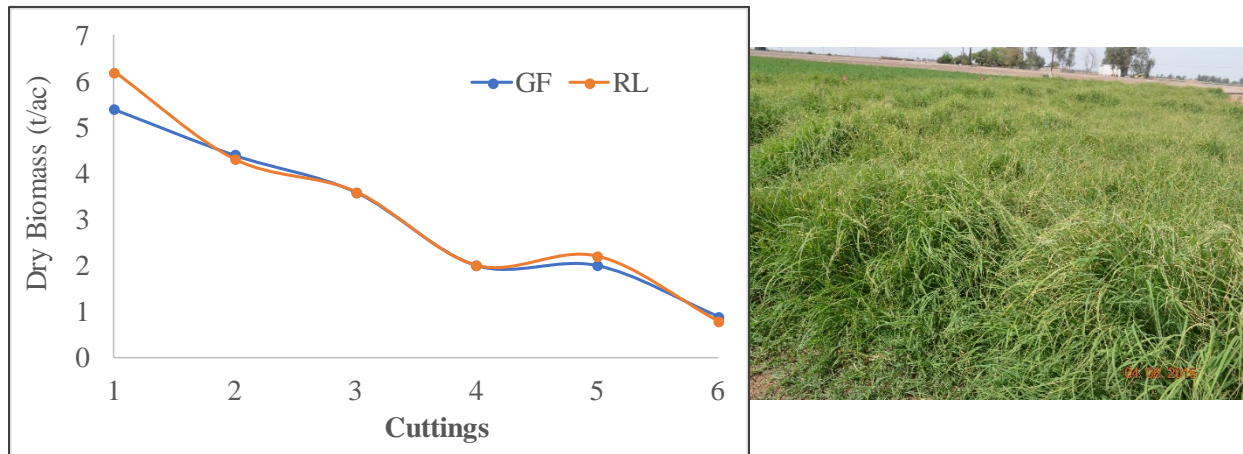


Figure 4: Biomass production (t/ac) over 6 cuttings during the first-year trial

While there were 6 cuttings over the growing season for the first-year trial, only 5 cuttings were possible during the second year. Like the first-year harvest, biomass productivity of the varieties during the second year were not significantly different from each other at any of the cutting cycles, except for the third cutting cycle ($p = 0.01$) where RL produced relatively higher biomass than GF. Total annual yield for the second-year crops was reduced to about 11.2 and 11.4 t/ac, respectively for Gulfcut and Reclainer. While biomass yield was lower during the second year, relative to the first year, Mazahrih (2016) suggested that Rhodes grass biomass yield during the second year is double those of the establishment year, depending on management & environmental conditions. Although, crop maintenance was the same in both years, we are not sure about the disparity between the two years. On speculation is the difference in cuttings (6 for

the first-year vs 5 for the second year). In a water stress study ranging from 40, 65, 100 and 125% reference evapotranspiration (ET_o) supply, over 12 cuttings in 514 days, Rhodes grass produced well under all irrigation levels (Mazahrih 2016), indicating water productivity and Water Use Efficiency (WUE) of Rhodes grass.

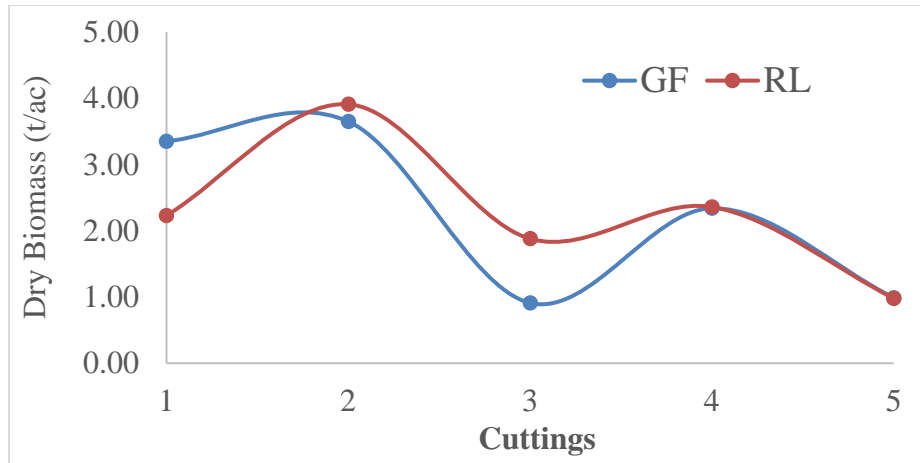


Figure 5: Graphical representation of Rhodes grass 2017 dry biomass (hay) production

The biomass yield patterns from the second-year cuttings (Figure 5) was somewhat different from the first-year cuttings (Figure 4). For the second year, biomass yield was alternating from high, low and then high, depending on the cutting cycles (Figure 2). However, just like the first-year yield, there were no significant differences between the two varieties at any of the cutting cycle, except at the third cutting. Biomass yields of second year crops were generally lower than the first year, particularly during the first few harvest cycles.

Biomass yield comparison of Rhodes grass to other forage crops (Table 2) indicates that Rhodes grass can be a very competitive alternative low desert forage crop, with comparable or higher biomass yields than most commonly grown forages of the low desert. Both varieties produced two to three times higher biomass during its first-year establishment relative to the other forages.

Crop	2016 yield (t/ac)
Alfalfa hay	7.19
Bermuda grass hay	7.89
Klein grass hay	10.0
Sudan grass hay	5.66
Rhodes grass	18-19

Table 2: Biomass yield comparison of Rhodes grass to other forage crops

Source: Ortiz, 2016 Imperial County Ag Crops & LS Report

The differences in biomass production at subsequent cuttings may be attributed to the variation in stand age, environmental condition and many other factors. Tolera, et al. (2006) showed that dry matter content of fresh forage increased with increasing age of regrowth, while Keftasa (2006) suggested nutrient supply and regrowth days for as responsible the variation in dry biomass. Many researchers obtained a recorded yield of about 12-16 t/ac, very similarity to our

finding. DM yields for Rhodes grass generally ranges from about 10-25 t/ha (4-10 t/ac), depending on variety, soil fertility, environmental conditions, & cutting frequency.

2. Forage quality

There were no significant differences between the two Rhodes grass varieties in any of the forage quality determinations (Table 2). Most of the forage quality determinants are within the standard forage qualities. For example, crude protein content of the test varieties ranged 12 to 14% (Table 2). It must be noted that forage quality can be affected by many factors, including fertilizer levels supplied, etc. According to Tolera et al. (2006), crude protein content of Rhodes grass was highest when 69 kg N / ha was applied. Although nutrient supply decisions vary upon locations, the researchers suggested that a split application of 50-100 kg/ha N are normal. Rhodes grass can be of high-quality forage also, if harvested young, providing up to 15% crude protein (Mero et al. 1997). Nutritional quality of Rhodes grass is also affected by crop maturity stages with steep decline to 9-10% crude protein after 10 weeks and as low as 8% after 15 weeks of regrowth (Milford et al., 1968). Rhodes grass produces no oxalate or prussic acid and hence can be fed to all animals. Many observed that well managed Rhodes grass hay may produce average hay quality of 12-14% crude protein (which is consistent with our current finding), below 60 NDF and around 30 ADF with good levels of energy (Mero et al., 21997), depending on varieties.

Table 2: Nutritional values of Rhodes grass from three harvest samples

Variety	CP%	AFD	dNDF	Ash	dNDF48	dNDF30	TDN
First cutting							
RL	14.1 ^a	37.5 ^a	65.4 ^a	9.9 ^a	38.1 ^a	23.5 ^a	59.8 ^a
GF	14.2 ^a	37.8 ^a	65.0 ^a	9.7 ^a	37.5 ^a	22.4 ^a	59.5 ^a
<i>Pr>F</i>	<i>0.94</i>	<i>0.62</i>	<i>0.74</i>	<i>0.63</i>	<i>0.57</i>	<i>0.24</i>	<i>0.64</i>
Second cutting							
RL	12.2 ^a	39.73 ^a	67.2 ^a	10.1 ^a	40.8 ^a	28.7 ^a	63.2 ^a
GF	12.1 ^a	41.2 ^a	68.8 ^a	10.0 ^a	41.6 ^a	28.9 ^a	61.8 ^a
<i>Pr>F</i>	<i>0.94</i>	<i>0.41</i>	<i>0.4</i>	<i>0.74</i>	<i>0.25</i>	<i>0.71</i>	<i>0.26</i>
Third cutting							
RL	12.4 ^a	38.9 ^a	69.4 ^a	10.1 ^a	40.0 ^a	28.9 ^a	59.2 ^a
GF	13.4 ^a	38.4 ^a	67.5 ^a	10.1 ^a	40.2 ^a	29.5 ^a	62.1 ^a
<i>Pr>F</i>	<i>0.24</i>	<i>0.69</i>	<i>0.32</i>	<i>0.93</i>	<i>0.68</i>	<i>0.62</i>	<i>0.16</i>

Means in each column followed by the same letter under each cutting is not significantly different from each other.

Crude protein and other forage quality indices show that Rhodes grass from our trials had lower crude protein content than alfalfa, but significantly higher than Bermuda, Sorghum, corn silage or wheat straw data not provided). It also had similar or better qualities in other forage quality parameters. Therefore, our findings indicate that Rhodes grass could produce high biomass and quality hay as a livestock feed when grown under low desert conditions. Another factor for

forage production and quality management, particularly under the low desert condition is salt accumulation in the soil and irrigation water. Salt accumulation can be the most serious environmental factors limiting the growth and yield of crops (Hillel 2000). Excess salinity induces various detrimental effects on major processes, such as growth, photosynthesis, protein synthesis, and energy and lipid metabolism (Parida and Das 2005). However, researchers pointed out that some forage crops, such as Rhodes grass may cope up with excess salinity by developing specific mechanisms, such as the ‘‘salt gland’’ (Waisel 1972, Kobayashi et al., 2007, (Naidoo and Naidoo 1998). Salt glands of Rhodes grass can secrete both Na⁺ and K⁺, but that the ability to secrete Na⁺ is greater than that of K⁺ secretion (Kobayashi et al., 2007). Salt gland density of Rhodes grass increases with Na⁺ treatment concentrations, suggesting an acclimation to promote salt excretion under high salinity (Takao et al., 2012). Rhodes grass genotypes have excellent potential to increase forage production in salt-affected areas (Daba et al., 2019). Because forage quality affects both market and crop management, it is one of the largest challenges for forage growers. The complexity of forage quality and its dependence on genetic, environmental and agronomic factors is an added challenge which ultimately must be defined in terms of livestock production.

3. Other desirable characteristics of Rhodes grass

Rhodes grass showed strong tolerance to mechanical damages (Figure 6) that happened at our research plots, but recovered as if there was no damage. In other areas, it is reported to withstand heavy grazing (Ponsens et al., (2010), after Humphreys, (1980) and hence used as a popular cultivated pasture species. As a pasture, Rhodes grass is suitable for rainfed & irrigated systems, drought resistant & high WUE. It is highly desirable for direct pasturing, palatable and suitable for all animals (Dairy, Beef, Horses, Goats & Sheep). Imaz et al. (2015) observed a remarkably fast recovery of Rhodes grass from late winter flooding and attaining biomass equivalent to that of non-flooded plants 1 month after water subsided (). Rhodes grass had no arthropod or pathogen or weed pressure under our trial field. Some researchers suggested that Rhodes grass may need broadleaf (BL) weed control during establishment, although it remains strong weed competitor once established. Furthermore, weeds in Rhodes grass can be suppressed with narrow planting space between lines (Rasool et al., 2017). Rhodes grass may also need to be monitored for Armyworm (*M. Unipuncta*) & Grasshoppers that are known to infest similar crops. In contrary to the desirable characteristics, Rhodes grass may have some shortcomings, such as short season of nutritive peak, poor adaptability to acid and infertile soils, and its fluffy seeds make it difficult to sow.



Figure 6: heavy mechanical damage that Rhodes overcome and developed into normal yield

Rhodes grass can be a strong selenium accumulator and hence may cause mortality or morbidity to livestock (NSWDPI, 2004).

CONCLUSION

Rhodes grass is highly drought tolerant, deep and resistant to flooding and high salinity crop. The high biomass productivity and high nutritional quality observed from low desert grown varieties indicates that Rhodes grass can be alternative forage crops for the low desert California and the US. The strong salt tolerance features of Rhodes grass would make it a desirable crop under irrigated low desert conditions where soil and irrigation water salt contents are high and very alarming. However, the promising accessions for different uses and environments (Ponsens et al. 2010) needs further evaluated across seasons and multilocal regions to be recommended for diverse regions. It seems spring and summer that best growing season for Rhodes grass under California's low desert conditions. We observed that the crop germinates quickly (4-7 days) and perform well under high heat and temperature conditions. The absence of pest incidences (weeds, pathogens and arthropods) suggests that Rhodes grass may be a low maintenance crop, at least for now.

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