agronomy

Article

Utilization of the Neighborhood Design to Evaluate Suitable Pasture Crops and Their Density for Navua Sedge (*Cyperus aromaticus*) Management

Chanwoo Kim and Bhagirath Singh Chauhan *

The Centre for Plant Science, Queensland Alliance for Agriculture and Food Innovation (QAAFI), University of Queensland, Gatton, QLD 4343, Australia; chanwoo.kim1@uq.net.au
* Correspondence: b.chauhan@uq.edu.au

Abstract: Navua sedge (*Cyperus aromaticus*), a perennial plant native to Africa, poses a significant weed concern due to its capacity for seed and rhizome fragment dissemination. Infestations can diminish pasture carrying capacity, displacing desirable species. Despite the burgeoning interest in integrated weed management strategies, information regarding the efficacy of competitive interactions with other pasture species for Navua sedge management remains limited. A pot trial investigated the competitive abilities of 14 diverse broadleaf and grass pasture species. The results indicated a range of the reduction in Navua sedge dry biomass from 6% to 98% across these species. Subsequently, three broadleaf species—burgundy bean (*Macroptilium bracteatum*), cowpea (*Vigna unguiculata*), and lablab (*Lablab purpureus*), and three grass species—Gatton panic (*Megathyrsus maximus*), Rhodes grass (*Chloris gayana*), and signal grass (*Urochloa decumbens*) were chosen for a follow-up pot trial based on their superior dry biomass performance. These six species were planted at three varying densities (44, 88, and 176 plants/m^2) surrounding a Navua sedge plant. Among the grass pasture species, Gatton panic and Rhodes grass exhibited high competitiveness, resulting in a minimum decrease of 86% and 99%, respectively, in Navua sedge dry biomass. Regarding the broadleaf species, lablab displayed the highest competitiveness, causing a minimum decrease of 99% in Navua sedge dry biomass. This study highlights the increasing efficacy of crop competition in suppressing weed growth and seed production, with the most significant suppression observed at a density of 176 plants/m^2.

Keywords: weed management; competitive interactions; crop competition; broadleaf species; grass species

Citation: Kim, C.; Chauhan, B.S. Utilization of the Neighborhood Design to Evaluate Suitable Pasture Crops and Their Density for Navua Sedge (*Cyperus aromaticus*) Management. *Agronomy* **2024**, *14*, 759. https://doi.org/10.3390/agronomy14040759

Academic Editor: Ilias Travlos

Received: 13 March 2024
Revised: 30 March 2024
Accepted: 5 April 2024
Published: 7 April 2024

1. Introduction

Navua sedge [*Cyperus aromaticus* (Ridl.) Mattf. & Kük.] is a perennial weed originally native to Africa, Madagascar, Mauritius, and the Seychelles [1]. It has now spread to various countries, including Australia, Sri Lanka, and Fiji. Since its introduction into Queensland, Australia, in the 1970s, it has further spread across the coastline, commonly found along roadsides, railways, pastures, and creek banks [2].

Navua sedge is a major concern for farmers due to its ability to spread by seeds and rhizome fragments in diverse environments [2,3]. This sedge is a prolific seed producer, capable of producing over 450 million seeds per hectare throughout the year [2,4]. These seeds disperse through various means, such as wind, animals, and machinery, while the extension of the rhizome and the dispersal of rhizome fragments during harvest and tillage can also introduce populations to uncontaminated areas [1]. Navua sedge seeds can germinate and thrive in a wide range of temperatures, soil moisture, salinity, and pH levels [2,5]. This flexibility further emphasizes the significant concerns posed by Navua sedge populations for farmers.

Navua sedge infestations decrease milk production and its quality in dairy farms. Previous studies have shown a 40% reduction in the carrying capacity of fields for livestock in Fiji [4,6,7]. Moreover, it is an undesirable pasture plant due to its unpalatable nature and very low nutritional value for cattle [4]. The sedge competes strongly for light, soil nutrients, and water with more desirable pasture crops, while also acting as a host for diseases and pests [1]. Presently, over 1000 dairy farmers, beef producers, and hay producers in north Queensland are affected by Navua sedge [2].

Mechanical control methods, such as crushing and mowing, are commonly used to manage Navua sedge populations along roadsides [2]. However, mechanical weed control is unsustainable, being less effective, necessitating regular repetition, and promoting seed spread to surrounding areas [2,6]. Tillage has been considered effective in burying seeds deeper into the soil [4], as the Navua sedge seed bank is primarily concentrated within the top 0 to 5 cm layer of soil, and Navua sedge seeds require exposure to light for germination [5,8]. However, this practice may prolong infestation by extending seed longevity in the soil seed bank and reducing seed losses [3].

Initially deemed more effective than mechanical methods, chemical control methods for Navua sedge are limited in Australia, with some herbicides raising concerns about their impact on non-target plants. Continuous herbicide applications can affect desirable pasture crops, ultimately reducing pasture field productivity [3]. Currently, halosulfuron-methyl is the primary herbicide used for controlling Navua sedge in Australia, requiring routine applications every 8 to 10 weeks throughout the year [2]. This herbicide is recommended in pastures, namely, signal grass (*Urochloa decumbens*), humidicola (*U. humidicola*), setaria (*Setaria* spp.), and Pangola grass (*Digitaria* spp.), for the control of this weed. However, this method is costly, estimated at AUD 435 per hectare annually [2]. Therefore, farmers must consider additional costs and unintended effects on desirable plants before implementing chemical control methods. A study found that halosulfuron-methyl, glyphosate, and paraquat provided complete control (100%) of Navua sedge in small plants (6-leaf stage) but were ineffective against very large plants (140–150 leaf stage) [9]. However, surviving plants did not produce seeds, suggesting that these herbicides could manage the Navua sedge seed bank. The current options for highly effective herbicides are limited to fallow periods or use along roadsides and fence lines, necessitating assessment of their suitability alongside other weed management options in future studies [9].

Integrated weed management utilizing crop competition to suppress weed growth and seed production is considered a sustainable option for farmers. Crop competition in the form of cover crops has been widely successful in weed suppression [10]. Living cover crops have been shown to suppress weed growth by reducing light transmittance and affecting soil temperatures, thereby reducing weed emergence [11]. Numerous studies have demonstrated the efficacy of crop competition in weed suppression [12,13]. Increasing crop planting density heightens crop competition, showing a negative correlation with weed biomass, as higher planting densities provide desirable plants with an advantage in developing canopy closure more rapidly, resulting in greater light interception [12,14].

Limited information is available on the effect of pasture competition on Navua sedge. One study evaluated crop competition responses in Navua sedge with only two pastures [15]. Rhodes grass (*Chloris gayana*) was found to be more competitive against Navua sedge than humidicola, especially at a high plant density. Plant characteristics such as height, biomass production, and leaf shape can influence the intensity of plant competition [16]. This suggests that different pastures may possess varying competitive abilities. Therefore, future studies should encompass a larger number of species. The study was conducted in a glasshouse [15]. Trials under controlled glasshouse conditions have shown differences in plant growth compared to trials conducted in an open environment, indicating that glasshouse and field conditions may impact plant growth differently [17,18]. The objective of this study was to investigate the effects of different grass and broadleaf pasture crops, grown in an open environment at varying planting densities, on the growth and seed production of Navua sedge.

2. Materials and Methods

2.1. Seed Collection

In November 2020, Navua sedge plants were uprooted with their roots intact from a pasture field in Ingham, Queensland. The plants were then placed in a plastic container and brought to the weed science research facility at the University of Queensland, Gatton, Australia. The plants were transplanted into plastic pots (24 cm in diameter), using a commercial potting mix (Centenary Landscaping, Mount Omanney, Brisbane, QLD, Australia). The potting mix contained biological organic-based products and had a pH of 5.6. The pots were placed on benches in the open at the Gatton research farm. The plants were watered daily, but no fertilizer was used. Seeds were collected in November 2020 and used in this study. The seeds were placed in an airtight container and stored at room temperature (25 ± 2 °C).

2.2. Trial 1. Morphological Performance of 14 Pasture Species

There was a total of 15 treatments, and each treatment had five replications. Pasture species selected for this study were burgundy bean [*Macroptilium bracteatum* (Nees & Mart.) Maréchal & Baudet], cardillo centro [*Centrosema molle* Mart. ex Benth.], cowpea [*Vigna unguiculata* (L.) Walp], Gatton panic [*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs], greenleaf desmodium [*Desmodium intortum* (Mill.) Urb], humidicola [*Urochloa humidicola* (Rendle) Morrone & Zuloaga], lablab [*Lablab purpureus* (L.) Sweet], oolloo centro [*Centrosema brasilianum* (L.) Benth], Rhodes grass [*Chloris gayana* Kunth], sabi grass [*Urochloa mosambicensis* (Hack.) Dandy], signal grass [*Urochloa decumbens* (Stapf) R.D. Webster], siratro [*Macroptilium atropurpureum* (DC.) Urb.], stylo [*Stylosanthes guianensis* (Aubl.) Sw.], and wynn cassia [*Chamaecrista rotundifolia* (Pers.) Greene].

Four to five seeds of Navua sedge were planted (October 2021) in the center of a 24 cm diameter pot and thinned to one plant after emergence. The pasture species were planted simultaneously surrounding the Navua sedge at a distance of 11 cm and a density of four plants per pot (88 plants/m^2). There was also one control treatment in which only Navua sedge was planted. A commercial potting mix was used as mentioned above, and the pots were regularly irrigated. The pots were placed in the same location as mentioned above. Plant height, branch number, seed head number, and plant diameter were measured 11 weeks after planting. All aboveground plant materials were cut and dried in an oven (TD-500F, Thermoline Scientific Equipment Pty Ltd., Wetherill Park, NSW 2164, Australia) at 70 °C for 72 h to measure dry biomass.

2.3. Trial 2. Effect of Three Grass and Three Broadleaf Pasture Species on Navua Sedge Suppression

Out of the fourteen pasture species grown in Trial 1, three grass and three broadleaf species were selected based on yielding the highest biomass: burgundy bean, cowpea, Gatton panic, lablab, Rhodes grass, and signal grass. The trial was managed as described above. A total of 5 seeds of Navua sedge were sown (January 2022 and October 2022) in the center of each pot, filled with commercial potting mix as mentioned above, alone or surrounded by 2, 4, or 8 plants of each pasture (equivalent to 44, 88, and 176 plants/m^2). Each treatment had five replications. These different planting densities represent the different levels of shading caused by the development of a canopy by pasture species. Immediately after Navua sedge emerged, it was thinned to one healthy seedling. The pots were irrigated daily and placed outside on benches. The same measurements were taken as mentioned above, along with an additional SPAD (SPAD 502 Plus Chlorophyll Meter, WMC Solutions Australia, North Lakes, Queensland 4509, Australia) reading to examine the effect of cover crop interference on Navua sedge growth and development. The plants were harvested 12 weeks after planting.

2.4. Statistical Analyses

All experiments were arranged in a randomized complete block design, with five replications. In Trial 2, each run showed significantly different results. Thus, each run has been presented separately (Run 1 and Run 2). An analysis of variance (ANOVA) was performed using GenStat (21st edition; VSN International, Hemel Hempstead, UK) to compare statistical significance between each pasture species. Interactions among treatments were examined using Fisher's protected least significant differences (LSD, $p \leq 0.05$) test.

3. Results and Discussion

3.1. Trial 1. Morphological Performance of 14 Pasture Species

The degree of freedom and p values for each parameter of Navua sedge are shown in Table 1. All of the selected 14 pastures showed varying results on Navua sedge growth and development (height, branch number, seed head number and diameter, and dry biomass). There were no significant differences between the height of Navua sedge when grown alone and when grown in competition with burgundy bean, Cardillo centro, greenleaf desmodium, humidicola, Oolloo centro, siratro, and wynn cassia. The remaining eight pastures resulted in a significant decline in Navua sedge height, with up to a 40% decline (Table 2). The seed head number was significantly reduced in all pastures, excluding cardillo centro and stylo, with at least a 30% decline and up to a 98% decline. Similarly, seed head diameter was significantly reduced in all pastures, excluding wynn cassia, with at least a 40% decline. All species resulted in a significant decrease in the Navua sedge branch number, ranging from 21% to 95%, and dry biomass, ranging from 6% to 98% (Table 2). All pasture species that provided less than a 40% decrease in weed biomass were broadleaf, indicating a higher competitiveness in grass pasture species.

Table 1. Analysis of variance (ANOVA) showing the degree of freedom and p-values for Navua sedge parameters.

Trial and Navua Sedge Parameters	Degree of Freedom	p-Value
Trial 1		
Height	14	<0.001
Branch	14	<0.001
Head	14	<0.001
Diameter	14	<0.001
Biomass	14	<0.001
Trial 2—Run 1		
Height	18	<0.001
Branch	18	<0.001
Head	18	<0.001
Biomass	18	<0.001
SPAD	18	<0.001
Trial 2—Run 2		
Height	18	<0.001
Branch	18	<0.001
Head	18	<0.001
Biomass	18	<0.001
SPAD	18	<0.001

Three broadleaf and grass pasture species with the highest dry biomass were selected to be used in Trial 2. The broadleaf species selected were burgundy bean, cowpea, and lablab, which provided the highest weed biomass decline with an 83%, 98%, and 90% decline, respectively (Table 1). The least competitive broadleaf species was stylo, which reduced Navua sedge biomass by only 6% (Table 1). The grass species with the highest biomass were Gatton panic, Rhodes grass, and signal grass, which provided the highest weed biomass decline of 94%, 96%, and 91%, respectively (Table 1). The least competitive grass species was humidicola, which provided a 59% decrease in weed biomass (Table 1). All six species resulted in a significant decline in weed seed head production, showing a reduction of at least 88% (Table 1).

Table 2. Growth and biomass of Navua sedge in response to competition with 88 plants/m^2 of different pasture species.

Pasture	Navua Sedge					Pasture	
	Height (cm)	Branch (No./Plant)	Head (No./Plant)	Diameter (mm)	Biomass (g/Plant)	Height (cm)	Biomass (g/Pot)
Control	59.0	165.6	85.2	7.8	62.9		
Burgundy bean (*Macroptilium bracteatum*)	60.2	20.4	10.2	1.1	11.0	95.9	103.4
Cardillo centro (*Centrosema molle*)	59.0	121.8	73.0	4.1	39.9	70.8	35.8
Cowpea (*Vigna unguiculata*)	35.6	8.0	2.0	0.0	1.4	55.8	248.6
Gatton panic (*Megathyrsus maximus*)	50.1	15.6	6.6	1.8	3.8	152.0	219.7
Greenleaf desmodium (*Desmodium intortum*)	57.4	48.4	20.2	3.6	14.5	85.4	79.9
Humidicola (*Urochloa humidicola*)	51.0	76.2	50.4	4.0	25.5	120.7	113.7
Lablab (*Lablab purpureus*)	45.6	22.6	7.0	1.2	6.2	109.6	126.8
Oolloo centro (*Centrosema brasilianum*)	55.4	52.8	140.6	4.3	46.4	64.4	20.5
Rhodes grass (*Chloris gayana*)	38.2	13.4	5.6	0.4	2.7	111.5	295.9
Sabi grass (*Urochloa mosambicensis*)	45.6	32.6	15.0	2.4	7.6	116.0	153.7
Signal grass (*Urochloa decumbens*)	36.2	22.8	7.2	1.6	5.9	96.4	202.0
Siratro (*Macroptilium atropurpureum*)	51.8	24.2	9.6	1.9	5.5	103.3	80.1
Stylo (*Stylosanthes guianensis*)	58.1	130.8	85.8	4.7	58.9	35.1	10.6
Wynn cassia (*Chamaecrista rotundifolia*)	61.9	124.4	59.6	7.3	45.9	49.0	21.3
LSD	8.8	20.4	14.2	0.9	6.8	21.1	23.7

Perennial weeds, such as Navua sedge, are often more competitive compared to annual weeds [19]. This makes them more challenging to control using crop competition and thus requires more vigorous crop species to have efficient results. Cowpea and lablab are desirable leguminous pasture species with a leaf-to-stem ratio of 50:50 [20]. Lablab has been found to have a greater level of light interception than other pasture species at the same shoot biomass [21]. This may be explained by its larger leaf size. Whilst lablab and stylo both have similar mature plant heights of around one meter, lablab has larger leaves than stylo [22,23]. This means that having faster canopy development due to its leaf shape and biomass gives lablab a competitive advantage compared to other broadleaf species and may explain the poor performance seen by stylo. Previous studies have found that Rhodes grass was more competitive than humidicola against Navua sedge [15,24], and similar results were observed in our study. This suggests that the difference in growth characteristics, such as the rate of development amongst grass pasture species, may substantially impact their competitive intensity.

3.2. Trial 2. Effect of Three Grass and Three Broadleaf Pasture Species on Navua Sedge Suppression

As mentioned above, Run 1 and Run 2 showed different results; therefore, they are presented separately for each run. Navua sedge height, branch number, seed head number, dry biomass, and SPAD values were significantly affected by pasture interference, excluding the height of Navua sedge that was planted with burgundy bean in Run 1 (Table 3). Burgundy bean also had a lower pasture height and dry biomass in Run 1 compared to Run 2. However, there were still significant reductions in weed biomass and seed head number in Run 1 with competition from burgundy bean, suggesting that height is not the best indicator for success in control.

Table 3. Effect of different densities of three broadleaf and three grass pasture species on growth and biomass of Navua sedge (Trial 2—Run 1).

Pasture	Density (Plants/m^2)	Navua Sedge					Pasture	
		Height (cm)	Branch (No./Plant)	Head (No./Plant)	Biomass (g/Plant)	SPAD	Height (cm)	Biomass (g/Pot)
Control	0	68.6	158.4	127.2	88.44	53.6	-	-
Burgundy bean	44	63.6	52.6	33.8	18.66	36.3	59.4	48
	88	62.0	30.6	20.0	9.87	35.7	52.8	51
	176	58.0	13.8	7.0	3.12	28.0	63.9	71
Cowpea	44	34.8	10.2	2.8	1.89	34.3	56.0	116
	88	37.4	6.8	2.0	1.21	30.5	52.0	156
	176	33.2	2.8	0.2	0.27	26.3	50.5	215
Lablab	44	43.4	7.8	2.8	1.13	34.2	107.9	196
	88	31.2	3.4	0.4	0.30	33.0	117.9	225
	176	14.6	0.8	0.0	0.04	9.4	116.8	241
Gatton panic	44	45.0	7.8	2.2	0.96	32.7	149.8	326
	88	26.6	2.8	0.0	0.23	28.0	153.3	342
	176	14.2	1.4	0.0	0.07	15.9	151.1	364
Rhodes grass	44	38.2	5.4	1.4	0.69	31.0	137.7	365
	88	29.8	2.8	0.4	0.29	26.0	124.0	372
	176	10.0	0.6	0.0	0.05	9.3	139.5	416
Signal grass	44	46.4	25.4	16.4	5.27	29.7	106.1	156
	88	49.8	17.4	11.8	3.93	30.6	109.9	235
	176	48.0	8.8	6.4	1.84	26.8	109.6	328
LSD		11.2	8.2	5.4	4.26	8.7	13.4	38

When grown with no pasture interference, Navua sedge dry biomass and seed head numbers were 88.4 g/plant and 127 plant^{-1} in Run 1, and 57.2 g/plant and 56 plant^{-1} in Run 2, respectively (Tables 3 and 4). In both runs, Navua sedge biomass and seed head number decreased as planting density (therefore, its competition intensity) increased. Lablab was the most effective broadleaf species for Navua sedge growth suppression, with 99% to 100% reductions in its biomass and seed head formation at all densities (i.e., 44, 88, and 176 plants/m^2) in both runs (Tables 3 and 4). Out of the three grass species, Gatton panic and Rhodes grass both provided the greatest control, providing 98% to 100% control of Navua sedge dry biomass across all planting densities in Run 1 (Table 3). This trend was also observed in Run 2, aside from Gatton panic planted at a density of 88 plants/m^2, which resulted in an 86% decrease in weed biomass (Table 4).

Pasture biomass was affected by their densities, with all six species producing from 48 g pot^{-1} to 416 g pot^{-1} (Tables 3 and 4). Burgundy bean produced the lowest biomass at all densities in both Run 1 and Run 2 (48 to 71 g pot^{-1} and 131 to 138 g pot^{-1}, respectively). Rhodes grass had a very high biomass in both Run 1 (365 to 416 g pot^{-1}) and Run 2 (338 to 355 g pot^{-1}).

Grass and broadleaf pasture species have different characteristics, such as growth form and density, which determine their efficacy in competing against weed species [25]. Gatton panic and Rhodes grass were very effective in controlling Navua sedge, with both grass species having been found to show high levels of competition. Gatton panic was widely known to be a highly invasive species around the world, with its ability to rapidly grow its biomass in a wide range of environments [26–28]. Rhodes grass is acknowledged as a desirable species to improve forage quality due to its high biomass production [29]. Therefore, the competitive nature of both species may explain their performance when compared to other grass pasture species. Amongst the broadleaf species, lablab resulted in the greatest suppression of Navua sedge. Lablab has previously been found to possess a highly competitive nature, suppressing the growth of mikania vine [*Mikania micrantha* Kunth] and parthenium [*Parthenium hysterophorus* L.] [30,31]. Mikania vine control increased when lablab was grown in conjunction with sweet potato [*Ipomoea batatas* (L.) Lam] [31]. However, lablab was found to be the key species required in a mixture of various rangeland species to effectively control parthenium [30]. This may suggest that in a pasture setting, where there are multiple species grown in the same area of land, the efficacy of Navua sedge control by a single species may differ in a functional pasture field compared to the results from this study.

Table 4. Effect of different densities of three broadleaf and three grass pasture species on growth and biomass of Navua sedge (Trial 2—Run 2).

Pasture	Density (Plants/m^2)	Navua Sedge					Pasture	
		Height (cm)	Branch (No./Plant)	Head (No./Plant)	Biomass (g/Plant)	SPAD	Height (cm)	Biomass (g/Pot)
Control	0	47.0	147.8	56.4	57.20	63.6	-	-
Burgundy bean	44	29.8	11.6	8.4	2.23	46.0	84.0	131
	88	30.0	12.2	8.4	1.96	38.7	75.1	139
	176	17.6	6.0	4.2	0.19	22.0	96.0	138
Cowpea	44	23.4	8.0	2.8	0.96	41.1	60.0	209
	88	14.0	3.8	1.0	0.17	26.5	62.7	228
	176	9.6	1.4	0.0	0.17	24.6	61.6	230
Lablab	44	13.8	4.0	0.8	0.39	26.6	113.2	188
	88	6.8	1.6	0.0	0.10	18.2	103.6	210
	176	11.2	1.2	0.2	0.10	19.5	82.1	222
Gatton panic	44	14.2	4.4	0.2	0.27	23.7	134.9	278
	88	11.6	0.6	0.0	8.24	25.6	137.6	355
	176	12.2	0.8	0.0	0.08	19.1	130.2	369
Rhodes grass	44	12.2	2.2	0.0	0.14	27.5	138.2	353
	88	12.0	1.4	0.4	0.10	24.0	123.8	355
	176	9.2	0.0	0.0	0.03	20.6	110.8	338
Signal grass	44	39.2	34.4	25.4	7.38	44.7	88.8	232
	88	30.8	16.0	10.2	2.03	37.2	86.8	308
	176	23.8	7.4	4.0	0.38	36.8	95.6	345
LSD		7.6	4.4	3.1	5.50	8.2	8.9	57

A previous study that used the neighborhood design to examine how weed growth is affected by different plant density regimes also found that weed plant height was not affected by an increase in densities, but there were significant reductions in tiller and leaf numbers [32]. Plant competition from pastures can increase weed death rates, reduce the rate of establishment, and cause a delay in plant development in weeds [25]. The weed plant height may not be a reliable measurement when examining the efficacy of an increased planting density, as the height may not dramatically decrease but other aspects of plant growth may be inhibited, which could suppress seed production and thus limit the amount of new weed seeds entering the soil seed bank.

Appropriate management of pastures is necessary to ensure populations of desirable plants, such as the highly competitive lablab, Gatton panic, and Rhodes grass, are maintained and accessible for grazing. The establishment, maintenance of growth, and efficient harvesting of these pastures are crucial steps in pasture management [20]. Pastures, such as Rhodes grass, can greatly benefit from fertilizer applications, increasing pasture quality and quantity [33,34]. Thus, graziers should be informed about responsible management techniques to ensure that desirable pasture species have been established and that these pastures respond well to grazing and other stressors. Furthermore, pastures could be maintained at a longer height range for increases in pasture productivity and increased weed control [35].

4. Conclusions

Out of the 14 broadleaf and grass pasture species, lablab, Gatton panic, and Rhodes grass were found to be the most effective in suppressing Navua sedge growth and seed production. This provides new implications for pasture management for graziers, providing them with potentially desirable species to have in pastures experiencing a Navua sedge infestation. By encouraging the growth of these competitive pasture species, graziers would be able to reduce their reliance on herbicides whilst reducing the weed seed bank. However, it should be noted that achieving a uniform plant population in pastures can be difficult, and as this study was conducted in pots in an open environment, results may differ in field conditions. Therefore, there is a need to further examine the effect of integrated weed management methods which include the use of herbicides.

Author Contributions: Conceptualization, B.S.C.; methodology, B.S.C.; formal analysis, B.S.C.; investigation, C.K. and B.S.C.; resources, B.S.C.; data curation, C.K.; writing—original draft preparation, C.K.; writing—review and editing, B.S.C.; supervision, B.S.C.; funding acquisition, B.S.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: All relevant data are within the manuscript.

Acknowledgments: The authors thank Tropical Pasture Seeds Australia Pty Ltd. for providing the pasture seeds.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Parsons, W.T.; Cuthbertson, E.G. *Noxious Weeds of Australia*, 2nd ed.; CSIRO Publishing: Victoria, Australia, 2001.
2. Shi, B.; Osunkoya, O.O.; Chadha, A.; Florentine, S.K.; Dhileepan, K. Biology, ecology and management of the invasive Navua sedge (*Cyperus aromaticus*)—A global review. *Plants* **2021**, *10*, 1851. [CrossRef]
3. Vitelli, J.S.; Madigan, B.A.; Haaren, P.E.v. Control techniques and management strategies for the problematic Navua sedge (*Cyperus aromaticus*). *Invasive Plant Sci. Manag.* **2010**, *3*, 315–326. [CrossRef]
4. Karan, B. Studies of Navua sedge (*Cyperus aromaticus*) Part 1. Review of the problem and study of morphology, seed output and germination. *Fiji Agric. J.* **1975**, *37*, 59–67.
5. Chauhan, B.S. Differential germination response of Navua sedge (*Cyperus aromaticus*) populations to environmental factors. *Weed Sci.* **2021**, *69*, 673–680. [CrossRef]
6. Black, I.D. Navua sedge in pastures in Fiji. *Aust. Weeds* **1984**, *3*, 16–25.
7. Kerr, D.V.; Fell, R.F.; Murray, A.J.; Chaseling, J. An assessment of factors associated with increased productivity of dairy farms in Fiji. *Asian-Australas. J. Anim. Sci.* **1995**, *8*, 481–487. [CrossRef]
8. Chadha, A.; Osunkoya, O.O.; Shi, B.; Florentine, S.K.; Dhileepan, K. Soil seed bank dynamics of pastures invaded by Navua sedge (*Cyperus aromaticus*) in tropical north Queensland. *Front. Agron.* **2022**, *4*, 897417. [CrossRef]
9. Chauhan, B.S.; Mahajan, G. Herbicide options for the management of Navua sedge (*Cyperus aromaticus*) plants established through seeds. *Agriculture* **2022**, *12*, 1709. [CrossRef]
10. Fernando, M.; Shrestha, A. The potential of cover crops for weed management: A sole tool or component of an integreated weed management system? *Plants* **2023**, *12*, 752. [CrossRef]
11. Teasdale, J.R.; Mohler, C.L. Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. *Agron. J.* **1993**, *85*, 673–680. [CrossRef]
12. Mirsky, S.B.; Ryan, M.R.; Teasdale, J.R.; Curran, W.S.; Reberg-Horton, C.S.; Spargo, J.T.; Wells, M.S.; Keene, C.L.; Moyer, J.W. Overcoming weed management challenges in cover crop–based organic rotational no-till soybean production in the Eastern United States. *Weed Technol.* **2013**, *27*, 193–203. [CrossRef]
13. Yeganehpoor, F.; Salmasi, S.Z.; Abedi, G.; Samadiyan, F.; Beyginiya, V. Effects of cover crops and weed management on corn yield. *J. Saudi Soc. Agr. Sci.* **2015**, *14*, 178–181. [CrossRef]
14. Menalled, U.D.; Adeux, G.; Cordeau, S.; Smith, R.G.; Mirsky, S.B.; Ryan, M.R. Cereal rye mulch biomass and crop density affect weed suppression and community assembly in no-till planted soybean. *Ecosphere* **2022**, *13*, e4147. [CrossRef]
15. Shi, B.; Osunkoya, O.O.; Soni, A.; Campbell, S.; Dhileepan, K. Growth of the invasive Navua sedge (*Cyperus aromaticus*) under competitive interaction with pasture species and simulated grazing conditions: Implication for management. *Ecol. Res.* **2023**, *38*, 331–346. [CrossRef]
16. Gaudet, C.L.; Keddy, P.A. A comparative approach to predicting competitive ability from plant traits. *Nature* **1988**, *334*, 242–243. [CrossRef]

17. Bennett, A.J.; Mead, A.; Whipps, J.M. Performance of carrot and onion seed primed with beneficial microorganisms in glasshouse and field trials. *Biol. Control* **2009**, *51*, 417–426. [CrossRef]
18. Limpens, J.; Granath, G.; Aerts, R.; Heijmans, M.M.P.D.; Sheppard, L.J.; Bragazza, L.; Williams, B.L.; Rydin, H.; Bubier, J.; Moore, T.; et al. Glasshouse vs. field experiments: Do they yield ecologically similar results for assessing N impacts on peat mosses? *New Phytol.* **2012**, *195*, 408–418. [CrossRef]
19. Teasdale, J.R.; Brandsæter, L.O.; Calegari, A.; Neto, F.S. Cover crops and weed management. In *Non-Chemical Weed Management: Principles, Concepts and Technology*; Upadhyaya, M.K., Blackshaw, R.E., Eds.; CAB International: Wallingford, UK, 2007; pp. 49–64.
20. Havilah, E.J. Forages and Pastures | Annual Forage and Pasture Crops—Establishment and Management. In *Encyclopedia of Dairy Sciences*, 2nd ed.; Fuquay, J.W., Ed.; Academic Press: Cambridge, MA, USA, 2011; pp. 563–575.
21. Mugi-Ngenga, E.; Bastiaans, L.; Anten, N.P.R.; Zingore, S.; Baijukya, F.; Giller, K.E. The role of inter-specific competition for water in maize-legume intercropping systems in northern Tanzania. *Agric. Syst.* **2023**, *207*, 103619. [CrossRef]
22. Cook, B. Stylo. Available online: https://keys.lucidcentral.org/keys/v3/pastures/Html/Stylo.htm (accessed on 1 October 2023).
23. Johnson, B.; Lloyd, D. Panics. Available online: https://keys.lucidcentral.org/keys/v3/pastures/Html/Panics.htm (accessed on 1 October 2023).
24. Shi, B.; Moilwa, M.; Osunkoya, O.O.; Dhileepan, K.; Adkins, S. Management of Navua sedge (*Cyperus aromaticus*): A role of competition using two pasture species. In Proceedings of the 22nd Australasian Weeds Conference, Adelaide, Australia, 25–29 September 2022; pp. 216–219.
25. Bourdôt, G.W.; Fowler, S.V.; Edwards, G.R.; Kriticos, D.J.; Kean, J.M.; Rahman, A.; Parsons, A.J. Pastoral weeds in New Zealand: Status and potential solutions. *N. Z. J. Agric. Res.* **2007**, *50*, 139–161. [CrossRef]
26. Cabrera, D.C.; Sobrero, M.T.; Pece, M.; Chaila, S. Effect of environmental factors on the germination of *Megathyrsus maximus*: An invasive weed in sugarcane in Argentina. *Planta Daninha* **2020**, *38*, e020216688. [CrossRef]
27. Cabin, R.J.; Weller, S.G.; Lorence, D.H.; Cordell, S.; Hadway, L.J.; Montgomery, R.; Goo, D.; Urakami, A. Effects of light, alien grass, and native species additions on Hawaiian dry forest restoration. *Ecol. Appl.* **2002**, *12*, 1595–1610. [CrossRef]
28. Overholt, W.A.; Franck, A.R. The invasive legacy of forage grass introductions into Florida. *Nat. Areas J.* **2017**, *37*, 254–264. [CrossRef]
29. Yisehak, K. Effect of seed proportions of Rhodes grass (*Chloris gayana*) and white sweet clover (*Melilotus alba*) at sowing on agronomic characteristics and nutritional quality. *Livest. Res. Rural Dev.* **2008**, *20*, 28. Available online: https://lrrd.cipav.org.co/lrrd20/2/yisecit.htm (accessed on 4 April 2024).
30. Ojija, F.; Arnold, S.E.J.; Treydte, A.C. Plant competition as an ecosystem-based management tool for suppressing *Parthenium hysterophorus* in rangelands. *Rangelands* **2021**, *43*, 57–64. [CrossRef]
31. Shen, S.; Xu, G.; Ma, G.; Li, D.; Yang, S.; Jinn, G.; Clements, D.R.; Chen, A.; Wen, L.; Cui, Y.; et al. Sweet potato (*Ipomoea batatas*) and hyacinth bean (*Lablab purpureus*) in combination provide greater suppression of mile-a-minute (*Mikania micrantha*) than either crop alone. *Front. Plant Sci.* **2023**, *14*, 1070674. [CrossRef] [PubMed]
32. Matloob, A.; Chauhan, B.S. Utilization of the neighborhood design to evaluate suitable cover crops and their density for *Echinochloa colona* management. *PLoS ONE* **2021**, *16*, e0254584. [CrossRef] [PubMed]
33. Havilah, E.; Warren, H.; Lawrie, R.; Senn, A.; Milham, P. *Fertilisers for Pastures*; NSW Department of Primary Industries: New South Wales, Australia, 2005.
34. Allah, Y.N.; Bello, A. The potentials of Rhodes grass (*Chloris gayana* Kunth) as drought resistant perennial forage grass in Nigeria. *Am. J. Biomed. Sci. Res.* **2019**, *6*. [CrossRef]
35. Eerens, J.P.J.; Rahman, A.; James, T.K. Optimising pasture production to minimise weed growth. *West Coast* **2002**, *64*, 143–146. [CrossRef]