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Effects of Varietal Competitiveness and Weed Control on Productivity in the Lowland Rice Farming System in Burkina Faso

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Abstract

Weeds remain a major limiting factor for rice productivity in Burkina Faso. During the 2023 rainy season, a study was conducted at the Environmental, Agricultural and Training Research Center of Kamboinsé to study the effects of varietal competitiveness and weeding methods on the productivity of lowland rice systems. Four lowland rice varieties were evaluated under five weeding treatments, namely: no weeding or zero weeding (S0); one late manual weeding (S1); two manual weedings (S2); a chemical weeding with a pre-emergence herbicide (S3); and a chemical weeding with a post-emergence herbicide (S4). A weed species inventory identified the most abundant species including: *Oryza longistaminata*, *Cyperus iria*, *Ipomoea aquatica*, *Echinochloa colona*, *Melochia corchorifolia*, and *Ludwigia hyssopifolia*. The effects of variety and weeding modality on grain yield, were highly significant in the lowland rice system. Furthermore, the effectiveness of weeding practices varied among the evaluated rice varieties. Two varieties, TS2 and Orylux6, exhibited the best performance when combined with post-emergence chemical weeding. This combination, resulted in reduced weed biomass at harvest, a higher panicle density per square meter, and optimal expression of their yield potential. In contrast, FKR56N and KBR8 achieved their highest yields under one late manual weeding and two manual weedings, respectively. Furthermore, FKR56N recorded the lowest weed biomass (1576.67 kg/ha) under the untreated control condition. The results indicate that two manual weedings, carried out between 21 and 49 days after sowing, are necessary under weed flora conditions dominated by

Oryza longistaminata and *Cyperus iria*. This study highlights the importance of understanding the specific response of each variety to varying levels of weed infestation for optimize yield potential.

Keywords

Lowland Rice, Weed, Varietal Competitiveness, Weeding Method, Burkina Faso

1. Introduction

The country's economy was primarily dominated by the tertiary sector over the period 2019-2021. Indeed, the tertiary sector, including taxes and duties, accounted for an average of 53.0% of GDP over the period of 2019-2021, followed by the secondary sector (26.4%) and the primary sector (20.6%) [1]. Burkina Faso agriculture is a subsistence rainfed system based primarily on cereals, which occupy more than 88% of the areas sown annually serving as a staple food for the majority of the population [2].

According to the five-year average from 2019 to 2023, rice ranks fourth among cereals in Burkina Faso, both in terms of both area (191,893 ha), and in production (413,667 tons) [3]. The country's rice needs are increasing rapidly due to population growth, particularly in urban areas [4]. These rice consumption needs were estimated in 2018 at 773,775 tons with projected needs of 1,500,000 tons in 2025 [5]. Rice is extremely important for the Burkina Faso's economy because the country relies on imports to meet ever-increasing demand, which contributes to a widening trade deficit. Imports were estimated in 2023 at nearly 777,233.3 tons of rice, the equivalent of 72.547 billion XOF [6] compare to a production of 504,254 tons of milled rice [3]. According to [2], the rice value chain has significant growth potential, evidenced by the existence of numerous production infrastructures, more than fifty improved rice varieties, and a large number of well-structured actors with interprofessional committee.

Rice productivity in Burkina Faso is strongly influenced by agro-climatic factors. According to [7], weeds are the second most limiting factor for rice, after water. Dense grass cover on plots during the first month of cultivation can lead to their abandonment by producers [8]. In addition, the rural population in developing countries spends more time weeding than on any other agricultural activity [9]. Labor requirements for this crop, although highly variable and strongly influenced by cropping systems, are estimated at about 50 person-days per hectare, with a frequent need for weeding under hydromorphic conditions in rice cultivation [10].

The present study aims to evaluate the combined effects of rice varietal competitiveness and weed control mode on the productivity of the lowland rice farming system in central Burkina Faso.

2. Materials and Methods

2.1. Materials

1) Study site

The study was conducted in 2023 in the Centre region located in the Sudano-Sahelian agro-climatic zone in lowland rice cultivation at the Kamboinsé research station (**Figure 1**). The cumulative rainfall recorded during the study period was 603 mm in 37 days between June 21 and October 10, 2023.

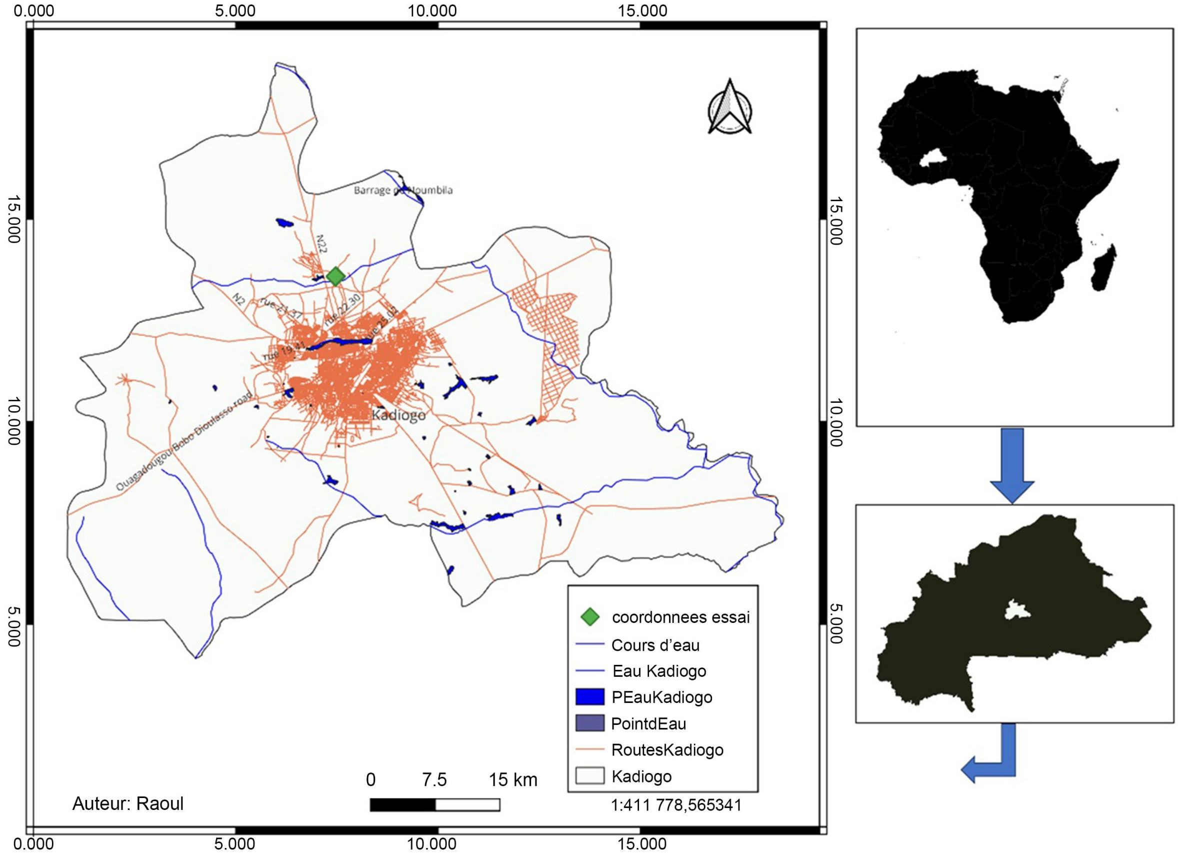

Figure 1. Location of the Kamboinsé Research Station in the Centre region.

According to [11], the soils of the Kamboinsé research station are tropical ferruginous soils leached on deep clay-sandy materials. The soil in lowland experimental plots (**Table 1**) had a pH of 5.7 to 5.8 and an organic matter content ranging from 1.17% to 2.47%.

Table 1. Test soil parameters.

Physico-chemical parameters	Replication		
Laboratory number	11	12	13
Original number	Block1	Block2	Block3
Sampling depth	0 - 20 cm	0 - 20 cm	0 - 20 cm
Total organic matter %	2.472	1.193	1.176

Continued

Total carbon %	1.434	0.692	0.682
Total nitrogen	0.105	0.138	0.114
C/N	14	5	6
Absorbable phosphorus ppm	4.74	2.88	3.57
Available potassium ppm	76.67	57.5	60.69
Meq/100 g exchangeable bases			
Calcium (Ca^{2+})	7.23	7.27	6.35
Magnesium (Mg^{2+})	2.18	1.79	1.51
Potassium(K^{+})	0.19	0.16	0.12
Sodium (Na^{+})	0.13	0.13	0.16
Sum of bases (S)	9.73	9.35	8.14
Exchange capacity (T) meq/100g	11.22	10.83	10.42
Saturation rate (S/T) %	87	86	78
Soil response			
pH water (W/V: 1/2.5)	5.8	5.7	5.7
Conductivity (W/V: 1/2.5) mS/cm	52.88	49.59	52.88

Source: Results of sample analyses by BUNASOLS in 2024.

2) Choice of rice varieties

The plant material consisted of four lowland rice varieties (Table 2). The varieties were chosen based on their adoption by rice farmers and consumer preference (TS2, Orylux6), as well as the prospects for improved yields offered by newer varieties (KBR8, FKR56N).

Table 2. Characteristics of rice varieties used in Kamboinsé in 2023.

Characteristics	Rice varieties used in the trial			
	FKR56N	KBR8	Orylux6	TS2
Ecology	L/I	L/I	L/I/U	L/I
Seeding-maturity cycle (days)	116	118	100	120
Height (cm)	115	115	114	92
Tillering	Good	Very good	Good	Medium
Plant habit	Erect	Erect	Semi-erect	Erect
Panicle leaf habit	Erect	Semi-erect	Erect	Erect
Yield potential (tons ha^{-1})	6 - 7	9 - 10	6.5	6 - 7
Thousand-kernel weight (g)	25.65	27.5	19.5	22.80

L = Lowland; I = Irrigated; U = Upland.

2.2. Experimental Design

The experimental design was a three-replication randomized Fisher block. Thus, design included 20 treatments (Table 3) each replicated in three blocks, for a total of 60 experimental units (20 treatments × 3 blocks). The treatments were arranged in a factorial design with two factors: rice variety (Factor 1) and weeding method (Factor 2). The specific levels of each factor are listed in Table 3.

Table 3. Combination of factors.

Weeding methods	Rice varieties			
	FKR56N (V1)	KBR8 (V2)	Orylux6 (V3)	TS2 (V4)
Zero (0) weeding (W0)/Dirty control	T1 = V1 S0	T6 = V2 S0	T11 = V3 S0	T16 = V4 S0
One (1) late Manual weeding at 49 DAS[a] (W1)	T2 = V1 S1	T7 = V2 S1	T12 = V3 S1	T17 = V4 S1
Two (2) Manual weeding (W2)	T3 = V1 S2	T8 = V2 S2	T13 = V3 S2	T18 = V4 S2
One application of pre-emergent herbicide (W3)	T4 = V1 S3	T9 = V2 S3	T14 = V3 S3	T19 = V4 S3
Two post-emergence herbicide applications (W4)	T5 = V1 S4	T10 = V2 S4	T15 = V3 S4	T20 = V4S4

[a]DAS, days after sowing.

Each elementary plots measured 4 m × 1.75 m, giving an area of 7 m^2 with one-metre (1 m) alleys separating plots within the same block while a 2 m path was maintained between two blocks. The total area for the study was 1044 m^2.

2.3. Cultivation Management

The plot was plowed with a tractor at the beginning of the season. Manual tillage was performed to prepare the seedbed. Organic manure (6 t/ha) and phosphate rock powder (400 kg/ha) were applied to the plots during this process. All elementary plots received 200 kg/ha of NPK (15 - 25 - 15) as a base fertilizer before sowing. Subsequently, 35 kg/ha and 65 kg/ha urea (46% N) were applied at 21 and 49 days after sowing. Sowing was carried out in pockets with a spacings of 20 cm × 20 cm at a seed rate of 80 kg/ha. The rice seed were treated with Permethrin (25 g/kg) + Thiram (250 g/kg). A pre-emergence herbicide, Pendimethalin (455 g/L) was applied at a rate of 3 L/ha the day after planting. A post-emergence herbicide bispyribac-sodium (100 g/L) was applied at a rate of 400 ml/ha at 21 and 49 days after planting. Pest control was performed with Emamectin benzoate (300 g/kg) at a dose of 40 g/ha as soon as the first silver shoot appeared, indicating the presence of rice gall midge.

2.4. Data Collection

Concerning weeds, the observations focused on:

- Weeds biomass (g) samples were taken from a 1 m^2 quadrat twice, just before weeding at 21 and 49 days after sowing (DAS) and at harvest;

With regard to rice, data collected include:

- The inventory of all weed species present was conducted on the entire elementary plot;
- The average height (cm) of 12 representative rice plants, was measured, from the soil surface to the tip of the highest panicle, one week before harvest;
- The rice straw dry biomass (g) was collected from two 1 m^2 quadrats;
- The number of panicles was counted from two 1 m^2 quadrats;
- The number of grains per panicle was calculated from 12 representative panicles;
- The thousand kernel weight (g), was determined by counting and weighing 1000 kernels with an electronic scale;
- The weight (g) of the rice grains of the entire elementary plot was weighed using a scale (max 25 kg; min 100 g).

2.5. Statistical Analysis of the Data

Data analysis was performed using R software. Normality (Shapiro-Wilk) and homogeneity (Levene) tests were conducted prior to the analysis of variances (ANOVA) followed by the mean separation test to compare treatment means.

3. Results

3.1. Adventitious Flora of the Trial

The list of weeds present in the trial ordered by class, family, genus and species is given in **Table 4**. Thus, the flora is composed of 19 species belonging to 17 genera and 14 families. The class of monocots has two families, the *Poaceae* and the *Cyperaceae*, which represent respectively 21.05% and 15.78% of the species of the flora. The broadleaf dicotyledons recorded 12 families, making up 85.71% of the overall families recorded. This family contain 13 genera and 13 species (68.42% of the species).

The most abundant species observed in the plots are: *Oryza longistaminata*, *Cyperus iria*, *Ipomoea aquatica*, *Echinochloa colona*, *Melochia corchorifolia*, and *Ludwigia hyssopifolia*.

Table 4. Floristic list of weeds inventoried during the study, 2023.

Classes, Families	*Genera*	*Species*
Monocots		
Cyperaceae	*Cyperus*	*Cyperus eragrostis Lam.*
Cyperaceae	*Cyperus*	*Cyperus Fulvus R. Br*
Cyperaceae	*Cyperus*	*Cyperus iria L.*
Poaceae	*Dactyloctenium*	*Dactyloctenium aegyptium (Linnaeus) Palisot de Beauvois*
Poaceae	*Oryza*	*Oryza longistaminata Steudlongistaminata Steud*
Poaceae	*Setaria*	*Setaria babata (Lam.) Kunth*
Poaceae	*Setaria*	*Setaria pumila (poiret) Roemer and Schultes*

Continued

Dicots		
Aizoaceae	*Trianthema*	*Trianthema portulacastrum L.*
Asteraceae	*Eclipta*	*Eclipta prostrata (L.) L. = alba (L.) Hassk.*
Caesalpiniaceae	*Cassia*	*Cassia mimosoids Linnaeus*
Convolvulaceae	*Ipomoea*	*Ipomoea aquatica Forssk*
Euphorbiaceae	*Phyllanthus*	*Phyllanthus amarus Schumacher and Thonning*
Fabaceae	*Alysicarpus*	*Alysicarpus vaginalis (L.) DC*
Fabaceae	*Aeschynomene*	*Aeschynomene Indica L*
Lythraceae	*Ammannia*	*Ammannia Auriculata Willd.*
Malvaceae	*Melochia*	*Melochia corchorifolia L.*
Nyctaginaceae	*Boerhavia*	*Boerhavia diffusa Linnaeus*
Nymphaeaceae	*Nymphaea*	*Nymphaea alba L.*
Oenotheraceae	*Ludwigia*	*Ludwigia hyssopifolia (G. Don) Exell*
Rubiaceae	*Mitracarpus*	*Mitracarpus villosus (Swartz) de Candolle*

3.2. Relationships between the Different Parameters Measured

3.2.1. Bivariate Relationships between the Different Parameters

The correlation matrix (**Figure 2**) reveals several key relationships for the lowland rice varieties in the study. The rice grain weight has a weak positive correlation (r = 0.33) with weed biomass at 49 DAS and a strong negative correlation (r = −0.85) with the weed biomass assessed at harvest. Additionally, weed biomass at harvest shows strong negative correlations with rice straw weight (r = −0.78), number of panicles/m^2 (r = −0.73), and weed dry biomass (r = −0.49) measured at 49 DAS.

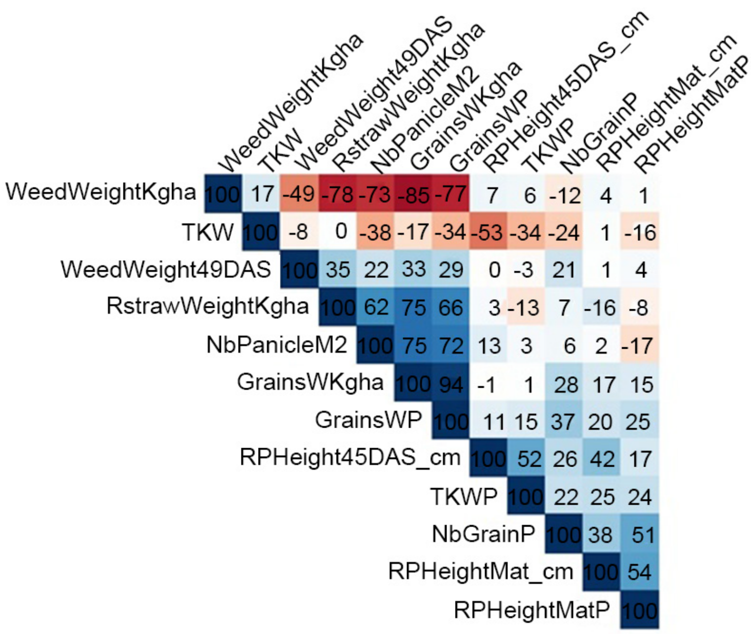

Figure 2. Correlations between the measured parameters of rice varieties and weeds in lowland rice cultivation.

3.2.2. Multivariate Relationships between the Different Parameters

Treatments which are a combination of rice varieties and weed control methods significantly explain the variability across the three dimensions ($R^2 > 0.80$, $p < 0.001$) (Table 5). Varieties have a significant effect on Dimension 2 and Dimension 3, but small influence on Dimension 1. Weeding primarily influences Dimension 1. Its effect on Dimension 2 is weak, and it has no significant effect on Dimension 3.

Table 5. Critical probability of factors by principal component analysis dimensions.

Dimensions	Factors	R^2	p-value
Dim[a] 1	Varieties	1.244E−01	5.737E−02
	Weeding	6.261E−01	3.238E−11
	Treatments	8.193E−01	1.562E−09
Dim 2	Varieties	5.446E−01	1.230E−09
	Weeding	1.614E−01	4.297E−02
	Treatments	8.008E−01	9.197E−09
Dim 3	Varieties	7.159E−01	2.573E−15
	Weeding	7.366E−02	3.690E−01
	Treatments	8.352E−01	2.890E−10

Meaning codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1; [a]Dim: dimension.

The correlation circle (Figure 3) shows that the two dimensions explain 58.7% of the total variances. Dimension 1 (36.8% of the variance) shows a strong correlation between GrainWeightP, RstrawWeightKg/ha, GrainWeightKg/ha and NbPanicle/m². Dimension 2 (21.9%) indicates that TKW is negatively correlated with the other productive variables.

The plant heights variables are weakly correlated with other variables and have low weight in both dimensions.

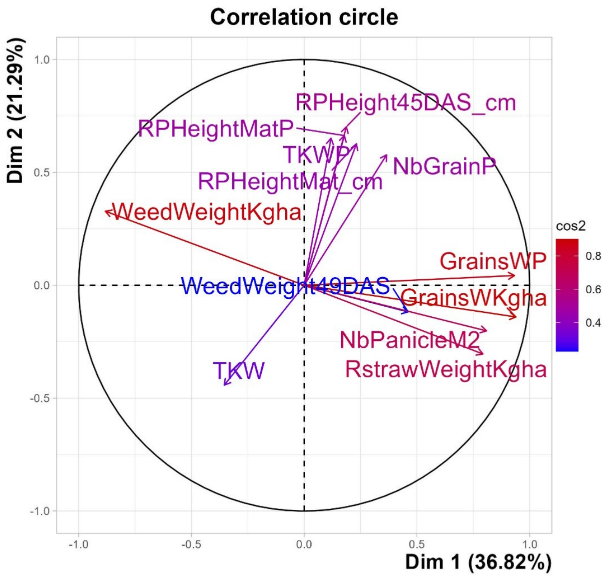

Figure 3. Variance explained by the axes of the principal component analysis for lowland rice varieties.

3.3. Effect of Weed Cover on Weed Weight at Harvest

The results of the analysis of variance showed that the varietal effect alone was not significant on weed biomass at harvest, however, the effect of the weed control factor was highly significant and its interaction with the varietal effect was also significant (Table 6).

Table 6. Results of the analysis of variance.

Factors		ANOVA
Varieties	F value	1.4808
	Pr (>F)	0.2343
Weedings	F value	61.7686
	Pr (>F)	<2E−16***
Weedings*Varieties	F value	2.2932
	Pr (>F)	0.0247*

Meaning Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Similarly, the results of the Tukey test (Table 7) indicate significant differences between the treatments. Specifically, the Dirty Control "a" and the 1ChPreW "a" are statistically different from the following modalities: 2PostChW21&49DAS "b", 1MW49DAS "b" and 2MW21&49DAS "b".

Table 7. The results of the Tukey test.

Comments	Factor modalities								
	Varieties				Weedings				
	FKR56N	KBR8	Orylux6	TS2	Dirty Control	1ChPreW	1MW49DAS	2PostChW21&49DAS	2MW21&49DAS
Weed weight (kg·ha^{-1})	"a"	"a"	"a"	"a"	"a"	"a"	"b"	"b"	"b"
Rice straw weight (kg·ha^{-1})	"a"	"a"	"a"	"a"	"cd"	"d"	"ab"	"bc"	"a"
Number of panicles m^{-2}	"ab"	"b"	"a"	"b"	"b"	"b"	"a"	"a"	"a"
Weight of rice grains (kg·ha^{-1})	"a"	"a"	"a"	"a"	"b"	"b"	"a"	"a"	"a"
Weight of rice grains (%)	"a"	"b"	"a"	"a"	"b"	"b"	"a"	"a"	"a"

Figure 4 shows that: On the one hand, the two post-emergence chemical weeding methods at 21 and 49 DAS (2PostChW21&49DAS) was the most effective in reducing weed weight measured at harvest for TS2 and Orylux6. On the other hand, the method of two manual weedings at 21 and 49 DAS (2MW21&49DAS) and late manual weeding at 49 DAS (1MW49DAS) gave the lowest weed weights measured at harvest for KBR8 (188.33 Kg/ha) and FKR56N (116.67 Kg/ha). The least effective treatment for all the varieties in the study was pre-emergence chemical weeding (1ChPreW). In addition, the effects of late manual weeding at 49 DAS

(1MW49DAS) and two manual weeding operations at 21 and 49 DAS (2MW21&49DAS) on reducing weed weight at harvest were similar for all varieties in the study.

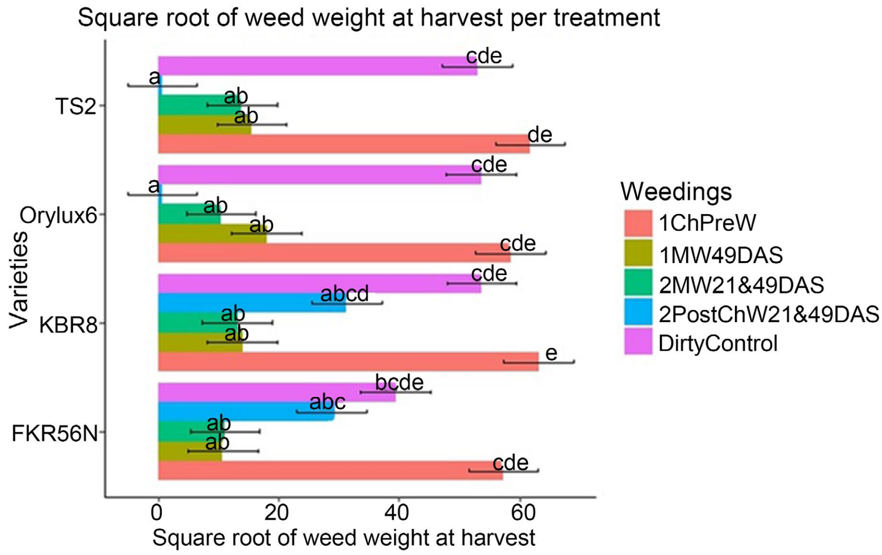

Figure 4. Average weight of weeds at harvest by variety and by method of weeding.

3.4. Effect of Grass Cover on the Weight of Rice Straw at Harvest

The results of the analysis of variance reported in **Table 8** show that weeding is the only factor with a highly significant difference effect on the weight of rice straw at harvest.

Table 8. The results of the analysis of variance.

Factors		ANOVA results
Varieties	F value	1.9266
	Pr (>F)	0.1408
Weedings	F value	21.2815
	Pr (>F)	1.815E−09***
Weedings*Varieties	F value	1.1097
	Pr (>F)	0.3794

Meaning Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

According to the Tukey test results (**Table 7**), 2MW21&49DAS "a" yields the highest weight of rice straw at harvest and 1ChPreW "d" results the lowest weight.

Figure 5 shows that the best rice straw harvest weights were obtained by applying two manual weedings at 21 and 49 DAS (2MW21&49DAS) for the varieties Orylux6 (6396.67 kg/ha), FKR56N (6195 kg/ha), KBR8 (5853.33 kg/ha), and TS2 (5296.66 kg/ha). The lowest rice straw weights at harvest were observed for FKR56N (3258.33 kg/ha), KBR8 (3775 kg/ha), and TS2 (2541.67 kg/ha) combined with the pre-emergence chemical weeding modality (1ChPreW). For the Orylux6 variety (2966 kg/ha), the lowest weight of rice straw at harvest was recorded in the dirty control modality.

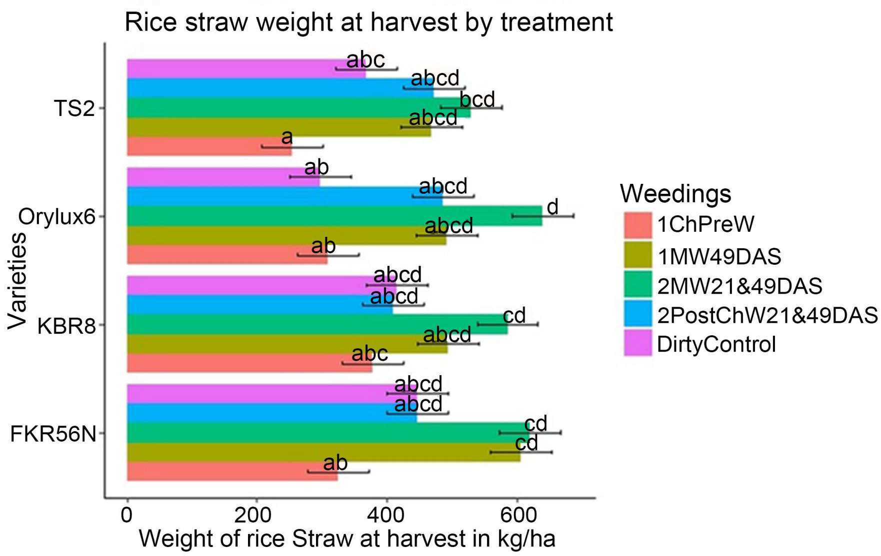

Figure 5. Average weight of rice straw at harvest by weeding and variety modalities.

3.5. Effect of Grass Cover on Rice Varietal Parameters

3.5.1. Weight of Rice Grains as a Percentage of Potential Yield

The results of the analysis of variances (**Table 8**) of the rice grains weight as a percentage of potential yield show a highly significant difference due to both the variety factor (Pr (>F) = 5.440e−07) and the weeding factor (Pr (>F) = 4.617e−09). According to the Tukey test (**Table 7**), the varieties FKR56N "a", Orylux6 "a" and TS2 "a" are statically distinct from the KBR8 variety "b". As far as the weeding factor is concerned, the 1MW49DAS "a", 2PostChW21&49DAS "a", 2MW21&49DAS "a" modalities are more efficient than the Dirty Control "b" and 1ChPreW "b" modalities. (**Table 9**)

Table 9. Results of the analysis of variance.

Factors		ANOVA results
Varieties	F value	16.01
	Pr (>F)	5.440E−07***
Weedings	F value	19.82
	Pr (>F)	4.617E−09***
Weedings*Varieties	F value	1.20
	Pr (>F)	0.316

Meaning codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

The performance of the treatments studied varies significantly according to the combinations between variety and method of weed control (**Figure 6**). The FKR56N variety recorded the highest yield, 73.93% of the potential yield under the single manual weeding treatment at 49 days (1MW49DAS). Pre-emergent chemical weeding treatment (1ChPreW) induced the lowest performance in this variety, with a yield of about 28.60%.

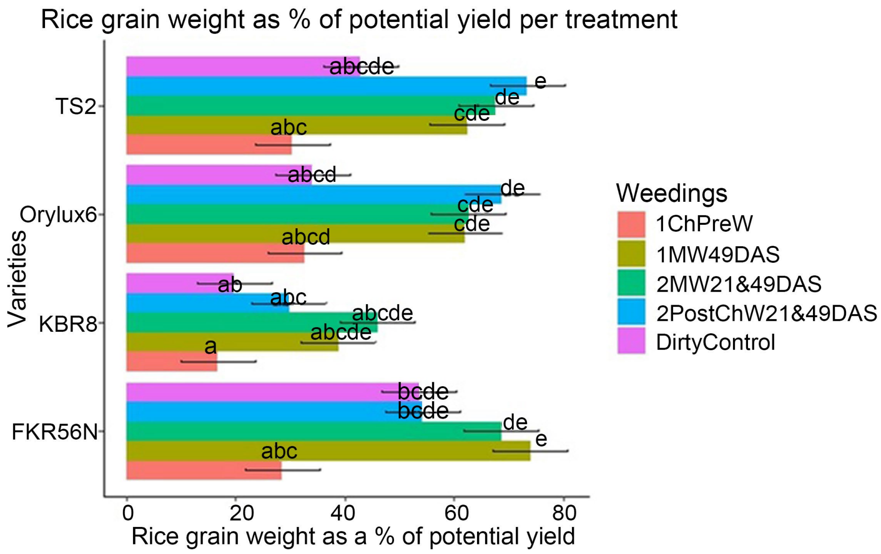

Figure 6. Weight of rice grains as a percentage of potential yield by variety and by method of weeding.

For the TS2 variety, the 2PostChW21&49DAS treatment also achieved a high yield (73.33%), while the worst-performing combination, 1ChPreW, led to a yield of around 30.42%.

In, Orylux6 the best response (68.8%) of the potential yield was obtained with the two post-emergence chemical weedings at 21 and 49 DAS (2PostChW21&49DAS), compared to 32.67% under 1ChPreW, which is the worst performing combination for this variety.

Finally, the KBR8 variety obtained its best performance (46.03%) with the application of two manual weedings at 21 and 49 DAS (2MW21&49DAS). The pre-emergent chemical weed control treatment (1ChPreW) had the lowest yield in the study, at less than 16.78%.

3.5.2. Number of Panicles Per m²

The analysis of variance of the number of panicles per m² (**Table 10**) shows a highly significant difference due to both the varietal effect (Pr (>F) = 0.000562) and the weeding (Pr (>F) = 9.202e−08). According to the Tukey test (**Table 7**), the Orylux6 "a" variety performed better than the KBR8 "b" and TS2 "b" varieties in terms of number of panicles per m². These results also show a better performance of the 1MW49DAS "a", 2PostChW21&49DAS "a", and 2MW21&49DAS "a" modalities, unlike the Dirty Control "b" and 1ChPreW "b" modalities.

Table 10. Results of the analysis of variance on panicle number by variety and modality.

Factors		ANOVA results
Varieties	F value	7.203
	Pr (>F)	0.000562***
Weedings	F value	15.574
	Pr (>F)	9.202E−08***
Weedings*Varieties	F value	1.081
	Pr (>F)	0.401155

Meaning Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

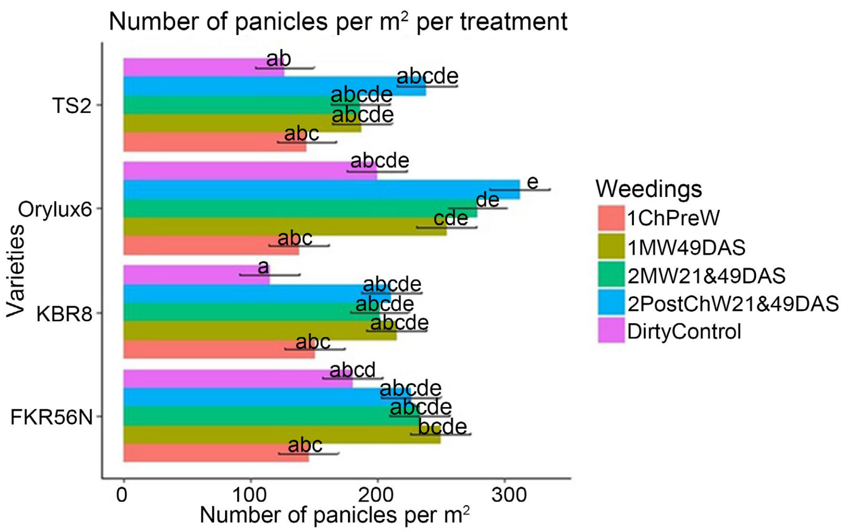

Figure 7. Average number of panicles per m² by weeding methods and by variety.

Figure 7 shows that the application of two post-emergence chemical weedings at 21 and 49 DAS (2PostChW21&49DAS) yielded the highest average numbers of panicles per m² (Appendix 3) for the varieties Orylux6 (313) and TS2 (239). For the KBR8 (215) and FKR56N (250) varieties, the highest average numbers of panicles per m² were observed with the application of late manual weeding at 49 DAS (1MW49DAS). The lowest numbers of panicles per m² were observed in KBR8 (116), and TS2 (127) with the dirty control. However, in Orylux6 (139) and FKR56N (146), it was the application of pre-emergent chemical weeding the day after sowing (1ChPreW) that resulted in the lowest numbers of panicles per m².

4. Discussion

Broadleaf dicotyledons were predominant in this study, accounting for 85.71% of families and 68.42% of species. The work of [12] found the same trends in a study carried out in rice cultivation in western Burkina Faso.

Despite particular attention paid to the extirpation of *Oryza longistaminata* rhizomes during soil preparation and various weedings, it remained the most dominant species on the majority of plots. *Oryza longistaminata* was not controlled by either pre-emergence or post-emergence herbicide treatments and initiated panicles before all rice varieties in the study. *Cyperus iria* completely covered some plots when it was flowering. After completing its cycle before the rice headed, it was subject to lodging, giving way to the rice.

The inventory of weed flora in this study highlighted the abundance of species such as *Oryza longistaminata*, *Cyperus iria*, *Ipomoea aquatica*, *Echinochloa colona*, *Melochia corchorifolia*, and *Ludwigia hyssopifolia.* An experiment conducted by [13] had identified some species on our list such as *Cyperus iria* L., and *Ludwigia hyssopifolia* (G. Don.) Excell as species resulting in significant yield losses. However, [14] observed in the lowlands of Casamance that the dominant families of flora were the *Poaceae* (22.29%) and the *Cyperaceae* (20%), accumulating 42.29% of the species encountered. The predominance of *Oryza longistaminata* over most of the trial, despite pre-emergence and post-emergence herbicide applications, was also reported by [15] [16]. [15] [16] point out that traditional weed management methods are often time-consuming, laborious, and less effective due to the possibility of weed regrowth from remaining roots or rhizomes. An increase in *Cyperaceae* biomass after application of bispyribac-sodium and an ineffectiveness of Pendimethalin against *Cyperaceae* in post-emergence were also reported by [17] [18].

The ineffectiveness of pre-emergence weed control under the trial conditions could be explained by the persistence of the rhizomes of *Oryza longistaminata* and the selectivity of Pendimethalin 455 g/L for rice.

The results of this study showed no significant difference between the weed biomass obtained with the following two manual weeding periods: one (1) late manual weeding (S1), and two (2) manual weedings (S2). [19] also found that the effectiveness of reducing weed biomass was statistically similar for two and four hoe weedings, although the lowest weed biomass was achieved with two weedings, as in the present study.

According to [7], manual weeding carried out during the first 30 days after transplanting contributes to the control of grass cover at the beginning of the season.

The reduction in rice straw weight of pendimethalin herbicide treatments compared to controls indicates phytotoxicity. Indeed, a low density of rice plants and poor development of plots treated with herbicides were observed during the work. According to [20], in no-till rice, all herbicides had adverse effects on the growth of rice seedlings, manifested by a reduction in root and shoot elongation, as well as a decrease in the number of leaves, roots and dry biomass.

The highest rice straw weights were recorded with manual weeding showing their positive impact on the development of rice plants. According to [21] suppression of weed competition facilitates and increases the growth and development of rice plants, resulting in higher grain and straw yields.

[22] also observed a higher number of tillers with two manual weedings.

A negative correlation was observed between the weight of rice grains and the biomass of weeds at harvest in the lowlands. [23] reported similar results. The analysis of grain weights as a percentage of potential yield revealed a highly significant difference in both the variety effect and the weed control effect. This indicates that the lowland rice varieties used in the study expressed their yield potential differently. In addition, the low grain weights as a percentage of yield potential observed in KBR8 and FKR56N following the application of pre-emergence and post-emergence herbicides may indicate herbicide susceptibility of these two varieties. In terms of efficacy, late manual weeding 49 DAS proved to be the best method of weeding for FKR56N, contrary to the results of [15] [16]. This could be explained by the nature of the weed flora present.

It was observed that the different weeding methods had a significant effect, mainly on the average number of panicles per m^2 in the Orylux6 variety. However, the best performance in terms of grain weight, a direct indicator of yield, was recorded with TS2 and Orylux6, particularly with the treatment of two manual weedings at 21 and 49 DAS. This treatment also resulted in the highest average number of panicles for these two varieties. These results confirm the importance of integrated and appropriate weed management. According to [24], an approach integrating cultural, manual and chemical methods is a sustainable strategy for controlling high weed pressure in lowland rice farming systems.

5. Conclusions

This study enabled the inventory of 19 species of weeds, of which *Oryza longistaminata*, *Cyperus iria*, *Ipomoea aquatica*, *Echinochloa colona*, *Melochia corchorifolia*, and *Ludwigia hyssopifolia* were the most abundant. The study also highlighted an important factor related to the inhomogeneous distribution of weed species throughout the trial. TS2 and Orylux6 are the most competitive varieties against weeds. The practice of two manual weedings before 50 days after sowing appeared to be the most effective method of weed control in lowland conditions, particularly when the flora is dominated by *Oryza longistaminata and Cyperus iria*.

The difference in the behaviors of the varieties used in the study according to the different weeding methods suggests future research to focus on the determination of their critical weeding periods, which could explain their differences in performance in terms of competition with weeds.

Author's Contribution

OCR, TVSE, SA, KA, YD, TH and BJI participated in the design of the research study project and carried out the study. They supervised the work and participated in the data processing. All these authors contributed to the writing of the manuscript submitted to your journal for publication.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] CNPE (2022) Rapport sur les perspectives économiques et financières 2023-2027 Burkina Faso. Secrétariat permanent du comité national de politique économique (CNPE), 88.

[2] Koutou, M., D'Alessandro, C., Tondel, F., Cortese, M.P. and Knaepen, H. (2021) Projet AgrInvest-Systèmes alimentaires—Évolutions récentes du secteur rizicole au Burkina Faso: Contraintes de développement et opportunités d'investissement privé. FAO. https://doi.org/10.4060/cb7557fr

[3] MARAH (2024) Rapport sur les résultats définitifs de l'enquête permanente agricole (EPA) de la campagne agricole 2023/2024. Ministère de l'Agriculture des Ressources Animales et Halieutiques (MARAH), 41.

[4] Traoré, H. and Yonli, D. (2001) Concurrence des adventices en riziculture pluviale: Détermination de la période optimale de désherbage dans l'Est du Burkina Faso. *Science et technique, Sciences naturelles et agronomie*, **25**, 16-29.

[5] MAAH (2021) Deuxième génération de la stratégie nationale de développement de la riziculture 2021-2030. Ministère de l'Agriculture et des aménagements hydro-agricoles, 129.

[6] INSD (2024) Annuaire du commerce extérieur 2023. Institut national de la statistique et de la démographie (INSD), 176.

[7] Traoré, H. and Yonli, D. (2018) Lutte contre les mauvaises herbes par un herbicide de post-levée (anilofos + éthoxysulfuron) en riziculture irriguée dans l'Ouest du Burkina Faso. *Sciences Naturelles et Appliquées*, **34**, 93-106.

[8] Traoré, H., Séré, Y. and Yonli, D. (1998) Lutte chimique contre les mauvaises herbes en riziculture pluviale dans l'Ouest du Burkina Faso. *ANPP-dix-septième conférence du COLUMA sur la lutte contre les mauvaises herbes*, Dijon, 9-11 Décembre 1998, 1221-1228.

[9] Johnson, D.E. (1997) Les adventices et la riziculture en Afrique de l'Ouest—Weeds of rice in West Africa. 312.

[10] Zigani, L.M., Sebgo, A. and Coulibaly, R. (2005) Evaluation à mi-parcours du Projet Riz Pluvial. Rapport définitif Décembre 2005, Projet Riz Pluvial, 64.

[11] Zerbo, L., Koné, N., Morant, P. and Paré, S. (1995) Utilisation combinée d'image multispectrale et haute résolution spatiale pour la cartographie des sols et de la végétation. *Séminaire national (BUNASOLS, INERA, AB-DLO) sur «L'interprétation agronomique des données de sols: Outil pour la gestion des sols et le développement agricole»*, Ouagadougou, 14-16 March 1995, 7. https://agritrop.cirad.fr/387821/

[12] Sanou, A., Issiaka, S., Dabire, G.T., Yonli, D., Somda, I. and Traoré, H. (2023) Gestion intégrée de la fertilité du sol et des mauvaises herbes en riziculture de bas-fond dans l'ouest du Burkina Faso. *Journal of Applied Biosciences*, **191**, 20231-20244. https://doi.org/10.35759/jabs.191.5

[13] Raj, S.K. and Syriac, E.K. (2017) Weed Management in Direct Seeded Rice: A Review. *Agricultural Reviews*, **38**, 41-50. https://doi.org/10.18805/ag.v0iof.7307

[14] Diedhiou, P., César Bassène, C., Mballo, R., Ka, S.L., Bamba, B. and Diatta, P. (2024) Caractérisation de la flore adventice du riz pluvial de bas-fond dans le département de Ziguinchor (Basse Casamance, Sénégal). *Journal of Animal & Plant Sciences*, **61**, 11246-11261.

[15] Navya, M.V., Jacob, D., Shalini, P.P., Raj, S.K. and Alex, V. (2024) Herbicide Combinations for Effective Weed Management in Rice. *International Journal of Environment and Climate Change*, **14**, 144-160.

https://doi.org/10.9734/ijecc/2024/v14i114535

[16] Bhuiyan, M., Salam, M. and Kabir, M. (2021) Integrated Weed Management Strategies for Sustainable Rice Production in Bangladesh. *Bangladesh Rice Journal*, **24**, 133-159. https://doi.org/10.3329/brj.v24i2.53454

[17] Ahmed, S., Kumar, V., Alam, M., Dewan, M.R., Bhuiyan, K.A., Miajy, A.A., *et al.* (2021) Integrated Weed Management in Transplanted Rice: Options for Addressing Labor Constraints and Improving Farmers' Income in Bangladesh. *Weed Technology*, **35**, 697-709. https://doi.org/10.1017/wet.2021.50

[18] Kaur, S. and Singh, S. (2015) Bio-Efficacy of Different Herbicides for Weed Control in Direct-Seeded Rice. *Indian Journal of Weed Science*, **47**, 106-109.

[19] Kolo, E., Adigun, J.A., Adeyemi, O.S. and Olorunmaiye, P.M. (2020) Growth and Yield Response of Upland Rice (*Oryza sativa* L.) to Different Nitrogen Fertilization and Weeding Levels. *Agriculturae Conspectus Scientificus*, **86**, 117-123.

[20] Khaliq, A. and Matloob, A. (2012) Germination and Growth Response of Rice and Weeds to Herbicides under Aerobic Conditions. *International Journal of Agriculture and Biology*, **14**, 775-780.

[21] Premnath, K., Suseendran, K., Kalaiyarasan, C. and Jawahar, S. (2024) Effect of Integrated Weed Management Practices in Rice (*Oryza sativa*) under Sri. *Journal of Scientific Research and Reports*, **30**, 22-27. https://doi.org/10.9734/jsrr/2024/v30i102426

[22] Ismaila, U. (2011) Efficacy and Profitability of Some Weed Control Practices in Upland Rice (*Oryza sativa* L.) at Badeggi, Nigeria. *American Journal of Experimental Agriculture*, **1**, 174-186. https://doi.org/10.9734/ajea/2011/224

[23] Ahmed, S., Hossain, A., Miajy, A.A. and Awan, T.H. (2020) Response of Soil Applied Herbicides at Different Application Timings on the Weed Control Efficacy and Phytotoxicity to Rice in Dry-Seeded Condition. *Bangladesh Agronomy Journal*, **22**, 15-25. https://doi.org/10.3329/baj.v22i1.44927

[24] Alagbo, O.O., Akinyemiju, O.A. and Chauhan, B.S. (2022) Weed Management in Rainfed Lowland Rice Ecology in Nigeria—Challenges and Opportunities. *Weed Technology*, **36**, 583-591. https://doi.org/10.1017/wet.2022.57