

Sokoine University of Agriculture



MSc. Dissertation

**Agronomic Performance of
Local and Improved Rice
(*Oryza Sativa* L.) Cultivars
under Weed Pressure in
Malinyi District, Morogoro,
Tanzania**

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February, 2024

**AGRONOMIC PERFORMANCE OF LOCAL AND
IMPROVED RICE (*Oryza sativa* L.) CULTIVARS UNDER
WEED PRESSURE IN MALINYI DISTRICT, MOROGORO,
TANZANIA.**

**Dissertation submitted to Sokoine University of
Agriculture in Fulfilment of the Requirements for
Master Degree in Crop Science**

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EXTENDD ABSTRACT

Weeds significantly reduce the quantity and quality of the rice harvest and raise the cost of production. More than half of the world's population relies primarily on rice (*Oryza sativa* L.), which accounts for more than 20% of all calories consumed. African continent is the third-most rice producer, after Asia and America. After maize, rice is Tanzania's second-most significant food and commercial crop, where the principal rice-producing regions are Morogoro, Mbeya, Rukwa, Tabora, Shinyanga and Mwanza. Rice is the primary crop planted in Malinyi District, Morogoro region, followed by maize. Local rice cultivars comprise more than 95% of the cultivated land area, while improved rice varieties occupy less than 5%. Compared to the national average yield of 2.5 t/ha, the rice productivity in Malinyi district is low at an average of 1.5 t/ha caused by both abiotic and biotic factors, including weeds as a key barrier. Farmers do weeding up to four times per season. Weeds can result in losses of up to 48 to 100%. In Tanzania, little is known about the cultivars of rice used by farmers to combat weeds in terms of their competitive ability and critical period for weed competition. Thus experiment was conducted at Malinyi district from January to July 2021 in which the main objective of the study was to boost the productivity of a few farmer-preferred rice cultivars in Malinyi district, Morogoro, Tanzania, through weed-competitive cultivars and effective weeding regime. Specific objectives of the study were (i) assess weed diversity and abundance in rice growing areas in Malinyi District, Morogoro and (ii) identify weed-competitive rice cultivars under natural weed pressure in Malinyi District, Morogoro.

For specific objective 1; Survey was conducted in 70 rice fields, each 0.4ha to identify weeds. Systematic quadrat sampling technique in diagonal pattern used. Ten samples from each field by using 1m² quadrat were recorded. Weeds in each field were identified, counted by species and the data were used to calculate frequency, uniformity, density, abundance of each species. Weed species diversity in each village was measure by Shannon weinner and Simpson indices while similarity of floristic composition between pairs of villages was obtained by Sorensen index. For objective 2, the experiment was laid out in Randomized Complete Block Design (RCBD) with 20 treatment combinations replicated three times. Factor A contained four rice cultivars and factor B had five weeding regimes as treatments. Subplots had 9 m². Space between replications was 1 meter. An alley of 0.5 m separated subplots and 1m separated main plots and 1.5 m border space. Sowing Space was 25 cm by 20 cm for inter and intra row. Four rice cultivars were randomly assigned with five weeding regimes. Data were collected for crop and weed plant growth and yield parameters. Summed dominance ratio and relative yield loss were computed by formulae. Two-way mode of analysis of varience used in data analysis and Turkey's honest and least significance difference test at 5% level used in mean separation.

The present survey identified 35 weed species from 13 families; 19 were annual, 16 perennial; 15 grassy, 3 sedges and 17 broad leaved weeds. This study revealed high relative abundance in grass weeds; *Paspalum scrobiculatum* (36.7%), sedges; *Fimbristylis miliacea* (26.0%) and broad leaved; *Ageratum conyzoides* (22.5%) The results indicated *Paspalum scrobiculatum* was more dominant than other weeds. Number of weed species count in villages ranged from 15 to 29 species. Shannon Wiener and Simpson index had the highest values (2.68, 1.95) and lowest value (0.92, 0.79), respectively; Indicating there is

medium weed species diversity due to uneven distribution. Similarity index between pairs of villages ranged from 50% which low to 89% which is high. Results revealed, out of six weed species, *Paspalum scrobiculatum* with summed dominant ratio (43.60), indicated that had greater contribution in competition. The results had statistical significance differences ($p < .001$) in relative yield loss ranging from 39.54% to 63.84%, Karimata cultivar with lowest value, demonstrated high tolerance to weeds while SARO 5 with high value had less tolerance. At least two weeding had positive effect ($p < .001$) on rice grain yield in all cultivar tested. Correlation between weed drymatter and grain yield had significant negative relationship ($p < .001$, $R^2 = 0.2691$).

This study revealed that *Paspalum scrobiculatum*, *Fimbristylis miliacea* and *Ageratum conyzoides* were the most prevalent and abundant grass, sedge and broadleaf groups, respectively. This may be they are highly adapted to the environment which favors reproduction and survival. These weeds need special attention to reduce their populations. This study also concludes that weed species in Malinyi district were moderately diverse and most similar between villages. The study concluded that Karimata contained weed competitiveness and high yield. Weeding at 15 and 45 DAE had no statistical significance difference of grain yield with weeding more than two.

This study recommends; regular survey is needed to identify possible problematic weed and weed population shifts, sequential cropping system proposed to rice farmers in order to minimize weed pressure, further research toward new or enhanced weed control measures, evaluation of karimata weed competitive ability and control methods of *Paspalum scrobiculatum* and *Ischaemum rugosum* weed species, and

farmers are advised do weeding at 15 and 45 DAE, as the optimal weeding.

Key words: Rice, Weeding, Weeds, Broadleaf, Grass, Sedges, Yield, Research, Biotic, Abiotic, Family

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IKISIRI KUU

Magugu hupunguza mavuno, ubora na kuongeza gharama za uzalishaji wa zao la mpunga. Zaidi ya nusu ya idadi ya watu duniani hutegemea mpunga (*Oryza sativa* L.), ambao huchangia zaidi ya 20% ya nishati ya mwili zinazotumiwa. Bara la Afrika ni la tatu kwa uzalishaji wa mpunga, baada ya Asia na Amerika. Baada ya mahindi, mpunga ni zao la pili la chakula na biashara nchini Tanzania, ambapo mikoa inayozalisha mpunga ni Morogoro, Mbeya, Rukwa, Tabora, Shinyanga na Mwanza. Mpunga ni zao la msingi linalolimwa katika Wilaya ya Malinyi, mkoani Morogoro, ikifuatiwa na mahindi. Kilimo cha mpunga wa kienyeji kinajumuisha zaidi ya 95% ya eneo la ardhi linalolimwa, wakati aina bora za mpunga huchukua chini ya 5%.

Ikilinganishwa na wastani wa mavuno ya kitaifa ya 2.5 t/ha, uzalishaji wa mpunga katika wilaya ya Malinyi ni mdogo kwa wastani wa 1.5 t /ha unaosababishwa na sababu zote za viumbe hai na mazingira, ikiwa ni pamoja na magugu kama kizuizi muhimu. Wakulima hupalilia hadi maranne kwa msimu. Ikiwa hayajashughulikiwa, magugu yanaweza kusababisha hasara hadi 48 hadi 100%. Nchini Tanzania, ni machache yanayojulikana kuhusu aina za mpunga zinazotumiwa na wakulima kupambana na magugu kulingana na uwezo wa ushindani na kipindi muhimu cha ushindani wa magugu. Kwa hiyo utafiti ulifanyika kuanzia Januari hadi Julai 2021 ikiwa lengo kuu la utafiti huo lilikuwa kuongeza uzalishaji wa mpunga katika wilaya ya Malinyi, Morongo, Tanzania, kupitia aina za mpunga zinazokinzana na magugu na palizi. Malengo mahususi ya utafiti yalikuwa (i) kutathimini utofauti wa magugu na wingi katika maeneo yanayolimwa mpunga katika Wilaya ya Malinyi, Morogoro, (ii) kutambua aina za mpunga zenye ushindani katika msongamano wa asili wa magugu katika Wilaya ya Malinyi, Morogoro.

Kwa lengo 1; Utafiti wa kutambua magugu ulifanyika katika mashamba 70 ya mpunga, kila moja lilikuwa na eneo la hekta 0.4. Sampuli zilichukuliwa katika eneo la mita mraba 1 kila baada ya mita 5 kwa mshazari. Sampuli 10 zilichukuliwa kwa kila shamba. Aina za magugu yaliyotambuliwa katika kila shamba yalihesabiwa kwa kuzingatia aina. Takwimu zilizopatikana zilitumika kupata vipimo mbalimbali vya hali ya magugu (frequency, uniformity, density na abundance). Utofauti wa aina za magugu kwa kila kijiji ulipimwa kwa kipimo cha Shannon weinmer na Simpson. Mfanano wa idadi ya aina ya mgugu katika jozi za vijiji ulipatikana kwa kutumia kipimo cha Sorensen. Katika kutafuta tofauti ya takwimu zilikusanywa (mpunga au magugu) mpango wa split plot (RCBD) wa ANOVA ulitumika kwa kufuatia aina za mpunga (Mbawambili, Karimata, Kisegesi na SARO 5) na idadi ya palizi (bila palizi – control, palizi 1, palizi 2, palizi 3 na palizi 4). Katika jaribio hili aina za mpunga zilikuwa ploti kuu na palizi zilikuwa ploti ndogo wakati vitalu vilichukuliwa kama athari ya nasibu. Wastani muhimu wa athari pekee za aina za mpunga au idadi ya palizi, zililinganishwa kwa kutumia tofauti ndogo ya umuhimu (LSD) lakini wastani uliotokana na mwingiliano kati ya mpunga na palizi ulilinganishwa kutumia SED katika $p < 5\%$ kupitia Tukey's post hoc.

Utafiti huu umetambua aina 35 za magugu katika jamii 13, aina 19 ni magugu ya msimuna 16 ya kudumu, ambapo 15 ni nyasi, 3 ndago na 17 majani mapana. Upembuzi umebaini nyasi zilizonyingi ni *Paspalum scrobiculatum* (36.7%), ndago; *Fimbristylis miliacea* (26.0%) na majani mapana ni *Ageratum conyzoides* (22.5%). Matokeo yamebaini *Paspalum scrobiculatum* limetawala zaidi kuliko magugu mengine. Idadi ya aina ya magugu katika vijiji ilianza 15 hadi 29. Kipimo cha Shannon Wiener na Simpson kilionesha majibu ya juu (2.68, 1.95) na majibu ya chini (0.92, 0.79); Ikimaanisha kulikuwa na utufauti wa aina za magugu kutokana na mtawanyiko usiofanana. Mfanano wa idadi ya aina ya magugu kati ya jozi za vijiji ulianza 50% hadi 89%. Matokeo yamebaini kati ya aina sita za magugu, *Paspalum scrobiculatum* lenye jumla ya uwiano wa kutawala (43.60), lilionesha kuwa na mchango mkubwa wa kushindana na zao la mpunga. Matokea yalithibitisha kuwepo kwa tofauti muhimu ($p < .001$) katika upotevu wa mavuno mdogo kwa Karimata (39.54%) na mkubwa kwa SARO 5 (63.84) ulisababishwa na magugu. Katika jaribio hili palizi 2 au zaidi zimeonesha mavuno chanya ($p < .001$). Pia jaribio hili limebaini uhusiano hasi kati ya uzito wa magugu makavu na nafaka ($p < .001$, $R^2 = 0.2691$).

Majaribio haya yamebaini kuwa magugu *Paspalum scrobiculatum*, *Fimbristylis miliacea* na *Ageratum conyzoides* yalikuwa mengi katika makundi ya nyasi, ndago na majani mapana. Hii inaweza kuwa mazingira haya yanayoruhusu magugu ya aina hii kustawi vizuri. Kwahiyo magugu haya yanahitaji umakini maalum ili kupunguza msongamano. Utafiti huu pia unahitimisha kuwa aina za magugu katika wilaya ya Malinyi zilikuwa tofauti au sawa kwa baadhi ya vijiji. Utafiti huo unahitimisha kuwa Karimata ilikuwa na ushindani mkubwa dhidi ya magugu na uwezo mkubwa wa uzalishaji. Palizi mbili (katika siku ya 15 na 45

baada ya mpunga kuota) hazikuwa na tofauti muhimu ya mavuno ya nafaka na palizi zaidi ya mbili.

Kutokana na matokeo ya utafiti huu, inapendekezwa kuwa mfumo wa kupanda mazao kwa kubadilisha unashauriwa kwa wakulima wa mpunga ili kupunguza msongamano wa magugu, utafiti zaidi unahitajika ili kutambua magugu mapya na korofi kwa zao la mpunga ili kupanga mbinu sahihi za kuyadhibiti, utafiti zaidi unahitajika ili kuthibitisha uwezo wa karimata kukinzana na magugu na wakulima kufanya palizi 2 (siku ya 15 na 45 baada ya mpunga kuota) ili kudhibiti magugu na kupunguza gharama za uzalishaji.

Ufunguo wa maneno: Mpunga, Palizi, Magugu, Majani mapana, Nyasi, Ndago, Mavuno, Utafiti, Viumbe hai, Mazingira, Jamii

DECLARATION

I, Halifa Ally Ilumbi do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted to any other institution.

Halifa Ally Ilumbi
(MSc. Crop Science Candidate)

Date

The above declaration is confirmed by;

Prof. K. P. Sibuga
(Supervisor)

Date

Dr. L. Shechambo
(Supervisor)

Date

**LIST OF PUBLISHED PAPER AND SUBMITTED
MANUSCRIPT**

1. Weed diversity and abundance in rice growing areas of Malinyi District, Morogogro, Tanzania
2. Weed – Competitive rice cultivars under natural weed pressure in Malinyi District, Morogoro, Tanzania

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DEDICATION

Special thanks to my parents (Ally Ilumbi and Biasha Lukindo, all of them deceased 26 years ago) and guardians (grandmother and uncle – all of them deceased 2 years ago), my wife (Rehema Ally Mpira) and my children (Meghamaha, Neghanie, Neema, Nimaha and Rafael Ilumbi) for their contribution in my academic prosperity.

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LIST OF ABBREVIATIONS AND SYMBOLS

%	Percent
°C	Degree centigrade
Cm	Centimeter
G	Gramme
m.a.s.l	metres above sea level
M ²	Square meter (an area)
SUA	Sokoine University of Agriculture
t/ha	Tonnes perhectare
DED	Distric Executive Director
DAICO	District Agriculture Irrigation and Cooperative Officer
WEO	Ward Executive Officer
VEO	Village Executive Officer

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 Background information

More than half of the world's population relies primarily on rice (*Oryza sativa* L.), which accounts for more than 20% of all calories consumed (Dass *et al.*, 2017). The Asian continent produces more than 50% of the world's rice, with China accounting for 36% of this total production (Rao *et al.*, 2017). It is farmed around the world for both commercial and dietary (calorie, protein, mineral, and vitamin) uses (Wilson & Lewis, 2015; Dass *et al.*, 2017; Zenna *et al.*, 2017; Fukagawa & Ziska, 2019). More than 100 nations on six continents grow rice and the African continent is the third-most riceproducer (3.4%), after Asia (90.7%) and America (5.2%). (Muthayya *et al.*, 2014; Rao *et al.*, 2017; Fahad *et al.*, 2019; FAOSTAT, 2021).

Tanzania, with an average per capita consumption of 36.9 kg, was the fourth-largest producer of rice in Africa in 2020, behind Nigeria, Egypt, and Madagascar (FAOSTAT, 2021; Mdoe *et al.*, 2021; Mgale *et al.*, 2021).

Tanzania is the first riceproducer in East Africa, followed by Kenya and Uganda. After maize, rice is Tanzania's second-most significant food and commercial crop, with a total yield of 3.02 million tons, rice is grown on nearly 1.2 million hectares (Kitilu *et al.*, 2019; Kadigi *et al.*, 2020; Mdoe *et al.*, 2021). Small-scale farmers cultivate 80% of the rice crop; the principal rice-producing regions are Morogoro (24%), Mbeya (14%), Rukwa (10%), Tabora (7%), Shinyanga (5%) and Mwanza (4%). Other regions make up 38% of the total (Ngailo *et al.*, 2016; Sekiya *et al.*, 2020; Mtembeji & Singh, 2021; Mdoe *et al.*, 2021). The major rice-producing regions produced 62% of the nation's rice in

2019 and cultivated 61% of the nation's total land area (Mtembeji & Singh, 2021).

Rice is the primary crop planted in Malinyi District, Morogoro region, followed by maize. Local rice cultivars comprise more than 95% of the cultivated land area, while improved rice varieties occupy less than 5%. (Msangya & Yihuan, 2016).

1.2 Problem Statement and Justification

Compared to the national average yield of 2.5 t/ha, the rice productivity in Malinyi district is low at an average of 1.5 t/ha (Kitilu *et al.*, 2019). Both abiotic and biotic factors, including weeds as a key barrier, contribute to low productivity (Morone *et al.*, 2021). Malinyi district rice farmers in Morogoro region they do weeding up to four times per season (Msangya & Yuan, 2016). If unchecked, weeds can result in losses of up to 48 to 100% (Touré *et al.*, 2011; Gharde *et al.*, 2018; Daramola *et al.*, 2020).

The necessity to evaluate rice cultivars for weed competitiveness is supported by high weed density and weed management expenses. Rice varieties with tall stature and quick early development use their growth to overcome the effects of weeds (Korres *et al.*, 2019). Examining rice cultivars that are weed-competitive may provide a chance to use them as an integrated weed management component in rice production. However, effective weed control strategies necessitate knowing the targeted weeds and their salient traits beforehand. According to Morone *et al.* (2021), certain local rice cultivars in nations other than Tanzania have demonstrated the capacity to outcompete weeds. In Tanzania, little is known about the cultivars of rice used by farmers to combat weeds in terms of their competitive ability and critical period for weed competition. The purpose of this

study is to determine the weed flora composition and the competitiveness of different rice cultivars.

1.3 Objectives

1.3.1 Overall objective

The study's main objective was to boost the productivity of a few farmer-preferred rice cultivars in the Malinyi district of Morongo, Tanzania, by using weed-competitive cultivars and an effective weeding regime.

1.3.2 Specific objectives

- i. To determine weed diversity and abundance in selected rice growing areas of Malinyi District, Morogoro.
- ii. To identify the weed - competitive rice cultivars under natural weed pressure in Malinyi District, Morogoro.

1.4 Dissertation Establishment

This dissertation is written in publishable manuscripts format consisting; -

Manuscript 1: Weed diversity and abundance in rice growing areas of Malinyi District, Morogoro and Manuscript 2: Weed - competitive rice cultivars under natural weed pressure in Malinyi District, Morogoro

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CHAPTER TWO

Manuscript One

WEED DIVERSITY AND ABUNDANCE IN RICE GROWING AREAS OF MALINYI DISTRICT, MOROGOGRO, TANZANIA

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Abstract

Weeds are globally foremost yield reducing factor in rice production. Therefore, it should be controlled before causing economic yield loss, but proper weed control is happened when they are well known. Thus a survey was conducted in 70 rice fields of 0.4ha each in Malinyi District to identify weeds associated with rice which is key information for weed management decision. Systematic quadrat sampling method in diagonal pattern was used and ten 1m² quadrat established in a field. Weeds in each quadrat were uprooted, identified and counted by species. Weed counts obtained used to calculate frequency, field uniformity, density and relative abundance for each species. Total of 35 weed species belonging to 13 families were identified. Among weed species identified 19 were annual and 16 perennial, in which 15 were grassy, 3 sedges and 17 broadleaved weeds. Out of 10 most prevalent and abundant weed species, there were six grasses, *Paspalum scrobiculatum* (36.7%), *Ischaemum regosum* (27.9%), *Echinochloa colona* (24.5%), *Oryza longistaminata* (21.8%), *Leptochloa chinensis* (13.1%), and *Leersia hexandra* (11.6%); two sedges, *Fimbristylis miliacea* (26.0%) and *Cyperus rotundus* (12%) and two broadleaved weeds, *Ageratum conyzoides* (22.5%) and *Physalis minima* (12.1%). Relative abundance indicated that, grassy weeds were dominant. Shanon wiener index had the highest value in Makerere village (2.84) and the lowest was in Usangule village (1.95). Diversity indices shown that weed species were moderately diverse which implies weeds were not evenly distributed. The study suggested that the most abundant weed species should be controlled for increasing rice production. Sequential cropping system is proposed for reducing weed pressure in rice fields. Moreover, more surveys are needed to identify possible problematic weed and weed population shifts and more research toward new or enhanced weed control measures.

Key words: Rice; weed; Uniformity; Frequency; Density;
Perennial; Annual; Diversity. Relative
abundance

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2.1 Introduction

Weeds are a significant yield-limiting problem in rice farming around the world. According to estimates, pests actually cause 40% of the yield losses, with weeds accounting for 32% of those losses (Juraimi *et al.*, 2013). Due to competition, weeds reduce rice yield by roughly 40–60%, but if they are not promptly and effectively removed, they can increase to 94–96%. (Chauhan *et al.*, 2011; Sarmah, 2019). The amount that weed competition reduces rice yield varies based on planting techniques, weed species, agricultural practices, and meteorological conditions (Jabran & Chauhan, 2015). Weeds can grow and reproduce in a variety of settings and are very aggressive (Bourgeois *et al.*, 2019). *Ischaemum rugosum* (saramollagrass), which may produce up to 4,000 seeds per plant and has the ability to flourish even in shady places, and *Echinochloa colona* (jungle rice), which primarily reproduces vegetatively but can also produce 3000 to 6000 seeds per plant, are two examples of weeds that do both. It begins to grow during the wet season or when the water level is rising and ends during the dry season.

Weed community patterns and variety are naturally dynamic and location-specific (Nichols *et al.*, 2015). A weed species' dynamics is the change in population size (number of plants per unit area) over time as a result of its biology, management, and environmental conditions (Joen & Kim, 2017). Therefore, environmental, farm management, and competition between weed species and rice crop species are the main drivers of weed species diversity (Kraehmer & Bell, 2019; Matloob *et al.*, 2015).

The amount of agricultural loss brought on by weed competition depends on the type of weed and how long it has been present in the crop. If weeds are not controlled, the crop's output is likely to decrease (Sarmah, 2019). For

example, it has been found that uncontrolled *Fimbristylis miliacea* (hoorahgrass) alone lowered grain yields by 42%. (Hakim, 2013). Light, water, and nutrients are the major resources that crops and weeds compete for. Typically aggressive, weeds consume nutrients more quickly than crops (Sarmah, 2019).

Weed control strategies include physical, chemical, and cultural weed control, among others. The fundamental approach for controlling weeds is to prevent their introduction and spread (Singh *et al.*, 2016). Use of weed-free seeds, upkeep of clean irrigation canals, fields, and borders, and washing of agricultural equipment are examples of preventive methods (Martin *et al.*, 2017). Except when community activities are taken to enforce rules and regulations, preventative efforts are not justifiable. One of the main reasons of weed infection, particularly in direct planting rice, is weed-contaminated rice seed.

Physical control can be exercised mechanically or manually. Rice can be mechanically weeded because different crops respond differently to disturbances, and monocotyledonous cereals are less sensitive than dicotyledons (Juraimin *et al.*, 2013). When rice is sown directly, harrowing has been found to be effective, particularly when the crop plants are larger than weeds to avoid harm (Singh *et al.*, 2016). Weeding by hand is a simple, environmentally friendly practice, but it is also time-consuming and labor-intensive. Furthermore, hand weeding is challenging when dealing with grassy weeds like *Ischaemum rugosum* and *Oryza longistaminata* because of their similar morphology to rice seedlings. Due to labor shortages and/or high labor costs, which also depend on hand weeding, this task is frequently postponed or even abandoned.

An international danger to weed control technology is the newly emerging problem of weed resistance to herbicide. Herbicide-resistant weeds currently provide a challenge to agriculture globally. According to Heap (2021), the number of weed species that are resistant to herbicides is rising, as are the impacted nations and herbicide sites of action.

Thus, boosting the ability of crops adjacent to weeds to compete is one cultural weed management strategy. Cultural approaches help to decrease weeds by giving crops a competitive edge in capturing light, moisture, nutrients, and physical space. They do not, however, completely eradicate weeds (Juraimi *et al.*, 2013). Applying proper cultural techniques on time can help with integrated weed control by lowering weed competition, density, and number of herbicide applications. It can also lessen herbicide resistance by lowering selection pressure.

In cropping systems, weed surveys are frequently used to demonstrate weed populations (Hakim, 2013). To address the present weed issues in rice fields, a thorough survey is essential for weed control programs. It is also crucial for developing objective and targeted research programs (Westwood *et al.*, 2018) Planning weed management programs and formulating suggestions for effective weed control strategies require detailed, in-depth understanding of the nature and extent of weed flora infestation in Malinyi District. Malinyi District's weed floristic makeup is not yet fully understood. For weed management decisions, the most recent information on the presence, composition, abundance, importance, and ranking of weed species is required (Saravanane, 2020). This study's goals included locating and cataloging the prevalent weed species in the rice fields in the Malinyi District and formulating a plan for lessening weed pressure.

2.2 Materials and Methods

2.2.1 Explanation of the research area

A survey was carried out in the Malinyi district, which is located in Tanzania's southern Morogoro at $8^{\circ} 56' 0''$ south, $36^{\circ} 8' 0''$ east, and has an elevation of 275 meters above sea level (Fig. 2.1). The annual average rainfall is between 800 and 1600 mm, while the average temperature is between 15.2° C and 34.3° C. On March 2021, during the long rainy season while the crop was in the field, 70 rice growers' fields in 10 Villages were physically surveyed (Fig. 2.1).

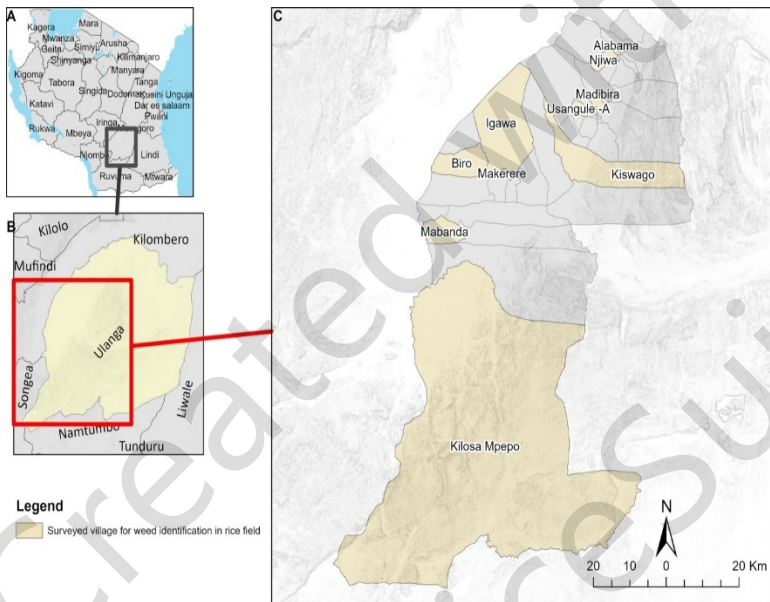


Figure 2.1: Map showing surveyed villages in Malinyi District, Morogoro.

2.2.2 Field survey

In ten villages of Malinyi district, farmer's fields were surveyed for weeds using field sampling and quadrat techniques as the primary data gathering strategy (Hakim *et al.*, 2013; Nkoa *et al.*, 2015). Seven fields of 0.4 hectares each were purposefully chosen in each of the ten Villages that were examined. In each field, ten (10) 1 m² quadrats were laid out in a diagonal pattern for a total of 70 quadrats per village (Hubert *et al.*, 2016; Kothari, 2019). To reduce edge impact, a 5 m space was left between quadrats, and 15 m were left at each end of the diagonal line (Ruwanza, 2018). The weeds inside quadrat were pulled up, their species determined, and their numbers recorded. Several of the reference books were used to identify the observed weed species (Caton *et al.*, 2010; Naidu, 2012).

2.2.3 Data analysis

According to the methods outlined by Nkoa *et al.* (2015) and explained in Appendix 1, weed density (number/m²), uniformity (%), frequency distribution (%), and abundance (%) were computed from the weed count records. Diversity indices (Shannon-Wieners and Simpson indices) were computed according to procedures described by Nkoa *et al.* (2015), as shown in Appendix 2. In order to compare weed species between villages based on their presence or absence, Sorenson's coefficient (S) was utilized. Each village was paired with every other village and the data acquired were reported as percentages. The formula shown below was employed (Slathia *et al.*, 2018).

$$Sorensen(S) = \left[\frac{2c}{a+b} \right] * 100$$

.....
(Eq.1)

Note : (S) = the index of similarity, c = number of weed species in both sites and 'a' = number of weed species in site A and 'b'=number of weed species in site B.

The formula-derived weed data were subjected to IBM SPSS statistical analysis to analyze several variables using one sample t-test and one way ANOVA to test the significance of differences between groups of weed species, diversity, and similarity indices on various response variables at significance level of 0.05.

2.3 Results

2.3.1 Floristic composition

There were 35 weed species found in this survey, divided into 34 genera and 13 families (Tables 2.1). 19 of them were annual weeds, while 16 of them were perennial. In the perennial category, there were 10 grassy, 3 sedge, and 3 broad-leaves weed species; in the annual category, there were 5 grassy and 14 broad-leaf species (Tables 2.1). Out of the 13 families that were seen, the Poaceae family had 15 species, Asteraceae family had 5, Cyperaceae family had 3, Fabaceae family and Malvaceae family had 2 each. These five families accounted for 68.57% of the observed weed species, while the other families had one species each (Fig. 2.2). All 35 weeds were recognized down to the species level, and the various life cycle types, behaviors, and kinds were recorded.

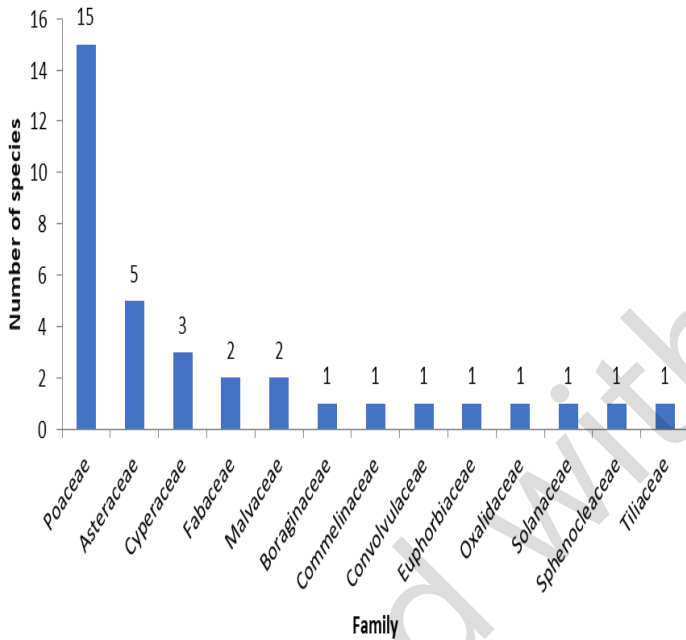


Figure 2.2: Weed species distribution by family

2.3.2 Frequency, uniformity, density and relative abundance

The average frequency of weeds in the district ranged from 4.3%, to 75.7%, the lowest was recorded in *Cassia tora* and the highest being for *Paspalum scrobiculatum* while relative frequency ranged from 0.3% to 8.5%, the lowest being for *Cassia tora* and the highest record for *Paspalum scrobiculatum*. The weed density (weed count/m²) of weed species ranged from 0.7% to 35%, the lowest being *Lactuca serriola* and *Cassia tora* and the highest record being for *Paspalum scrobiculatum* while relative density ranged from 0.1%, being for *Lactuca serriola* and *Cassia tora* to 17% being the highest for *Paspalum scrobiculatum* (Table 2.1).

Uniformity ranged from 1.4%, to 50.9%, the lowest being for *Cassia tora* and highest being for *Paspalum scrobiculatum*, respectively while relative uniformity the lowest record of 0.3

being for *Cassia tora* and highest record of 11.1%, being for *Paspalum scrobiculatum*, respectively (Table 2.1). Relative abundance ranged from 0.7 % to 36.7%, with lowest value being for *Cassia tora* and the highest being for *Paspalum scrobiculatum*, respectively (Table 2.1). *Paspalum scrobiculatum* followed by *Eschaemaum rogusum* occurred in most of the villages and were among the most abundant weed species (Plate 2.1 and Table 2.3a and 2.3b). The ten (10) most abundant weed species in Malinyi district with values higher than 10% are represented in Fig. 2.3.

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Table 2.1: Summarized indices of weed species in rice fields in Malinyi district

S/N	Weed Species	Type	Family	Lifespan	Frequency (%)	Uniformity (%)	Density (plants/m ²)	Relative Frequency (%)	Relative Uniformity (%)	Relative Density (%)	Relative Abundance
1	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	75.7	50.9	35.0	8.5	11.1	17.1	36.7
2	<i>Ischaemum rugosum</i> Salsb.	Grass	poaceae	Perennial	67.1	39.7	26.0	7.6	8.8	11.5	27.9
3	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	67.1	34.0	21.6	7.9	7.8	10.3	26.0
4	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	67.1	35.9	21.0	4.7	8.0	8.9	24.5
5	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	65.7	36.6	14.8	7.5	8.2	6.8	22.5
6	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	61.4	33.9	19.4	6.7	7.3	7.8	21.8
7	<i>Lapochloa chinensis</i> L.	Grass	poaceae	Perennial	38.6	20.7	16.9	4.3	4.6	4.2	13.1
8	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	45.7	21.0	9.7	5.2	4.7	2.6	12.5
9	<i>Physalis minima</i> L.	Broadleaf	Solanaceae	Annual	42.9	20.1	6.2	4.7	4.5	2.9	12.1
10	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	37.1	18.4	13.1	4.0	3.8	3.8	11.6
11	<i>Alopecurus myosuroides</i> L.	Grass	Poaceae	Annual	30.0	15.0	11.1	4.7	3.3	2.8	9.4
12	<i>Rottboellia cochinchinensis</i>	Grass	Poaceae	Annual	32.9	14.0	9.2	4.7	2.5	2.5	9.2
13	<i>Stenotaphrum secundatum</i> (Walter) Kuntze	Grass	Poaceae	Perennial	25.7	12.3	10.5	4.7	3.0	2.9	9.0
14	<i>Commelina benghalensis</i> L.	Broadleaf	Commelinaceae	Annual	22.9	10.1	6.8	2.3	2.0	1.6	5.9
15	<i>Ipomoea aquatica</i> Forsk.	Broadleaf	Convolvulaceae	Annual	21.4	12.1	3.9	4.7	2.4	0.8	5.4
16	<i>Eleusine indica</i> L.	Grass	Poaceae	Annual	21.4	8.1	6.3	4.7	1.4	1.4	4.8
17	<i>Galinsoga parviflora</i> Cav.	Broadleaf	Asteraceae	Annual	14.3	6.7	11.7	4.7	1.6	1.6	4.8

18	<i>Sphenoclea zeylanica</i>	Broadleaf	Sphenocleaceae	Annual	17.1	7.7	4.2	4.7	1.6	0.7	4.0
19	<i>Corchorus aestuans</i> L.	Broadleaf	Tiliaceae	Annual	15.7	7.3	4.5	4.7	1.6	0.7	4.0
20	<i>Hackelelochloa granularis</i> L.	Grass	Poaceae	Annual	12.9	5.6	2.4	4.7	1.2	1.2	3.3
21	<i>Mimosa pudica</i> L.	Broadleaf	Fabaceae	Perennial	11.4	5.7	1.1	4.7	1.1	0.8	3.0
22	<i>Cynodon dactylon</i> L.	Grass	Poaceae	Perennial	11.4	4.6	5.9	4.7	1.0	0.8	3.0
23	<i>Oxalis latifolia</i> Sorrel.	Broadleaf	Oxalidaceae	Perennial	5.7	4.0	3.6	4.7	0.9	1.3	2.9
24	<i>Paspalum dilatatum</i> Poir.	Grass	Poaceae	Perennial	7.1	3.4	1.5	4.7	0.9	0.9	2.9
25	<i>Phyllanthus niruri</i> L.	Broadleaf	Euphorbiaceae	Annual	10.0	4.1	4.1	4.7	0.9	0.8	2.8
26	<i>Hibiscus trionum</i> L.	Broadleaf	Malvaceae	Perennial	11.4	4.1	2.7	4.7	0.9	0.3	2.4
27	<i>Melochia corchirifolia</i> L.	Broadleaf	Malvaceae	Annual	11.4	3.6	2.2	4.7	0.7	0.4	2.4
28	<i>Brachiaria erusiformis</i> (Sm.)	Grass	Poaceae	Annual	8.6	3.1	6.5	4.7	0.6	0.7	2.2
29	<i>Bidens pilosa</i> L.	Broadleaf	Asteraceae	Annual	10.0	3.0	5.2	4.7	0.6	0.5	2.1
30	<i>Tridax procumbens</i> L.	Broadleaf	Asteraceae	Annual	11.4	3.3	3.3	4.7	0.6	0.4	2.1
31	<i>Carex stipata</i> Muhl.	Sedge	Cyperaceae	Perennial	8.6	3.6	1.7	4.7	0.7	0.3	1.8
32	<i>Trichodesma zeylanicum</i>	Broadleaf	Boraginaceae	Annual	5.7	1.7	1.4	4.7	0.4	0.4	1.6
33	<i>Sorghum leiocladum</i> Hack.	Grass	Poaceae	Perennial	4.3	1.9	2.0	4.7	0.4	0.2	1.0
34	<i>Lactuca serriola</i> L.	Broadleaf	Asteraceae	Annual	4.3	2.2	0.7	4.7	0.4	0.1	0.8
35	<i>Cassia tora</i> L.	Broadleaf	Fabaceae	Annual	4.3	1.4	1.2	4.7	0.3	0.1	0.7

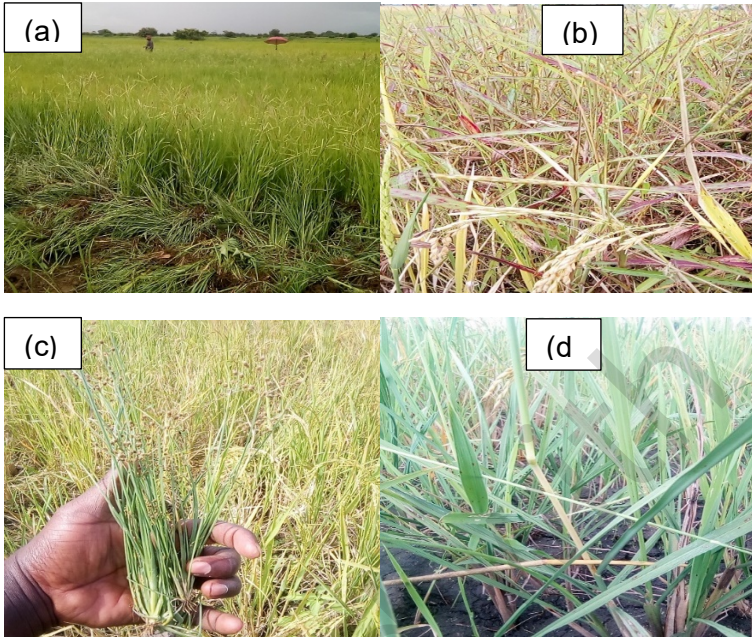
Table 2.2a: Five most dominant weed species in rice for each surveyed village

Village	SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (plnts/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance
Alabama	1	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	85.7	54.3	22.6	10.7	11.7	12.6	35
	2	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	71.4	44.3	27.1	8.9	9.5	12.6	31
	3	<i>Oxalis latifolia</i> Sorrel	Broadleaf	Oxalidaceae	Perennial	57.1	40	36.1	7.1	8.6	13.5	29.2
	4	<i>Paspalum scrobiculatum</i>	Grass	Poaceae	Perennial	71.4	45.7	20.7	8.9	9.8	9.7	28.4
	5	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	71.4	42.9	21.8	8.9	9.2	10.1	28.3
Njiwa	1	<i>Paspalum scrobiculatum</i>	Grass	Poaceae	Perennial	100	70	55.1	11.9	15.1	24.9	51.9
	2	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	100	61.4	38.9	11.9	13.3	17.5	42.7
	3	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	71.4	40	27.9	8.5	8.6	9	26.1
	4	<i>Stenotaphrum secundatum</i>	Grass	Poaceae	Perennial	71.4	34.3	19.9	8.5	7.4	6.4	22.3
	5	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	57.1	40	17.7	6.8	8.6	4.6	20
Madibila	1	<i>Paspalum scrobiculatum</i>	Grass	Poaceae	Perennial	100	67.1	46.1	9.1	12.4	22.8	44.2
	2	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	85.7	48.6	36	7.8	8.9	15.3	32
	3	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	85.7	51.4	22.9	7.8	9.5	9.7	27
	4	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	57.1	32.9	9.4	11.7	6.1	6	23.7
	5	<i>Alopecurus myosuroides</i>	Grass	Poaceae	Annual	71.4	41.4	13.4	6.5	7.6	4.7	18.9
Usangule A	1	<i>Paspalum scrobiculatum</i>	Grass	Poaceae	Perennial	100	71.4	61.4	13.5	19.6	34.3	67.4
	2	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	100	62.9	46.6	13.5	17.3	26	56.7
	3	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	85.7	41.4	24	11.5	11.4	11.5	34.4
	4	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	57.1	27.1	6.2	15.4	7.5	4	26.8
	5	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	71.4	34.3	14.8	9.6	9.4	5.9	24.9
Kiswago	1	<i>Paspalum scrobiculatum</i>	Grass	Poaceae	Perennial	100	72.9	57.6	7.4	12.3	28.9	48.6
	2	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	71.4	42.9	25.4	5.3	7.2	9.1	21.7
	3	<i>Lapochloa chinensis</i> L.	Grass	poaceae	Perennial	71.4	40	20.7	5.3	6.8	7.4	19.5
	4	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	57.1	38.6	26.2	4.3	6.5	7.5	18.3
	5	<i>Eleusine indica</i> L.	Grass	Poaceae	Annual	85.7	27.1	10.5	6.4	4.6	4.5	15.5

Table 2.2b: Five most dominant weed species in rice for each surveyed village

Village	S N	Weed species	Type	Family	Lifecycle	Frequenc y (%)	Uniformity (%)	Density (plnts/m2)	Relative frequency (%)	Relative uniformit y (%)	Relative density (%)	Relative abundan ce
Igawa	1	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennia 	100	58.6	17.5	10	1.3	1.8	3.1
	2	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennia 	85.7	55.7	23.7	8.6	0.7	3.7	33
	3	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennia 	85.7	50	19.4	8.6	9.6	1.2	29.4
	4	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennia 	85.7	44.3	15	8.6	8.5	8.7	25.8
	5	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennia 	71.4	42.9	21.7	7.1	8.2	10.4	25.8
Makerere	1	<i>Ageratum conyzoides</i> L.	Broadlea f	Asteraceae	Annual	100	60	13.7	8.9	1.3	9.8	29.9
	2	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennia 	100	51.4	15.6	8.9	9.7	11.1	29.6
	3	<i>Mimosa pudica</i> L.	Broadlea f	Fabaceae	Perennia 	100	55.7	10.9	8.9	10.5	7.8	27.1
	4	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperacea e	Perennia 	85.7	40	19	7.6	7.5	11.7	26.8
	5	<i>Cyperus rotundus</i> L.	Sedge	Cyperacea e	Perennia 	85.7	45.7	9.6	7.6	8.6	5.9	22.1
Biro	1	<i>Ageratum conyzoides</i> L.	Broadlea f	Asteraceae	Annual	100	55.7	16.1	14	15.3	15.9	15.2
	2	<i>Physalis sp</i>	Broadlea f	Solanaceae	Annual	85.7	51.4	10.7	12	14.1	9	35.2
	3	<i>Laptochloa chinensis</i> L.	Grass	poaceae	Perennia 	57.1	32.9	13.4	8	9	7.6	24.6
	4	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennia 	57.1	27.1	14.5	8	7.5	8.2	23.6

	5	<i>Rottboellia cochinchinensis</i> Lour.	Grass	Poaceae	Annual	57.1	24.3	10.9	8	6.7	6.2	20.8
Mabanda	1	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennia	85.7	48.6	27.1	12.5	13	19.9	15.5
	2	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennia	85.7	52.9	22.6	12.5	14.2	16.6	13.3
	3	<i>Alopecurus myosuroides</i> L.	Grass	Poaceae	Annual	85.7	47.1	17.5	12.5	12.6	12.9	38
	4	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennia	57.1	40	20.9	8.3	10.7	10.2	29.3
	5	<i>Paspalum dilatatum</i>	Grass	Poaceae	Perennia	71.4	34.3	14.5	10.4	9.2	8.9	28.5
Kilosa mpepo	1	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennia	71.4	40	21.3	9.8	10.9	14.8	35.5
	2	<i>Stenotaphrum secundatum</i>	Grass	Poaceae	Perennia	71.4	40	13.8	9.8	10.9	9.6	30.3
	3	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennia	57.1	34.3	20.6	7.8	9.3	11.5	28.7
	4	<i>Ageratum conyzoides</i> L.	Broadlea	Asteraceae	Annual	71.4	37.1	12.4	9.8	10.1	8.6	28.6
	5	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennia	42.9	31.4	25.3	5.9	8.6	10.6	25



(a) = *Paspalum scrobiculatum* (b) = *Eschaemaum rogusum* (c) = *Fimbristylis miliacea* (d) = *Oryza longistaminata*

Plate 2.1: Most abundant weed species in rice fields

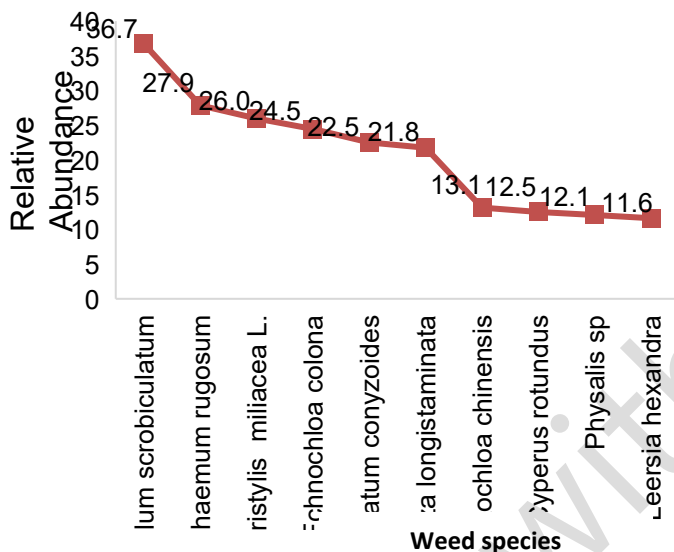


Figure 2.3: Ten (10) important weed species in rice fields in Malinyi District

The frequency, uniformity, density, relative frequency, relative uniformity, and relative abundance of weed species varied statistically significantly. As a result, the distribution of weed species in the Malinyi district differed.

2.3.4 Diversity indices

Each village's weed species count ranged from 15 to 29 species. Usangule Village recorded the lowest while Kiswago Village recorded the highest number of species; also see Appendix 3 for details. The Simpson distribution index had the highest values in Makerere Village and the lowest in Usangule A Village (Table 2.3). The Shannon-Wiener index, the highest value was recorded in Makerere village and the lowest value was recorded in Usangule village (Table 2.3).

Table 2.3: Diversity indices of weed in rice fields for 10 Villages in Malinyi District

SN	Village	Shannon Wiener Index (H')	Simpson Index (1 - D)	Number of Species
1	Alabama	2.62	0.91	21
2	Njiwa	2.47	0.88	25
3	Madibila	2.61	0.89	23
4	Usangule A	1.95	0.79	15
5	Kiswago	2.72	0.88	29
6	Igawa	2.61	0.91	20
7	Makerere	2.84	0.93	25
8	Biro	2.68	0.92	18
9	Mabanda	2.34	0.88	17
10	Kilosa mpepo	2.60	0.91	19

Note: the classes range of species diversity according to Haris *et al.* (2019), H 'value > 3: high species diversity, $1 \leq H \leq 3$ value: moderate species diversity and $H' < 1$ value: low or small species diversity.

There was statistical significant difference for weed diversity among villages. This result assures that the surveyed villages had variations.

2.3.5 Similarity index (Sorensen (S) similarity index)

Table 2.4 shows the weed species similarity index across pairs of villages; the results varied from 50 to 89.4%. The values between Mabanda and Usangule Village were the lowest, while those between Biro and Kilosa Mpepo Village were the highest.

Table 2.4: Similarity index of weed species (%) between pairs of rice growing Villages in Malinyi District

Village/ Location	Alabama	Njiwa	Madibila	Usangule	Kiswago	Igawa	Makerere	Biro	Mabanda	Kilosa Mpepo
Alabama	100	75.5	68.1	72.2	76.6	73	73.9	56.4	57.8	68.2
Njiwa	75.5	100	81.6	76.9	83.6	77.2	81.6	66.6	73.1	77.2
Madibila	68.1	81.6	100	68.4	61.5	74.4	75	73.1	70	74.4
Usangule	72.2	76.9	68.4	100	63.6	74.2	65	78.7	50	80
Kiswago	76.6	83.6	61.5	63.6	100	73.4	81.5	76.5	65.2	81.6
Igawa	73	77.2	74.4	74.2	73.4	100	84.4	78.9	59.4	80
Makerere	73.9	81.6	75	65	81.5	84.4	100	69.7	66.6	75.5
Biro	56.4	66.6	73.1	78.7	76.5	78.9	69.7	100	57.1	89.4
Mabanda	57.8	73.1	70	50	65.2	59.4	66.6	57.1	100	59.4
Kilosa Mpepo	68.2	77.2	74.4	80	81.6	80	75.5	89.4	59.4	100

Note: Site is not similar in weed species if $< 65\%$ sites are similar in weed species

There was a statistically significant difference in the similarity of weed species between linked villages. As a result, the weed species varied amongst the villages.

2.4 Discussion

According to Haris *et al.* (2019), based on floristic composition, the dominance among families in the weed species community have been divided into three groups which are dominant (>20% of all individual species), co - dominant (10% - 20%) and not dominant if <10%. Under this study Poaceae family with 15 out of 35 weed species which is equivalent to 43% of all individual weed species (Fig. 2.2), therefore this family was dominant. In terms of types/groups weed species identified in this study was different to findings by Golmohammadi *et al.* (2018), where cyperaceae had the highest weed species among 29 families observed; annual weeds had higher number than perennial and broadleaved weeds were the highest.

The results from this study showed an opposite tendency, with a higher number of species in the poaceae family with 15 species. This may be because of their excellent adaptation and effective dispersal system in the environmental conditions that supported their prodigious populations. Weed distribution has been shown to be influenced by variables including dissemination mode, structure, period of germination, viability of seeds, and soil seeds bank (HE *et al.*, 2019). The presence of weeds in a particular location is consequently influenced by edaphic conditions (pH, nutrients, and moisture), weed management methods, and the history of the fields where the weeds were located (Travlos *et al.*, 2020).

The frequency of weed species has been divided into classes A to E in intervals of 20%, reported by Haile *et al.* (2021) and Duary *et al.* (2015), but the number of species tends to decline as the percentage rises. This phenomenon has been demonstrated under this study in which 20 species are class A (1 – 20%), 7 species in class B (21 – 40%), 2 species in class C (41 – 60%) and 6 species in class D (61 – 80%) were , there was no species in class E (81 – 100%).

High frequency weed species are highly adapted to the environments in which they are found and demonstrate the dispersion of weed species. This study found that some species, such as *Paspalum scrobiculatum*, had a high incidence of this condition, followed by *Ischaemum rugosum*, *Fimbristylis miliacea*, and *Echinochloa colona*. All other weed species with low frequency values indicated that they were either less competitive, successfully managed by weed control techniques applied in the study area, or the environment was unfavorable at that time of year.

Usually, high weed density is a threat to rice growth because of competition. Less weeds cause low yield loss and weed biomass have negative relationship to rice yield that is increased weed biomass lower the rice yield (Nazir *et al.*, 2022). Different weed species compete with rice differently because some germinate in large densities, requiring more resources (Gharde *et al.*, 2018). In this study revealed that *Paspalum scrobiculatum* having high density, followed by *Ischaemum rugosum* and *Fimbristylis miliacea* which means these weeds had greater contributions in reducing rice yield. If the seeds are viable and the environment is favorable, massive seed banks may be the cause of the high density of weed species (HE *et al.*, 2019). Due to the considerable capacity of species with high seed output to live, disperse, and establish themselves, the big seed bank may ensure their dense population (Osca *et al.*, 2021).

Weed species uniformity measures the evenness of the weeds in a given area. It shows how the species spread in a given location. High uniformity values denote wide spread while low values indicate that it is localized. The most abundant weed species observed in this study had higher values of uniformity. The results of this study is supported by Hakim *et al.* (2013), found that *Echinochloa crusgalli* recorded highest frequency, uniformity and density followed by other species like revealed in this study for *Paspalum*

scrobiculatum, *Ischaemum rugosum*, *Fimbristylis miliacea*, *Echinochloa colona*, *Ageratum conyzoides* and *Oryza longistaminata*.

Relative abundance it combines the frequency, uniformity, and density of a specific weed species compared to all other detected species to calculate the predominance of that species in a given area. The larger relative abundance value indicates the higher relative uniformity (FU), frequency, and density values, respectively (Golmohammadi *et al.*, 2018). It serves as a warning about the overall weed problem that a species has brought about.

The outstanding differences in the abundance of weed species in Malinyi district showed that the rice fields had weeds species which are most dominant and abundant. A gently steep slope in the relative abundance (Fig.2.3) indicates slightly differences to most weeds species except few which had high values. High-ranking species were few but abundant (large number of individuals and widely distributed) than the low-ranking species were greater in number of members with few individuals (Hakim *et al.*, 2013). In this study revealed that *Paspalum scrobiculatum* had the highest relative abundance over all other weed species, therefore is dominant weed followed by *Ischaemum rugosum* (Fig.2.3). Similar observations had also been reported by Golmohammadi *et al.* (2018). The reasons of being dominant and abundant may be due to suitable environment and availability of dissemination agent for a specific weed species. These weeds supposed to be managed to a level that cannot cause economic yield loss by employing integrated weed management and abandon mono cropping (Andreset *et al.*, 2021; Jiyaet *et al.*, 2019).

The Simpson distribution index prioritizes weed species that are more prevalent. The relative abundance of dominant weed species is higher (Nkoa *et al.*, 2015). A high score

suggests a diverse population, whereas a low score implies a homogeneous population. The diversity score rises with the expansion of weed species and evenness. Makerere Village had the highest index scores in this survey, while Usangule A Villages had the lowest (Table 2.3). As a result, the weed species in the research area were diversified, as indicated by the results that there were variances between villages.

The Shannon-Wiener index places more emphasis on the abundant and evenness of the species present. Diversity can be promoted by having many different species. Additionally, increasing the consistency of individual distribution within and between species will boost diversity. The diversity index is highest when each individual is from a different species. The highest value was recorded in Makerere village and the lowest value was recorded in Usangule village (Table 2.3). These values fall under the same category (Moderate) according to Haris *et al.* (2019) which may be due to fields found in similar ecology.

According to Khan *et al.* (2018) in weed similarity, the values obtained by paired test are greater or equal to 65%, then communities is similar, but when it is less than 65%, the communities become not similar. The similarity test results in this study found that only seven sets of two villages had different weed species compositions. (Haile *et al.*, 2021) acknowledged that two sites have diverse weed communities if the similarity index value is less than 65%, which supports the conclusion. A larger value of the similarity index reveals more or less uniform environmental circumstances, whereas a smaller value reveals noticeable heterogeneity. The low similarity index may be caused by varied environmental conditions at the analyzed areas (Singh, 2012). The findings of this study (Table 2.4) indicated that most of the paired village had similarity index above 65%, meant they had similar community, and few had similarity index below 65%, which meant the weed species in the paired villages were not similar. It is implied that similar weed management techniques may be used by the slight variance in weed communities found among the rice fields.

2.5 Conclusions and Recommendations

The results of the survey provide a quantitative comparison of the weed species in rice fields of Malinyi District. Regarding relative abundance, the most prevalent and abundant weed species were grasses followed by sedge and broadleaved. Based on relative abundance indicates that, annual weeds were more dominant than perennial. Shanon wiener index had the highest value in Makerere village and the lowest value in Usangule village. Simpson index had the highest values in Biro Village and the lowest in Usangule A Village. This indicates that the weed species in Malinyi district are diverse.

Paspalum scrobiculatum and *Ischamum rugosum* weed species were the most abundant and dominant in Malinyi

district, therefore they should be controlled. Sequential cropping system (type of crop rotation) is proposed to be practiced by rice farmers in order to minimize weed pressure. Moreover, further survey work is recommended to identify possible problematic weeds and weed population shifts. Also more research towards new or enhanced weed control measures is suggested.

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CHAPTER THREE

Manuscript Two

Weed – Competitive Rice Cultivars under Natural Weed Pressure in Malinyi District, Morogoro, Tanzania

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Abstract

Weed-competitive rice cultivars and weeding interval are viable tools for integrated weed management in rice field among other control methods which may reduce effect of weeds. Based on these ideas, a field trial was piloted in 2021 in the rainy season at Kiswago Village (located at 8° 54' 0" south, 36° 17' 0" east) to determine the weed competitiveness of rice cultivars and appropriate weeding regime. Four cultivars were evaluated under natural weed pressure conditions. The trial was laid out in a Randomized Complete Block Design in split plot arrangement with three replications. Sowing space was 25 by 20 cm for interrow and intrarow respectively. Data collected for crop were; Plant height, number of tillers and leaves, duration to 90% grain maturity, panicle weight, grain filling, weight of 1000 seeds, grain yield, relative and straw biomass, for weeds were; weed count and biomass. Significant differences among means were separated by Tukey honest and least significance difference test (LSD) at $p \leq 0.05$. Out of six weed species observed, *Paspalum scrobiculatum* with greater Summed

dominance ration (39.60), indicated that had greater contribution in competition. The results revealed significant differences ($p < .001$) in relative yield loss ranging from 39.54% to 63.84%. Karimata with lowest value demonstrated high tolerance to weeds while SARO 5 with high value had less tolerance. Twice and more weeding had positive effect ($p < .001$) on grain yield in all cultivar tested. Weed drymatter and grain yield had significant negative relationship ($R^2 = 0.2691$). Karimata contained high weed competitive ability than others three cultivars tested. Farmers are recommended to use twice weeding (at 15 and 45 DAE) to reduce cost, save time and increase productivity, more research is requested to evaluate karimata weed competitive potentials and control methods of *Paspalum scrobiculatum* and *Ischaemum rugosum* weed species.

Key words: Rice cultivar; weed pressure; yield; relative yield loss; summed dominance ratio;

3.1 Introduction

Based on water availability and topography, rice (*Oryza sativa* L.) is grown in four ecosystems: (i) rain fed upland rice on the plateau and hydroponic slopes (39%), (ii) rain fed lowland rice in the valley bottoms and flood plains (33%), (iii) irrigated rice delta flood plains and highlands (19%) and (iv) deep-water floating rice along the river and mangrove-swamp rice in lagoon (Mkanthama *et al.*, 2018; Rugumamu, 2014; Rao *et al.*, 2017). From the genus *Oryza*, rice is an annual grass. There are 23 recognized species of rice, of which two have a high commercial value and are widely grown (Teeken *et al.*, 2012). There are two types of rice: *Oryza sativa* (Asian rice), which is grown all over the world, and *Oryza glaberrima* (African rice), which is farmed in South Africa (Teeken *et al.*, 2012). The indica species from tropical Asia is frequently identified by its long, wide to narrow, light green leaves, abundant tillering, long and thin grains, and numerous secondary ramifications. *Oryza glaberrima* comes from the Niger River's interior delta and is

distinguished by a lot of vegetative growth, short, rounded ligules, no or few secondary ramifications, crimson caryopsis, and a protracted dormancy (Coudert *et al.*, 2010). Rice cultivars differ greatly in the overall productivity (Dimaano *et al.*, 2017). Kitilu *et al.* (2019) presented that grain yield of different cultivars such as SARO 5 yielded 7 – 8.5 t/ha and NERICA1, 3 – 4.5t/ha.

Rice is grown under varying conditions of altitude, from sea level to 3000 meters high. It requires hot and humid climate, with prolonged sunshine and reliable water supply and temperature range of 21 to 37° C. Clay soils are most suited for rice growth due to capability of holding water for long and sustain crop (Fageria, 2013).

Planting weed-contaminated crop seeds affect weed competitiveness of rice cultivar because act as source and early infestation of clean fields with weeds. Weeds such as *Ishaemum rogosum* (Saramolla grass), *Paspalum scroculatum* (kodo millet), *Echinochloa colona* (Jungle rice), red rice and *Ageratum conyzoides* (Goat weed), are distributed when planting rice seeds (Martin *et al.*, 2017; Gervilla *et al.*, 2019). Moisture regimes of the soil affects growth of weeds and their competition referring to submerged, water-saturated, and usual dry land conditions. The biomass of weeds per unit area is higher in water-saturated and dry land fields, but lower in submerged fields (Samoy-Pascual *et al.*, 2020). Degree of weed pressure in rice fields affect competitive ability of rice cultivars. The best weed control knowledge, however, will not prevent yield losses due to weeds when rice is grown continually on the same land (Upasani *et al.*, 2014; Andres *et al.*, 2021). Crop rotations alone are incomplete in preventing weeds from causing yield losses in rice (Pardo *et al.*, 2021). Integrated system of weed control is required to prevent

weeds from increasing to economic threshold levels (Jiya *et al.*, 2019).

Crop competitiveness is made up of two components: weed suppressive ability, or the crop's capacity to limit weed growth in terms of dry matter accumulation, and tolerance to weed infestation, or the capacity to maintain high yields under weedy conditions (Andrew *et al.*, 2015; Rasmussen *et al.*, 2021). However, there aren't many rice genotypes known to have greater weed competitiveness (Dimaano *et al.*, 2017; Fahad *et al.*, 2019). The growth and competitiveness of plants are influenced by the availability of nutrients, water, and light. The amount of these resources in a rice environment is theoretically set; what one plant species uses cannot be used by another. In general, there is a negative relationship between rice yield and weed biomass, meaning that more weed biomass results in lower rice output (Nazir *et al.*, 2022; Thi *et al.*, 2020). The ability of different weed species to compete with rice varies (Gharde *et al.*, 2018).

The main factors influencing the relative competitiveness of annual and perennial weeds are their species and the environmental factors in which they are flourishing (Teka, 2014). Crop height appeared to have the greatest impact on competitive ability, with the shortest cultivars experiencing the largest yield reductions and allowing the greatest weed growth (Sunyob *et al.*, 2015). According to Andrew *et al.* (2015), yield gains of 7– 9% have been identified in “competitive” aerobic cultivars when compared with “noncompetitive” cultivars. Also critical period of weed control is one of the important tools in integrated weed management (Kifelew *et al.*, 2015). It is an intermission in the life cycle of a crop which must be kept without weed, is not necessarily the time of extreme interference, but is the number of weeks after crop emergence during which a crop must be free of weeds in order to prevent yield losses (Ismaila *et al.*, 2013; Kifelew *et al.*, 2015). In rice, this is

before it has formed a congested canopy and when the crop is tillering (Sebastain *et al.*, 2013). Weed management during the early growth stages of rice is essential to reduce the competition (Saito *et al.*, 2018). Critical period of weed control is one of the important tools in integrated weed management (Kifelew *et al.*, 2015).

Weeds cause 15 to 20% of rice production loss, but under extreme circumstances, the yield loss might reach 50% or even 100% (Sureshkumar *et al.*, 2016). According to research by Rodenburg *et al.* (2015) and Gharde *et al.* (2018), weeds can reduce rice yields by 12 to 98%, depending on the method used to establish the crop. Yield losses are greater in rice systems that use direct seed sowing than in transplanted rice. Yield losses due to uncontrolled weed growth and weed competition were least in transplanted rice, and the highest in rainfed direct sowing rice without proper land preparation (Bajwa *et al.*, 2017; Ghosh *et al.*, 2017; Ismaila *et al.*, 2013). The amount of yield loss also depends on the weed density (high density may cause high competition which lead to greater yield loss), type of weeds (more competitive weeds cause greater yield loss, example; wild rice) and the competition duration (longer period of competition cause greater yield loss than shorter period of competition) (Touré *et al.*, 2011; Gharde *et al.*, 2018).

In addition to drastically lowering rice yields, weeds raise cultivation costs and decrease input efficiency. In addition, it serves as a substitute host for a number of illnesses and insect pests alters the ecosystem's aesthetics and natural biodiversity, has an impact on cattle and human health, and lowers grain quality (Teka, 2014; Swanton *et al.*, 2015; Jha *et al.*, 2017). A successful weed management program needs to take into account a number of variables that vary from crop to crop and from season to season, such as planting date and climate (Danimaigoro *et al.*, 2019). In

between the life cycle and prior to seeding, weed management can start. Since there is no one solution that works for all weeds, an integrated weed management system should be taken into consideration (Alagbo et al., 2022). Kone *et al.* (2014) claimed that using cultivars that are competitive with weeds may help control weeds effectively and raise rice yield. Finding the competitive rice cultivars under natural weed pressure and figuring out the ideal number of weedings to achieve maximum yield were the goals of this study.

3.2 Materials and Methods

3.2.1 Site description

Field study was conducted to determine the effect of weed competition on the performance of rice cultivars in direct-sowing conditions in the rainy seasons from January to July, 2021. The experiment was laid out at Kiswago village, Malinyi District (located at 8° 54' 0" south, 36° 17' 0" east, elevation of 275 metre above sea level with an average rainfall of 800 to 1600 mm per year) in Morogoro region (Fig.3.1). In 2021, the monthly mean rain fall was 241.7, 156.1, 230.6, 319.7, 61.4 and 8.6 mm for January to June, respectively (TMA, 2021). The soil type at the experimental site was sandy clay loam with 1.25% organic matter and a pH of 5.92. The total N content in the soil was 0.14%. The available P (0.1mg/kg) and K contents (0.90Cmol+/kg) in soil. Field had the history of rice production for more than 5 years. Soil was analyzed at SUA Soil Science Laboratory.

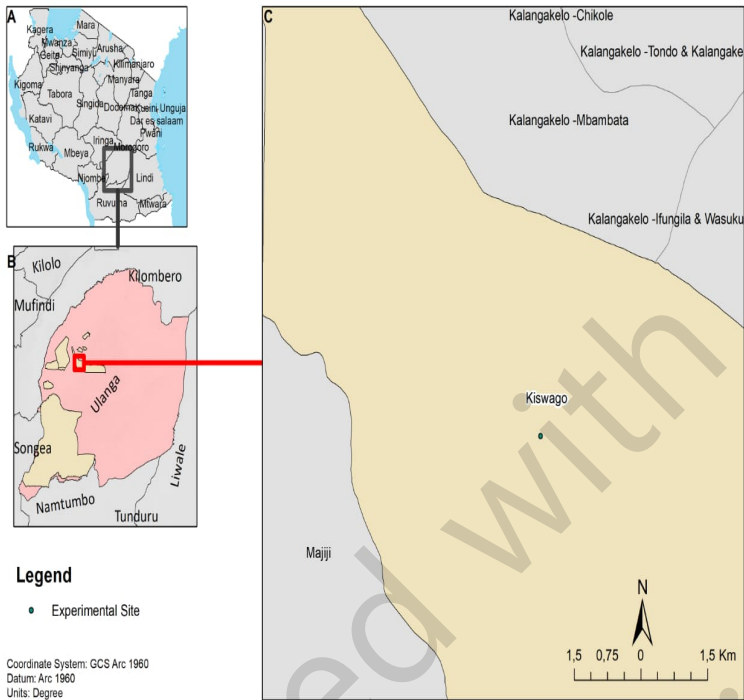


Figure 3.1: Map showing Experimental site

3.2.2 Experimental Material

Three local rice cultivars; Karimata, Kisegesi and Mbawambili (Hubert *et al.*, 2016; Nkuba *et al.*, 2016) were bought from farmers and one improved variety SARO 5 (TXD 306) from TARI Ifakara. Local cultivar characterized by tall stature, moderately short duration to maturity (100 – 110 days), grows well under stagnant water. They are aromatic cultivars with moderate yielding of 1.5 – 4 t ha⁻¹ (Kitilu *et al.*, 2019). TXD 306 (SARO 5), an improved rice variety registered in Tanzania, was developed and released by TARI Dakawa in 2002. It is a high yielding semi aromatic (7.0 – 8.5 t ha⁻¹), with moderate duration (120 - 125 days) and is a photosensitive variety. It can tolerate water logging (Kitilu *et al.*, 2019; Kangile *et al.*, 2018).

3.2.3 Experimental design and treatments

The experiment was laid out in a randomized complete block design in split plot arrangement with three replications (Sunyob *et al.*, 2015). The net size of each main plot was 15 meters and sub plot was 9 m² (3.0 m × 3.0 m). The space between replications was 1 meter. An alley of 0.5 m separated subplots and 1m separated main plots, while border space was 1.5 m and total area was 74 m by 14 m.

Spacing used was 25 cm by 20 cm for inter and intra row, respectively. Four rice cultivars in Main plots had five subplots (weeding regimes). Weeding regimes were no weeding all season, one weeding at 15 days after emergence (DAE), two weedings at 15 and 45 DAE, three weedings at 15, 30 and 45 DAE and as weed free, weeding at 15, 30, 45 and 60 DAE.

3.2.4 Crop management

Fields were prepared by cultivating twice using a mold board plow, followed by harrowing and leveling with hand hoe (Ismaila *et al.*, 2013). Seeds were sown by a single-row dibbling at a seeding rate of 30 kg ha⁻¹. Weeding was done as explained in section 3.2.3 above and source of water was rainfall. The Nitrogen (N) fertilizer at the rate of 50 kg N ha⁻¹ was top dressed once at 45 DAS (Sunyob *et al.*, 2015).

3.2.5 Methods

3.2.5.1 Crop data

During data collection, fifteen (15) rice plants were chosen at random from 4m² center of each plot then tagged and used to record Plant height, number of tillers and leaves. Rice plant height in centimeter was measured by using tape measure from the ground level to the tip of flag leaf. Data taking repeated in two weeks interval. Fifty-four (54) rice plant sample in 4m² centre of each plot used to determine number of days that 90% of panicles were at maturity stage. At maturity stage, after harvesting, rice panicles from 10 rice plants chosen at randomly from 4m² centre of each plot were counted and weighed. The average panicle weight was recorded. Rice panicles harvested from the 4m² centre of each plot, threshed, dried until constant (at moisture content range of 10 – 14% (Mbie, 2017)) weight and then weighed to determine grain yield in t/ ha. From grain one thousand seeds from each plot were weighed to determine weight. Rice straws at maturity stage (after removing panicles) were cut at ground level from 1m² centers of each plot and then weighed for fresh weight. The biomass were sun-dried followed by oven-dried at 70 °C for 72 hours until constant weight. Weight stated in t/ha.

3.2.5.2 Weed data

All weeds in 1 by 1 meter centre of each plot were identified and counted by species in 15 days interval and recorded. All weeds from 1 m² center of each plot were clipped to ground level, separated by species, weighed for fresh biomass, and then followed by sun drying. After oven dried for 72 hours at 70 °C, were weighed to get dry biomass in t/ ha.

3.2.6 Statistical analyses

In assessing the variability of measured variables (in rice or weeds), a split – plot design of the analysis of variance (ANOVA) was performed following rice cultivars (Mbawambili, Karimata, Kisegesi and SARO 5 – TXD 306) and weeding regimes (not weeded – control, weeded once, weeded twice, weeded thrice, weeded four times). The fixed main effects in the design were the rice cultivars considered as the main plot and weeding regimes as the sub–plot whereas replicates were treated as random effect. The significant treatment means with respect to the sole effect of rice cultivars or weeding regimes were compared using the least significance difference (LSD) while significant means resulting from interactions between rice cultivars and weeding regimes were compared using the standard error of differences of means (SED) at 5% threshold by Tukey’s post hoc multiple comparisons (Baker *et al.*, 2021). Computer package GENSTAT software version 16 was used. The factors effect model as shown in equation 1

$$Y_{ij} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ij} \quad \text{.....(1)}$$

Where

Y_{ij} is observed measured variable in the ij th factors; μ is the overall (grand) mean of the measured variable; α_i and β_j are the main effects of the factors rice cultivars and weeding regimes respectively; $(\alpha\beta)_{ij}$ is the two – way (first order) interactions between the factors rice cultivars and weeding regimes; ϵ_{ij} is the random error associated with the observation of the measured variables in the ij th factors.

The relative yield loss (YL) of the crop faced by weed competition under field conditions was estimated using the following equation (Ahmed *et al.*, 2020).

$$RYL\% = \left| 1 - \frac{YCW}{YCM} \right| \times 100, \quad \text{..... (2)}$$

YCW and YCM = crop yields in competition with weeds and in weed-free conditions, respectively.

Total weed density and total weed dry weight were recorded and expressed as weed count/ m² and t/ha, respectively. Degree of infestation (relative density) of individual weed species {Density of a given weed species/ Total weed density} × 100} was also calculated (Rahman *et al.*, 2017; Travlos *et al.*, 2018; Varsha *et al.*, 2019). Weed dry biomass data collected was correlated to rice grain yield in order to determine their relationship (Rahman *et al.*, 2017; Dimaano *et al.*, 2017).

The summed dominance ratio (SDR) was calculated to identify the dominant weed species using the following equations (Islam *et al.*, 2021):

SDR of a weed species =

$$\frac{\text{Relative density} + \text{Relative weed biomass}}{2} \dots \dots \dots (3)$$

Where

$$\text{Relative density (\%)} = \frac{\text{Density of a given weed species} * 100}{\text{Total weed density}} \dots (4)$$

$$\text{Relative weed biomass (\%)} = \frac{\text{Biomass of a given weed species} * 100}{\text{Total weed biomass}}$$

$$\dots \dots \dots (5)$$

3.3 Results

In this study the interactions of factors (weeding regimes and rice cultivars) for all variables had no statistical significant difference with p values ranging from 0.058 to 0.944 which are greater than 0.05 significance level. Therefore factor based (main effects) results are presented.

3.3.1 Weed species composition

Six weed species belonging to three different families were identified, among them two were grasses, two were broadleaves, and two were sedge. The most dominant weed species encountered was *Paspalum scrobiculatum* with greater summed dominance ratio and the least dominant one was *Cyperus rotundus* with smaller summed dominance ratio (Table 3.1).

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Table 3.1: Weed species and their summed dominance ratio

SN	Weed species	Type	Family	Lifecycle	Relative Density	Relative biomass	Summed dominance ratio
1	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	37.40	49.79	43.60
2	<i>Ischaemum rugosum</i> Salsb.	Grass	poaceae	Perennial	19.40	27.78	23.59
3	<i>Galinsoga parviflora</i> Cav.	Broadleaf	Asteraceae	Annual	18.20	18.57	18.39
4	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	14.00	7.26	10.63
5	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	10.00	3.44	6.72
6	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	1.00	1.15	1.08

3.3.2 Plant heights (Cm)

Weeding regimes were assessed for their effect on rice plant heights. Table 3.2 illustrates the average plant heights of rice plants at 40, 54, 68 and 82 days after sowing under five weeding regimes. There was no statistical significant influence of weeding regime on rice plant heights 40 days after sowing (p -value = 0.172) at a 5% significance level. None of the weeded plots had plants that were taller than the non-weeded plots (controls).

At 54 DAS, weeding regimes had significant impact on average rice plant heights (p -value 0.003) (Table 3.2). Plant heights averaged 49.81 cm in plots where weeds were controlled twice (at 15 and 45 DAE), while plant heights were 46.36 cm in plots weeds managed three times per season (weeding at 15, 30, and 45 DAE). Only twice weeding (at 15 and 45 DAE) resulted in considerably taller average plant heights than control plots (no weeding). At 68 DAS, weed management strategies had no significant effect on average rice plant heights (p -value = 0.64) and at 82 DAS (p -value = 0.832), the observed variations in mean plant heights were not significant enough to support the influence of weed management strategies. SARO-5 cultivar had considerably shorter mean plant heights at 40, 54, 68 and 82 DAS ($p < 0.001$) than the other cultivars, despite the fact that the rest of the cultivars had statistically equal plant heights (Table 3.3). Generally the trend of plant height was increasing with increasing number of days.

Table 3.2: Effects weeding regimes on vegetative variables of rice plants

Weeding regime	Mean Plant height(Cm)				Mean Number of Tillers/plant				Mean Number of Leaves/plant			
	40 DAS	54 DAS	68 DAS	82 DAS	40 DAS	54 DAS	68 DAS	82 DAS	40 DAS	54 DAS	68 DAS	82 DAS
Control	32.28	48.25	67.30	79.17	1.79	2.54	3.04	3.32	6.53	8.72	10.59	12.83
Weeding 15 DAE	32.60	49.32	68.29	80.15	2.00	2.93	4.18	4.31	7.15	10.58	13.84	16.67
Weeding 15 and 45 DAE	33.12	49.81	67.58	80.25	2.14	2.96	4.26	4.96	8.00	10.46	14.13	17.32
Weeding 15, 30 and 45 DAE	33.68	46.36	67.20	78.43	2.02	2.92	4.41	5.08	7.61	9.95	14.20	17.91
Weeding 15, 30, 45, and 60 DAE	34.30	46.98	66.32	79.09	2.08	2.93	4.64	5.37	7.31	10.25	14.81	18.30
Grand mean	33.19	48.14	67.33	79.41	1.986	2.856	4.106	4.608	7.32	9.992	13.51	16.60
LSD	2.678	2.674	2.562	3.668	0.208	0.371	0.565	0.611	0.918	1.635	1.643	2.256
Pvalue	0.172	0.058	0.640	0.832	0.023	0.14	<.001	<.001	0.053	0.053	<.001	<.001

DAE = Days after Emergence, DAS = Days after sowing, PV = P-value, and LSD = Least Significant Differences.

3.3.3 Number of tillers

There was statistical significant influence of weeding on rice number of tillers among rice cultivars at 40 days after sowing ($p = 0.023$) at the 5% significance level (Table 3.2). There was no significant influence of weeding on rice plant number of tiller at 54 days after sowing (p -value = 0.114). The weeded plots had no plants with more tillers than the non-weeded plots (controls). At 68 and 82 DAS, weeding had a significant impact on average rice number of tiller ($p < 0.001$). Plant number of tillers averaged 4.64 in plots where weeds were controlled four times (at 15, 30, 45 and 60 DAE), while number of tillers were 3.04 in unweeded (control) plots. Rice cultivars (Karimata, Kisegesi, Mbawambili, and SARO-5) were evaluated for their ability on producing plant tillers, at 68 days after sowing, there was statistical significant difference among rice cultivars ($p = 0.033$) (Table 3.3). Number of tillers was increasing with increasing number of days.

3.3.4 Number of leaves

Five weeding regimes were evaluated for their impact on rice leaf count and the results are presented in Table 3.2. Generally, at 5 % significance level, there was no significant influence of weeding on rice leaf count at 40 and 54 days after sowing ($p = 0.053$). But att 68 and 82 days after sowing, there was statistical significant influence of weeding on rice leaves count (p -value <0.001) (Table 3.2). The results presented in Table 3.3, indicate that there was no significant differences between number of leaves of rice plants among different cultivars at 40, 54, 68 and 82 days after sowing. Number of leaves was increasing with increasing number of days.

Table 3.3: Effects rice cultivars on vegetative variables of rice plants

Rice Cultivar	Mean Plant height (Cm)				Mean Number of Tiller /plant				Mean Number of Leaves/plant				
	40 DAS	54 DAS	68 DAS	82 DAS	40 DAS	54 DAS	68 DAS	82 DAS	40 DAS	54 DAS	68 DAS	82 DAS	
SARO 5	21.84	31.53	40.04	52.10	2.285	3.419	5.46	5.92	8.25	11.35	11.25	21.25	
MBAWAMBILI	36.26	52.1	75.74	87.89	1.867	2.552	3.22	4.13	6.98	9.06	12.34	13.42	
KARIMATA	37.22	54.6	79.46	91.92	1.881	2.632	3.61	3.95	6.72	9.95	13.93	14.77	
KISEGESI	37.46	54.34	74.11	85.76	2.011	2.837	4.13	4.43	7.32	9.61	16.54	17.00	
Grand mean	33.19	48.142	67.337	79.417	2.011	2.86	4.105	4.607	7.317	9.992	13.51	16.61	
	5									5			
LSD	1.795	2.391	8.431	10.095	0.456	0.792	1.408	1.997	2.031		4.69	5.609	
p-value	<.001	<.001	<.001	<.001	0.194	0.122	0.033	0.163	0.357	0.165	0.282	0.125	0.057

DAS = Days after sowing, PV = P-value, and LSD = Least Significant Differences.

3.3.5 Duration to 90% grain maturity (days)

Five weeding regimes were evaluated for their influence on duration of rice to 90% grain maturity and the results are presented in Table 3.4. The influence of weed management practice was not significant at 5 % significance level ($p = 0.745$). Among the four rice cultivars, there was significant difference on duration to 90% grain maturity at $p < 0.001$. SARO-5 took longer duration to 90% grain maturity (125.3 days) while mbawambili, karimata and kisesesi took shorter duration (109.3 to 112.1 days) (Table 3.5).

Table 3.4: Effects of weeding regimes on yield components of rice crop

Weeding regime	Days 90% maturity	Panicle Weight (g)	Grain Filling %	Weight of 1000 (g)
Control	114.2	4.142	89.60	31.29
Weeding 15 DAE	114.1	4.185	90.48	31.34
Weeding 15 and 45 DAE	114.2	4.442	91.36	31.57
Weeding 15, 30 and 45 DAE	114.2	4.449	93.58	31.65
Weeding 15, 30, 45, and 60 DAE	113.6	4.491	99.37	31.90
Grand mean	22.84	4.341	92.878	31.55
LSD	1.11	0.501	12.435	1.67
Pvalue	0.74	0.478	0.52	0.948

DAE = Days after Emergence, DAS = Days after sowing, PV = P-value, and LSD = Least Significant Differences.

3.3.6 Panicle weight (gm/panicle)

Results for the panicle weights of rice plants grown under varying weeding regimes are presented in Table 3.4. At 5 % significance level, there was no significant influence of weeding regimes on rice panicle weights (p -value = 0.478). Table 3.5 indicates panicle weights of different rice cultivars investigated under this study. Among rice cultivars studied, SARO-5 produced significantly lowest panicle weights (3.6g) whereas Karimata producing the highest (6.05g) panicle weights (p -value = 0.021).

Table 3.5: Effects of rice cultivars on yield components of rice crop

Rice Cultivar	Days 90% maturity	Panicle Weight (g)	Grain Filling (%)	Weight of 1000 (g)
Saro 5	125.3	3.16	88.73	28.91
Mbawambili	109.3	3.97	91.80	31.26
Kisegese	112.1	4.16	95.48	31.67
Karimata	109.3	6.05	95.51	34.35
Grand mean	114	4.335	92.8	31.55
LSD	1.00	1.59	2.28	1.49
p-value	<0.001	0.021	<0.001	<0.001

DAS = Days after sowing, PV = P-value, and LSD = Least Significant Differences,

3.3.7 Grain filling

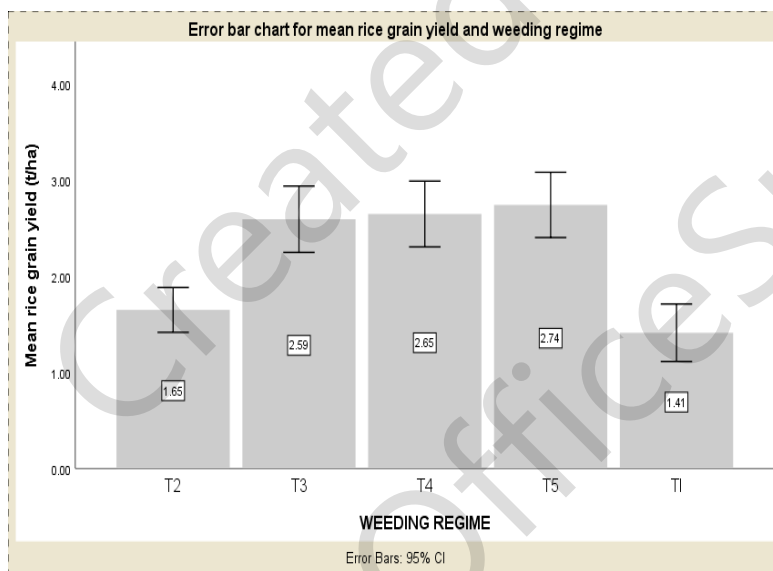
Grain filling (%) of rice was not significantly influenced by weeding regimes applied in this study (p -value = 0.52) (Table 3.4). Grain filling (%) of the studied rice cultivars varied significantly (p -value <0.001). The significantly higher grain filling observed was 95.51 for Karimata and the lowest was 88.73 for SARO 5 (Table 3.5).

3.3.8 Weight of 1000 seeds (gm)

The 1000 seed weight of rice was not significantly affected by weed management practices (Table 3.4) used under this study (p -value = 0.948). The studied rice cultivars (Karimata, Kisegesi, Mbawambili, and SARO-5) had statistically insignificant difference weights of their 1000 seeds (p -value < 0.001) (Table 3.5).

3.3.9 Rice Grain yield (t/ha)

Five weeding regimes were evaluated for their influence on rice grain yield. Figure 3.4 shows the trend of rice grain yield across weeding regime. In ANOVA the results indicated there was statistical significant difference at 5 % significance level (p -value < 0.001), where by weeding for at least two times (T3, T4 and T5) per season demonstrates positive effect on rice grain yield.



T1 = Control (no weeding), T2= Weeding at 15DAE, T3= Weeding at 15 and 45DAE, T4= Weeding at 15, 30 and 45DAE, T5= Weeding at 15, 30, 45 and 60DAE. DAE = Days after rice emergence.

Figure 3.2: Error bar chart for mean rice grain yield and weeding regime

Among the four rice cultivars, rice grain yield of KARIMATA (2.92 t/ha) was significantly higher, followed by Mbawambili while SARO-5 variety had the lowest net grain-weight (1.77 t/ha). The influence of rice cultivars towards yield was significant at 5 % significance level (p -value <0.001) (Fig. 3.3).

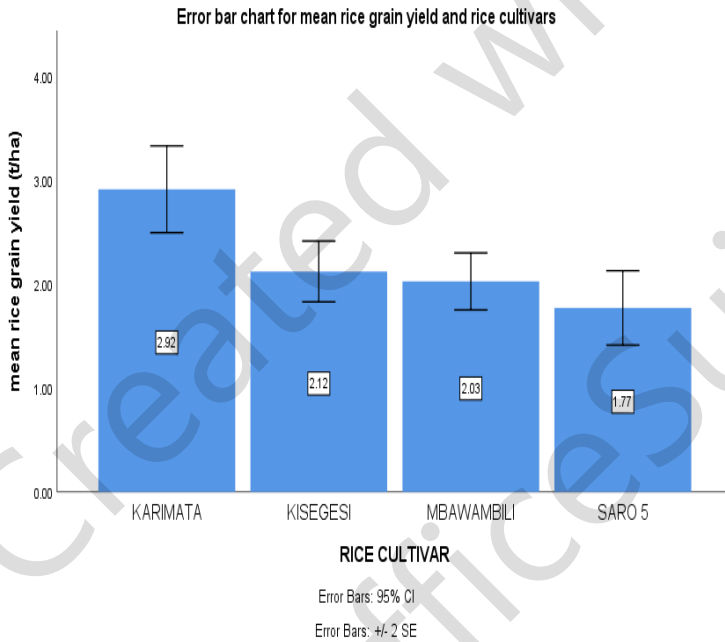
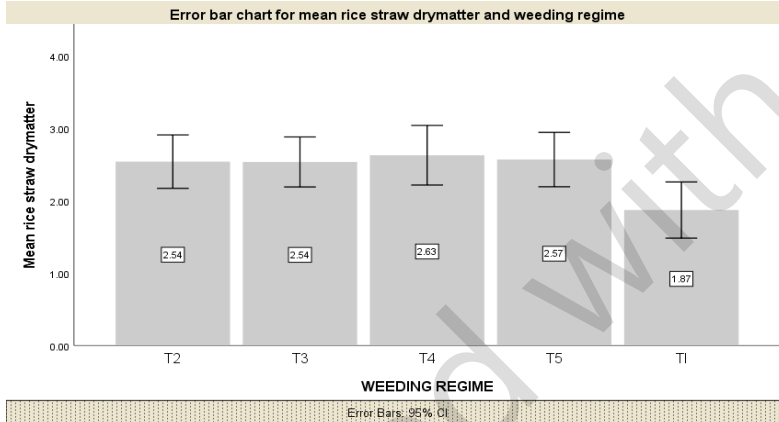


Figure 3.3: Error bar chart for mean rice grain yield and rice cultivars

3.3.10 Rice Straw dry weight (t/ha).

Five weeding regimes were evaluated for their effect on rice straw dry-weight and the results showed any of the weeding regime under this study caused significantly higher straw dry weight of rice plants (P -value $<.001$). Fig.3.4 shows the trend of rice straws drymatter over weeding regime.



T1 = Control (no weeding), T2= Weeding at 15DAE, T3= Weeding at 15 and 45DAE, T4= Weeding at 15, 30 and 45DAE, T5= Weeding at 15, 30, 45 and 60DAE. DAE = Days after rice emergence.

Figure 3.4: Error bar chart for mean rice straw drymatter and weeding regime

The results for rice straw dry weight of different cultivars are presented in Fig.3.5. There was no significant differences in straw weight of different cultivars (p -value = 0.672).

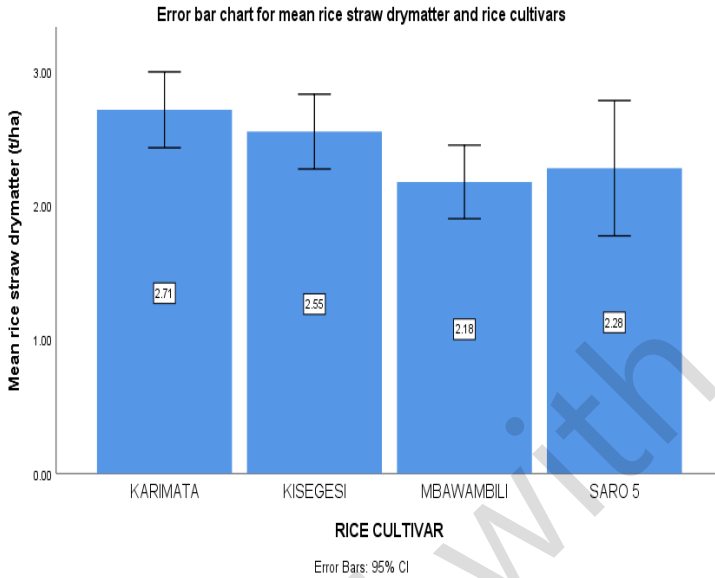


Figure 3.5: Error bar chart for mean rice straw drymatter and rice cultivars.

3.3.11 Weed dry biomass and density

Weed total drymatter and individual weed species, Ps – *Paspalum scrobiculatum* and Ir- *Ischaemum rugosum* had the highest drymatter and there was statistical significant different difference ($p < 0.001$) among the weeding regimes, in which control plots recorded the highest value and weed free plots with lowest value. But other weed species which are Fm- *Fimbristylis miliacea* ($p = 0.015$) and Cr – *Cyperus rondus* ($p = 0.011$) showed significance differences (Table 3.6).

Table 3.6: Effect of weeding regimes on weed species

Weeding Regime	Dry Weights of Weed Species (t/ha)							Total weed count/m ²
	Ac	Cr	Fm	Gp	Ir	PS	Tw	
Control	0.09	0.04	0.13	0.41	0.96	1.22	2.85	194.7
Weeding 15 and 45 DAE	0.02	0.01	0.08	0.28	0.18	0.39	0.97	171.0
Weeding 15 DAE	0.02	0.00	0.05	0.06	0.04	0.11	0.27	194.3
Weeding 15, 30, 45, and 60 DAE	0.01	0.00	0.04	0.03	0.03	0.08	0.13	171.8
Weeding 15, 30 and 45 DAE	0.01	0.00	0.03	0.03	0.02	0.04	0.19	190.1
Grand mean	0.03	0.01	0.06	0.16	0.24	0.36	0.88	184.38
LSD	0.04	0	6	2	6	8	2	39.41
	5	8	0.06	0.28	0.49	0.25	0.69	
				2	7	7	4	
p-value	0.40	0.01	0.01	0.24	0.00	<.00	<.00	0.24
		1	5	0	2	1	1	

DAE = Days after Emergence, P-value = probability value, and LSD = Least Significant Differences, Ir = *Ischaemum rugosum*, Fm = *Fimbristylis miliacea*, Cr = *Cyperus rondus*, Tw = total weed dry weight, Ps = *Paspalum scro biculatum*

The weed density was affected significantly among rice cultivars ($p < 0.001$) where Karimata cultivar recorded the lowest mean density of 151.5 weeds/m² while total and individual weed species drymatter had no significance differences (Table 3.7).

Table 3.7: Influence of rice cultivar on weed species

Rice Cultivar	Dry Weights of Weed Species (t/ha)							Total weed count/m ²
	Ac	Cr	Fm	Gp	Ir	PS	Tw	
KARIMATA	0.043	0.02	0.05	0.34	0.13	0.41	0.99	151.5
SARO 5	0	0.00	0.07	0.15	0.40	0.17	0.79	188.5
MBAWAMBILI	0.034	0.00	0.06	0.08	0.31	0.43	0.91	198.4
KISEGESI	0.044	0.02	0.07	0.09	0.14	0.46	0.82	199.1
Grand mean	0.030	0.01	0.062	0.016	0.245	0.036	0.877	182.35
LSD	0.04	0.025	0.054	0.252	0.444	0.23	0.621	35.24
p-value	0.104	0.156	0.898	0.147	0.535	0.062	0.908	<.001

P-value = probability value, and LSD = Least Significant Differences, Ir = *Ischaemum rugosum*, Fm = *Fimbristylis miliacea*, Cr = *Cyperus rondus*, Tw = total weed dry weight, Ps = *Paspalum scrobiculatum*

3.3.12 Relative yield loss (%)

Relative yield loss had statistically significance differences among rice cultivars ($p = 0.02$) in which Karimata cultivar recorded the lowest yield loss and the highest yield loss recorded in SARO5 (Fig. 3.6).

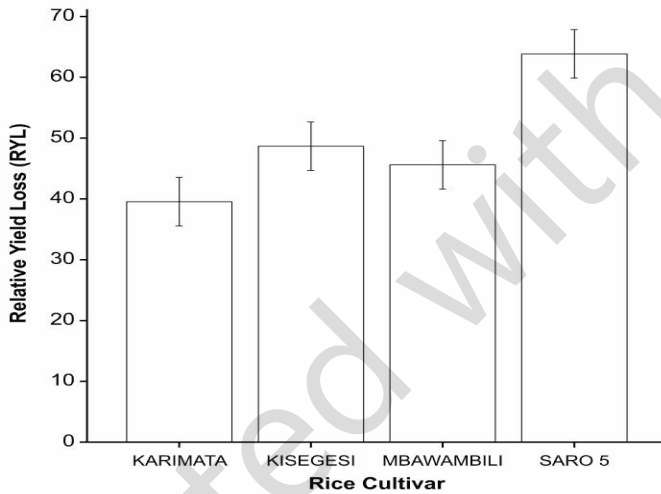


Figure 3.6: Rice relative yield loss in rice cultivars

3.3.13 Correlation analysis

Correlation of weed drymatter and grain yield had significant negative relationship ($p < .001$, $R^2 = 0.2691$) (Fig. 3.7). If weed drymatter increases the rice grain yield drops.

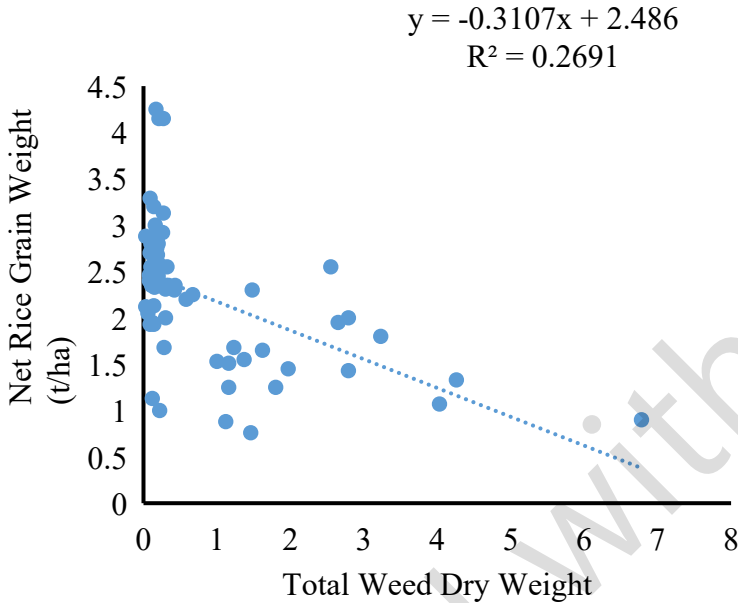


Figure 3.7: Relationship between rice grain yield and total weed dry weight

3.4 Discussion

Among the weed species observed in the experimental field, *Paspalum scrobiculatum*, was the most dominant followed by *Ischaemum rugosum*. *Paspalum scrobiculatum* had the highest summed dominance ratio which was linked to its contribution in competition and reducing crop yield. Similar results were reported by Sunyob *et al.* (2012) detected those grasses were dominant in the rice fields. But Anwar *et al.* (2012) also recorded dominance of broadleaf weeds in their experimental rice field. The dissimilarity in weed community might be due to differences in weed seed bank structure between experimental sites (Varsha *et al.*, 2019).

A crop plant's capacity to outcompete weeds is gauged by its relative yield loss. According to this study, the Karimata rice

cultivar, which was followed by the Mbawambili cultivar in terms of relative yield loss, had the greatest capacity to outcompete weeds. Similar to the findings of this study regarding rice varieties, it was also demonstrated that droopy-plant-type rice varieties with long leaves exhibit a high early growth rate, faster canopy covering, tall, high tillering ability, efficient growth resources utilization, and early maturing encounter less competition from weeds because they provide weeds with less space to grow (Awan *et al.*, 2018; Arefin *et al.*, 2018). These traits have been observed in Karimata rice cultivars for its competitive ability as evident in gaining higher panicle weight, grain filling percentage and 1000seeds weight. Differences in weed competitiveness between rice cultivars have previously been reported (Rahman *et al.*, 2017). The cultivar competitive ability not only depends on its characteristics, but also affected by the weed species and abundance. Among rice cultivars, Karimata showed the lowest relative yield loss, which indicates its higher weed tolerance potential. Apart from these characteristics, Karimata is also drought tolerant. Mahajan *et al.* (2014) proposed that competitive varieties need to be weed competitive and possess tolerance against other biotic and abiotic stresses.

The highest grain yield was observed in weed-free conditions compared to weedy conditions, regardless of cultivars due to no or less crop-weed competition for resources in weed-free plots as reported earlier in dry direct-sown, aerobic system of rice production (Shabi *et al.*, 2018). Differential weed suppressive abilities of rice cultivars were also reported by Chauhan *et al.* (2012) and Dass *et al.* (2017) concluded that rice-weed competition remained tougher for weeds having similar morphological characteristics with rice plants such as wild rice and weedy rice. The results showed that the average yield potential of local rice cultivars was higher than improved variety. This is

because of low weed competitive ability and moisture stress conditions that affect dry matter assimilation by the crop. The longer growth duration of the rice variety also trigger higher grain yield loss. In this study local cultivars were found as strong weed suppressive/tolerant combined with high yield potential, except improved rice varieties, SARO 5. Environmental factors such as water availability greatly affect the performance of a particular crop plant/variety in a given environment. Naturally Crop weed competition is common and when crops are subjected to more competition, the physiological features of the growth and development of crops are typically altered. In a community, when the crop growth and development are altered due to competition, this result is brought by the differences in the use of essential environmental resources, especially the water, which disturb CO₂ in leaf mesophyll and leaf temperature (Islam *et al.*, 2021).

Dry biomass for both, crop and weeds determine the effect of competition in the plant community. Under this study weeding regimes had effects over dry matter accumulation, where in unweeded plots (control), weeds accumulated greater dry matter than rice crop. This study is supported by work of Mahajan *et al.* (2014) and Islam *et al.* (2021), reported that dry matter accumulation of weeds and rice crop were affected by weeding regimes; where in partial weeded plots weight of dry matter found higher for weeds and less for rice straws biomass. In weed free plots the rice crop accumulated greater dry matter, which is due to no or less competition for growth resources

3.5 Conclusion and recommendations

Paspalum scrobiculatum and *Eschaemum rugosum* were the two most dominant weeds in this experiment, with grasses making up the majority of the dominant weeds and accounting for more than 60% of the total dominance ratio. This study found that there were differences in performance under weed pressure because of various varietal characteristics of rice. Compared to shorter rice cultivars like SARO 5, which have longer growth durations, Karimata, which have taller plants and somewhat shorter growth durations, performed better against weeds. Karimata had superior weed competitive ability as evidenced by lower/higher weed dry weight and low relative yield loss. Additionally, all cultivars studied showed better grain yields with two, three, and four weeding. For this reason, it is advised that farmers weed between 15 and 45 DAE in order to save operating costs, save time, and boost output. It is advised to conduct more thorough research to assess the competitive potential of karimata against weeds and the management strategies for the weed species *Paspalum scrobiculatum* and *Ischaemum rugosum*.

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CHAPTER FOUR

4.0 General Discussion

This study documents the floristic composition, as well as the weed species relative abundance, diversity, and similarity indices, found in the Malinyi district, which serves as the starting point for future studies of a similar nature. It also reports the recognition of an optimal weeding regime for rice crop productivity and weed-competitive rice cultivars.

Thirty-five (35) weed species have been identified and documented as part of this research project, which is one of the guiding principles of weed management programs. Based on the relative abundance, which is a quantitative sum of relative density, frequency, and uniformity, it was found that there was a significant difference between the lowest and highest weed species. Relative abundance range was 0.7% (*Cassia tora*) to 36.7 % (*Paspalum scrobiculatum*). This indicates that *Paspalum scrobiculatum* was the most abundant and dominant weed species in Malinyi district.

Additionally, this study found that, according to the Sorensen similarity index scores of paired Villages, the composition of weed species for the majority of the Villages was comparable (Khan *et al.*, 2018; Haile *et al.*, 2021). This suggested that a similar weed management strategy would be appropriate for the district (Olayinka *et al.*, 2020). Based on the results of the weed species diversity indices used in this study, it was found that there was a medium diversity of weed species present in all Villages. The findings suggest that the distribution of weeds was uneven and that some weed species predominated (such as *Paspalum scrobiculatum* and *Ischaemum rugosum*). Instantaneous integrated weed management methods are required for these weeds.

Moreover, results of this study shown that yield of rice differed with cultivars. Out of four rice cultivars the highest (2.92 t/ha) yield observed in Karimata and lowest (1.77 t/ha) in SARO 5 rice cultivars. Additionally, in five weeding regimes, high yields were as well found in plots weeded more than one while plots weeded less than two times had low yields. Yields in control plots (unweeded) were the lowest (1.41t/ha) and in four times weeded plots gained the highest (2.74t/ha). The differences in yields are linked with rice cultivars and weeding regime frequency effects under study area conditions.

This study detected that yields were statistically similar between two, three and four times weeding and also found the same for unweeded and one weeding plots. Numerical results of this study revealed that yield increased with increasing number of weeding. This could be due to minimized weed pressure brought by increased weeding frequency which led to less competition (Dass *et al.*, 2017). According to Korav *et al.* (2018) high weed density in rice crop fields for long period beyond critical period of weed control, rice yield is greatly reduced due to competition for growth resources. Karimata local rice cultivars revealed lower relative yield loss compared to other cultivars. This ascertains that Karimata is weed - competitive rice cultivar which could be due to takes short duration to maturity, tall stature, high growth vigour and long droppy leaves that render the effects of weeds (Khan *et al.*, 2019).

Undesirable effects of weeds on rice yield were previously reported (Nadiret *et al.*, 2017; Gharde *et al.*, 2018; Islamet *et al.*, 2018; Singh *et al.*, 2016; Khan *et al.*, 2019). The use of weed – competitive rice cultivars in rice production reduces the yield loss due to weeds which in turn increases productivity

(Sandhu *et al.*, 2021). Likewise, optimized weeding regime reduces weed pressure, cost of weed control and increases productivity of rice (Ajibola & Modupeola, 2014). Exploration on weed - competitive rice cultivars under weed pressure are however rare or inadequate but in other countries have been reported (Nagargade *et al.*, 2018; Shrestha *et al.*, 2020).

This study showed that weed dry matter affected levels of rice grain yield negatively, meant that its increase reduces the rice yield. However, the levels of effects towards rice grain yield did not significantly vary between rice cultivars. Furthermore, in this study found that among weed species dry matter and summed dominance ratio values were higher in *Paspalum scrobiculatum* followed by *Ischaemum rugosum*. These therefore had greater contribution in competition with rice crop. Effects of various weed species on rice crop have been studied (Ziska *et al.*, 2015; Rodenburg *et al.*, 2016; Ramesh *et al.*, 2017; Uno *et al.*, 2021). It was important to study the effects of individual weed species towards rice crop performance because impact of an individual weed species could be different.

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CHAPTER FIVE

5.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study revealed that *Paspalum scrobiculatum*, *Fimbristylis miliacea* and *Ageratum conyzoides* were the most prevalent and abundant grass, sedge and broadleaf groups, respectively.

This maybe they are highly adapted to the environment which favors reproduction and survival. These weeds need special attention to reduce their populations.

This study also concludes that weed species in Malinyi district were moderately diverse due to uneven weed species distribution and less/more similar between villages. Also, study concluded that Karimata contained weed competitiveness and high yield potential, where weeding twice had no statistical significance difference of grain yield with weeding more than two.

5.2 Recommendations

- i. Therefore, farmers should do weeding at 15 and 45 DAE as the optimal weeding to increase productivity.
- ii. Farmers should practice crop rotation in order to minimize crop associated weeds.
- iii. Further research toward new or enhanced weed control measures.
- iv. Further research to evaluate weed - competitive potentials of karimata rice cultivar.
- v. This study recommends that regular survey is needed to identify possible problematic weed and weed population shifts.

APPENDICES

Appendix 1: Weed density, frequency, uniformity and abundance

Various weed species indices were calculated by using the following formulae; Frequency (F) is the ratio of the number of fields having a specific weed species to the total number of the fields, it is expressed in percentage. Frequency indicates the presence or absence of a species in a quadrat, or a field, and does not mean the number or quantity of the species (Eq. 1):

$$F_k = \sum (Y_i/n) \times 100 \dots\dots\dots (\text{Eq. 1})$$

Equation above, F_k represents the frequency of the species, Y_i the presence or absence of the species, “n” the number of fields surveyed.

Density refers to the number of individuals weed species in m^2 in the field (Eq. ii):

$$D_{ki} = \sum Z_j/n \dots\dots\dots (\text{Eq.2})$$

Equation above, D_{ki} refers to the density of species k in field i and Z_j the number of plants in quadrat j.

Mean field density (MFDk) shows the average number of plants of each species m^2 in the fields (Eq. 3):

$$\text{MFDk} = \sum D_{ki} / n \dots\dots\dots (\text{Eq. 3})$$

In the above equation, D_{ki} represents density in each field and “n” the total number of surveyed fields.

Mean infested field density (MIFD_k) referring to number of fields the weed species were present (Eq. 4):

$$MIFD_k = \sum D_{ki} \div (n - a) \dots\dots\dots (Eq. 4)$$

In the above equation, D_{ki} represents density in each field and “n” the total number of surveyed fields, “a” total number of fields with absent weed species.

Uniformity (U) articulates the proportion infestation of the field by the specific species and indicates the area occupied by the weed (Eq. 5):

$$U_k = \frac{(\sum \sum X_{ij} \div n) \times 100}{\sum F_k} \dots\dots\dots (Eq. 5)$$

Equation above, U_k denotes uniformity of species k in the fields, X_{ij} denotes presence (1) or absence (0) of species k in quadrat “j” and in field “i”.

Relative abundance (RA_k) is the overall evaluation of the importance of each weed species. It is determined by individual values for relative frequency (R_{Fk}), relative uniformity (RU_k) and relative density (RD_k) (Eq. 6 – 9)

$$RD_k = \frac{D_{nk}}{\sum D \text{ of all species}} \times 100 \dots\dots\dots (Eq.6)$$

$$RF_k = \frac{F_k}{\sum F \text{ of all species}} \times 100 \dots\dots\dots$$

$$\dots\dots\dots (Eq. 7)$$

$$RU_k = \frac{U_k}{\sum U \text{ of all species}} \times 100 \dots\dots\dots (Eq. 8)$$

Therefore, relative abundance (RA_k) RAK = RD_k + RF_k + RU_k
 (Eq.10)

Appendix 2: Weed species diversity indices

Weed species diversity were computed using the Shannon-Wiener index (H') and Simpson indices by the equations 1 and 2 (Poggio *et al.*, 2004; Golmohammadi *et al.*, 2018).

$$H' = - \sum_{i=1}^s (P_i * \ln(P_i)) \dots \dots \dots \text{(Eq. 1)}$$

$$D = 1 - \sum_{i=1}^s (P_i)^2 \dots \dots \dots \text{(Eq. 2)}$$

In the above equations, P_i = relative abundance of a specific species (the i th species) that is calculated as $P_i = n_i/N$ and \ln is natural logarithm, n_i = number of individuals of a species, S = number of species, N = total number of individuals of all species of a sample.

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Appendix 3: Weed species for ten villages of Malinyi district, Morogoro

Alabama Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (plants/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance
1	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	85.7	54.3	22.6	10.7	11.7	12.6	35.0
2	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	71.4	44.3	27.1	8.9	9.5	12.6	31.0
3	<i>Oxalis latifolia</i> Sorrel	Broadleaf	Oxalidaceae	Perennial	57.1	40.0	36.1	7.1	8.6	13.5	29.2
4	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	71.4	45.7	20.7	8.9	9.8	9.7	28.4
5	<i>Ischaemum rugosum</i> Salsb.	Grass	poaceae	Perennial	71.4	42.9	21.8	8.9	9.2	10.1	28.3
6	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	71.4	40.0	20.5	8.9	8.6	9.5	27.0
7	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	42.9	28.6	25.5	5.4	6.1	7.1	18.6
8	<i>Sphenoclea zeylanica</i> Gaertn.	Broadleaf	Sphenocleaceae	Annual	42.9	28.6	13.4	5.4	6.1	3.7	15.2
9	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	42.9	22.9	13.0	5.4	4.9	3.6	13.9
10	<i>Melochia corchiriifolia</i> L.	Broadleaf	Malvaceae	Annual	42.9	15.7	8.6	5.4	3.4	2.4	11.1
11	<i>Cynodon dactylon</i> L.	Grass	Poaceae	Perennial	28.6	15.7	17.7	3.6	3.4	3.3	10.2
12	<i>Lapochloa chinensis</i> L.	Grass	poaceae	Perennial	28.6	14.3	15.1	3.6	3.1	2.8	9.4
13	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	28.6	11.4	9.2	3.6	2.5	1.7	7.7
14	<i>Sorghum leiocladum</i> Hack.	Grass	Poaceae	Perennial	14.3	11.4	12.4	1.8	2.5	1.2	5.4
15	<i>Bidens pilosa</i> L.	Broadleaf	Asteraceae	Annual	14.3	7.1	13.4	1.8	1.5	1.2	4.6
16	<i>Hibiscus trionum</i> L.	Broadleaf	Malvaceae	Perennial	14.3	11.4	4.0	1.8	2.5	0.4	4.6
17	<i>Tridax procumbens</i> L.	Broadleaf	Asteraceae	Annual	14.3	7.1	12.1	1.8	1.5	1.1	4.4
18	<i>Ipomoea aquatica</i> Forsk.	Broadleaf	Convolvulaceae	Annual	14.3	8.6	7.1	1.8	1.8	0.7	4.3
19	<i>Rottboellia cochinchinensis</i> Lour.	Grass	Poaceae	Annual	14.3	5.7	11.4	1.8	1.2	1.1	4.1
20	<i>Corchorus aestuans</i> L.	Broadleaf	Tiliaceae	Annual	14.3	5.7	10.1	1.8	1.2	0.9	4.0
21	<i>Commelina benghalensis</i> L.	Broadleaf	Commelinaceae	Annual	14.3	4.3	8.3	1.8	0.9	0.8	3.5

Njiwa Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (plants/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	100.0	70.0	55.1	11.9	15.1	24.9	51.9
2	<i>Ischaemum rugosum</i> Salsb.	Grass	poaceae	Perennial	100.0	61.4	38.9	11.9	13.3	17.5	42.7
3	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	71.4	40.0	27.9	8.5	8.6	9.0	26.1
4	<i>Stenotaphrum secundatum</i> (Walter) Kuntze	Grass	Poaceae	Perennial	71.4	34.3	19.9	8.5	7.4	6.4	22.3
5	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	57.1	40.0	17.7	6.8	8.6	4.6	20.0
6	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	57.1	27.1	23.3	6.8	5.9	6.0	18.7
8	<i>Lapochloa chinensis</i> L.	Grass	poaceae	Perennial	42.9	27.1	29.6	5.1	5.9	5.7	16.7
9	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	42.9	24.3	30.6	5.1	5.2	5.9	16.2
10	<i>Eleusine indica</i> L.	Grass	Poaceae	Annual	42.9	21.4	18.9	5.1	4.6	3.6	13.4
11	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	28.6	17.1	35.4	3.4	3.7	4.6	11.7
12	<i>Galinsoga parviflora</i> Cav.	Broadleaf	Asteraceae	Annual	28.6	12.9	17.5	3.4	2.8	2.3	8.4
13	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	28.6	15.7	12.2	3.4	3.4	1.6	8.4
14	<i>Brachiaria erusiformis</i>	Grass	Poaceae	Annual	14.3	11.4	32.1	1.7	2.5	2.1	6.2
15	<i>Alopecurus myosuroides</i> L.	Grass	Poaceae	Annual	14.3	8.6	25.1	1.7	1.9	1.6	5.2
16	<i>Sphenoclea zeylanica</i> Gaertn.	Broadleaf	Sphenocleaceae	Annual	14.3	12.9	10.3	1.7	2.8	0.7	5.1
17	<i>Physalis minima</i> L.	Broadleaf	Solanaceae	Annual	14.3	7.1	7.1	1.7	1.5	0.5	3.7
18	<i>Melochia corchirifolia</i> L.	Broadleaf	Malvaceae	Annual	14.3	5.7	5.9	1.7	1.2	0.4	3.3
19	<i>Rottboellia cochinchinensis</i>	Grass	Poaceae	Annual	14.3	4.3	9.9	1.7	0.9	0.6	3.3
20	<i>Bidens pilosa</i> L.	Broadleaf	Asteraceae	Annual	14.3	4.3	9.0	1.7	0.9	0.6	3.2
21	<i>Corchorus aestuans</i> L.	Broadleaf	Tiliaceae	Annual	14.3	4.3	7.6	1.7	0.9	0.5	3.1
22	<i>Tridax procumbens</i> L.	Broadleaf	Asteraceae	Annual	14.3	4.3	6.4	1.7	0.9	0.4	3.0
23	<i>Cynodon dactylon</i> L.	Grass	Poaceae	Perennial	14.3	2.9	5.9	1.7	0.6	0.4	2.7
24	<i>Ipomoea aquatica</i> Forsk.	Broadleaf	Convolvulaceae	Annual	14.3	2.9	2.1	1.7	0.6	0.1	2.5
25	<i>Hibiscus trionum</i> L.	Broadleaf	Malvaceae	Perennial	14.3	2.9	1.0	1.7	0.6	0.1	2.4

Madibila Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (plants/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Paspalum scrobiculatum</i>	Grass	Poaceae	Perennial	100.0	67.1	46.1	9.1	12.4	22.8	44.2
2	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	85.7	48.6	36.0	7.8	8.9	15.3	32.0
3	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	85.7	51.4	22.9	7.8	9.5	9.7	27.0
4	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	57.1	32.9	9.4	11.7	6.1	6.0	23.7
5	<i>Alopecurus myosuroides</i>	Grass	Poaceae	Annual	71.4	41.4	13.4	6.5	7.6	4.7	18.9
6	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	57.1	32.9	18.2	5.2	6.1	5.1	16.4
7	<i>Laptochloa chinensis</i> L.	Grass	poaceae	Perennial	57.1	30.0	18.2	5.2	5.5	5.1	15.9
8	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	57.1	22.9	20.7	5.2	4.2	5.9	15.3
9	<i>Commelina benghalensis</i>	Broadleaf	Commelinaceae	Annual	57.1	30.0	16.1	5.2	5.5	4.5	15.3
10	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	57.1	27.1	15.5	5.2	5.0	4.4	14.6
11	<i>Rottboellia cochinchinensis</i>	Grass	Poaceae	Annual	42.9	27.1	13.8	3.9	5.0	2.9	11.8
12	<i>Lactuca serriola</i> L.	Broadleaf	Asteraceae	Annual	42.9	15.7	7.0	3.9	2.9	1.5	8.3
13	<i>Physalis minima</i> L.	Broadleaf	Solanaceae	Annual	42.9	15.7	4.7	3.9	2.9	1.0	7.8
14	<i>Ipomoea aquatica</i> Forsk.	Broadleaf	Convolvulaceae	Annual	28.6	22.9	5.6	2.6	4.2	0.8	7.6
15	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	28.6	15.7	14.1	2.6	2.9	2.0	7.5
16	<i>Cynodon dactylon</i> L.	Grass	Poaceae	Perennial	28.6	15.7	12.1	2.6	2.9	1.7	7.2
17	<i>Eleusine indica</i> L.	Grass	Poaceae	Annual	28.6	10.0	10.2	2.6	1.8	1.4	5.9
18	<i>Corchorus aestuans</i> L.	Broadleaf	Tiliaceae	Annual	28.6	10.0	6.7	2.6	1.8	0.9	5.4
19	<i>Galinsoga parviflora</i> Cav.	Broadleaf	Asteraceae	Annual	14.3	7.1	26.9	1.3	1.3	1.9	4.5
20	<i>Brachiaria erusiformis</i>	Grass	Poaceae	Annual	14.3	4.3	10.1	1.3	0.8	0.7	2.8
21	<i>Bidens pilosa</i> L.	Broadleaf	Asteraceae	Annual	14.3	4.3	10.6	1.3	0.8	0.7	2.8
22	<i>Cassia tora</i> L.	Broadleaf	Fabaceae	Annual	14.3	5.7	5.9	1.3	1.1	0.4	2.8
23	<i>Sphenoclea zeylanica</i>	Broadleaf	Sphenocleaceae	Annual	14.3	4.3	6.1	1.3	0.8	0.4	2.5

Usangule A Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (plants/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	100.0	71.4	61.4	13.5	19.6	34.3	67.4
2	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	100.0	62.9	46.6	13.5	17.3	26.0	56.7
3	<i>Fimbristylis miliacea</i>	Sedge	Cyperaceae	Perennial	85.7	41.4	24.0	11.5	11.4	11.5	34.4
4	<i>Cyperus rotundus</i>	Sedge	Cyperaceae	Perennial	57.1	27.1	6.2	15.4	7.5	4.0	26.8
5	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	71.4	34.3	14.8	9.6	9.4	5.9	24.9
6	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	42.9	27.1	20.8	5.8	7.5	5.0	18.2
7	<i>Corchorus aestuans</i>	Broadleaf	Tiliaceae	Annual	42.9	27.1	10.2	5.8	7.5	2.5	15.7
8	<i>Rottboellia cochinchinensis</i>	Grass	Poaceae	Annual	57.1	12.9	8.1	7.7	3.5	2.6	13.8
9	<i>Oryza longistaminata</i>	Grass	Poaceae	Perennial	28.6	15.7	15.1	3.8	4.3	2.4	10.6
10	<i>Ipomoea aquatica</i>	Broadleaf	Convolvulaceae	Annual	28.6	14.3	4.0	3.8	3.9	0.6	8.4
11	<i>Laptochloa chinensis</i>	Grass	poaceae	Perennial	14.3	8.6	26.0	1.9	2.4	2.1	6.4
12	<i>Hibiscus trionum</i> L.	Broadleaf	Malvaceae	Perennial	14.3	7.1	6.0	1.9	2.0	0.5	4.4
13	<i>Cynodon dactylon</i> L.	Grass	Poaceae	Perennial	14.3	5.7	10.0	1.9	1.6	0.8	4.3
14	<i>Galinsoga parviflora</i>	Broadleaf	Asteraceae	Annual	14.3	4.3	11.4	1.9	1.2	0.9	4.0
15	<i>Stenotaphrum secundatum</i>	Grass	Poaceae	Perennial	14.3	4.3	11.6	1.9	1.2	0.9	4.0

Kiswago Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	density (nu. Plant/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	100.0	72.9	57.6	7.4	12.3	28.9	48.6
2	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	71.4	42.9	25.4	5.3	7.2	9.1	21.7
3	<i>Laptochloa chinensis</i> L.	Grass	poaceae	Perennial	71.4	40.0	20.7	5.3	6.8	7.4	19.5
4	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	57.1	38.6	26.2	4.3	6.5	7.5	18.3
5	<i>Eleusine indica</i> L.	Grass	Poaceae	Annual	85.7	27.1	10.5	6.4	4.6	4.5	15.5
6	<i>Rottboellia cochinchinensis</i>	Grass	Poaceae	Annual	71.4	28.6	13.3	5.3	4.8	4.8	14.9
7	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	57.1	28.6	16.2	4.3	4.8	4.6	13.7
8	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	57.1	28.6	13.1	4.3	4.8	3.7	12.8
9	<i>Physalis minima</i> L.	Broadleaf	Solanaceae	Annual	71.4	30.0	6.1	5.3	5.1	2.2	12.6
10	<i>Carex stipata</i> Muhl.	Sedge	Cyperaceae	Perennial	57.1	30.0	6.8	4.3	5.1	2.0	11.3
11	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	42.9	18.6	16.5	3.2	3.1	3.5	9.9
12	<i>Alopecurus myosuroides</i>	Grass	Poaceae	Annual	57.1	18.6	5.8	4.3	3.1	1.7	9.1
13	<i>Ipomoea aquatica</i> Forsk.	Broadleaf	Convolvulaceae	Annual	42.9	27.1	4.9	3.2	4.6	1.0	8.8
14	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	42.9	17.1	12.7	3.2	2.9	2.7	8.8
15	<i>Corchorus aestuans</i> L.	Broadleaf	Tiliaceae	Annual	42.9	24.3	7.1	3.2	4.1	1.5	8.8
16	<i>Sphenoclea zeylanica</i>	Broadleaf	Sphenocleaceae	Annual	57.1	18.6	2.7	4.3	3.1	0.8	8.2
17	<i>Brachiaria erusiformis</i>	Grass	Poaceae	Annual	42.9	10.0	12.8	3.2	1.7	2.7	7.6
18	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	42.9	12.9	9.1	3.2	2.2	2.0	7.3
19	<i>Hibiscus trionum</i> L.	Broadleaf	Malvaceae	Perennial	42.9	14.3	5.8	3.2	2.4	1.2	6.8
20	<i>Phyllanthus niruri</i> L.	Broadleaf	Euphorbiaceae	Annual	28.6	12.9	10.8	2.1	2.2	1.5	5.8
21	<i>Melochia corchirifolia</i> L.	Broadleaf	Malvaceae	Annual	42.9	10.0	4.2	3.2	1.7	0.9	5.8
22	<i>Tridax procumbens</i> L.	Broadleaf	Asteraceae	Annual	42.9	7.1	5.2	3.2	1.2	1.1	5.5
23	<i>Cassia tora</i> L.	Broadleaf	Fabaceae	Annual	28.6	8.6	5.6	2.1	1.4	0.8	4.4
24	<i>Gallinsoga parviflora</i> Cav.	Broadleaf	Asteraceae	Annual	14.3	8.6	21.1	1.1	1.4	1.5	4.0
25	<i>Stenotaphrum secundatum</i> (Walter)	Grass	Poaceae	Perennial	14.3	4.3	14.6	1.1	0.7	1.0	2.8
26	<i>Commelina benghalensis</i>	Broadleaf	Commelinaceae	Annual	14.3	4.3	6.4	1.1	0.7	0.5	2.2
27	<i>Trichodesma zeylanicum</i>	Broadleaf	Boraginaceae	Annual	14.3	2.9	4.0	1.1	0.5	0.3	1.8
28	<i>Sorghum leiocladum</i> Hack.	Grass	Poaceae	Perennial	14.3	2.9	3.3	1.1	0.5	0.2	1.8

29 *Bidens pilosa* L. Broadleaf Asteraceae Annual 14.3 1.4 4.0 1.1 0.2 0.3 1.6

Igawa Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (nu. Plant/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	100.0	58.6	17.5	10.0	11.3	11.8	33.1
2	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	85.7	55.7	23.7	8.6	10.7	13.7	33.0
3	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	85.7	50.0	19.4	8.6	9.6	11.2	29.4
4	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	85.7	44.3	15.0	8.6	8.5	8.7	25.8
5	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	71.4	42.9	21.7	7.1	8.2	10.4	25.8
6	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	71.4	34.3	19.3	7.1	6.6	9.3	23.0
7	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	71.4	38.6	14.9	7.1	7.4	7.2	21.8
8	<i>Physalis minima</i> L.	Broadleaf	Solanaceae	Annual	71.4	35.7	11.7	7.1	6.9	5.6	19.7
9	<i>Ipomoea aquatica</i> Forsk.	Broadleaf	Convolvulaceae	Annual	57.1	32.9	6.5	5.7	6.3	2.5	14.6
10	<i>Hackelechloa granularis</i> L.	Grass	Poaceae	Annual	57.1	22.9	10.2	5.7	4.4	3.9	14.0
11	<i>Rottboellia cochinchinensis</i>	Grass	Poaceae	Annual	42.9	22.9	12.9	4.3	4.4	3.7	12.4
12	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	42.9	24.3	8.5	4.3	4.7	2.5	11.4
13	<i>Commelina benghalensis</i>	Broadleaf	Commelinaceae	Annual	42.9	18.6	8.0	4.3	3.6	2.3	10.2
14	<i>Stenotaphrum secundatum</i>	Grass	Poaceae	Perennial	28.6	14.3	16.1	2.9	2.7	3.1	8.7
15	<i>Alopecurus myosuroides</i> L.	Grass	Poaceae	Annual	14.3	5.7	9.6	1.4	1.1	0.9	3.5
16	<i>Laptochloa chinensis</i> L.	Grass	poaceae	Perennial	14.3	5.7	8.7	1.4	1.1	0.8	3.4
17	<i>Phyllanthus niruri</i> L.	Broadleaf	Euphorbiaceae	Annual	14.3	4.3	7.3	1.4	0.8	0.7	3.0
18	<i>Cynodon dactylon</i> L.	Grass	Poaceae	Perennial	14.3	2.9	6.0	1.4	0.5	0.6	2.6
19	<i>Bidens pilosa</i> L.	Broadleaf	Asteraceae	Annual	14.3	2.9	4.7	1.4	0.5	0.5	2.4
20	<i>Tridax procumbens</i> L.	Broadleaf	Asteraceae	Annual	14.3	2.9	3.9	1.4	0.5	0.4	2.4

Makerere Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (plants/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Ageratum conyzoides</i>	Broadleaf	Asteraceae	Annual	100.0	60.0	13.7	8.9	11.3	9.8	29.9
2	<i>Oryza longistaminata</i>	Grass	Poaceae	Perennial	100.0	51.4	15.6	8.9	9.7	11.1	29.6
3	<i>Mimosa pudica</i> L.	Broadleaf	Fabaceae	Perennial	100.0	55.7	10.9	8.9	10.5	7.8	27.1
4	<i>Fimbristylis miliacea</i>	Sedge	Cyperaceae	Perennial	85.7	40.0	19.0	7.6	7.5	11.7	26.8
5	<i>Cyperus rotundus</i>	Sedge	Cyperaceae	Perennial	85.7	45.7	9.6	7.6	8.6	5.9	22.1
6	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	57.1	31.4	20.5	5.1	5.9	8.4	19.4
7	<i>Hackelelochloa granularis</i> L.	Grass	Poaceae	Annual	71.4	32.9	13.6	6.3	6.2	7.0	19.4
8	<i>Commelina benghalensis</i> L.	Broadleaf	Commelinaceae	Annual	71.4	30.0	10.1	6.3	5.6	5.2	17.1
9	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	42.9	24.3	21.2	3.8	4.6	6.5	14.9
10	<i>Physalis minima</i> L.	Broadleaf	Solanaceae	Annual	57.1	25.7	7.8	5.1	4.8	3.2	13.1
11	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	42.9	21.4	15.4	3.8	4.0	4.7	12.6
12	<i>Alopecurus myosuroides</i> L.	Grass	Poaceae	Annual	28.6	15.7	14.9	2.5	2.9	3.1	8.5
13	<i>Eleusine indica</i> L.	Grass	Poaceae	Annual	42.9	8.6	7.9	3.8	1.6	2.4	7.8
14	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	28.6	14.3	11.1	2.5	2.7	2.3	7.5
15	<i>Laptochloa chinensis</i>	Grass	poaceae	Perennial	28.6	11.4	9.2	2.5	2.1	1.9	6.6
16	<i>Bidens pilosa</i> L.	Broadleaf	Asteraceae	Annual	28.6	10.0	10.3	2.5	1.9	2.1	6.5
17	<i>Tridax procumbens</i>	Broadleaf	Asteraceae	Annual	28.6	11.4	5.4	2.5	2.1	1.1	5.8
18	<i>Sphenoclea zeylanica</i>	Broadleaf	Sphenocleaceae	Annual	28.6	8.6	3.2	2.5	1.6	0.7	4.8
19	<i>Stenotaphrum secundatum</i>	Grass	Poaceae	Perennial	14.3	5.7	12.9	1.3	1.1	1.3	3.7
20	<i>Galinsoga parviflora</i>	Broadleaf	Asteraceae	Annual	14.3	5.7	12.1	1.3	1.1	1.2	3.6
21	<i>Ipomoea aquatica</i>	Broadleaf	Convolvulaceae	Annual	14.3	8.6	3.3	1.3	1.6	0.3	3.2
22	<i>Hibiscus trionum</i> L.	Broadleaf	Malvaceae	Perennial	14.3	4.3	8.0	1.3	0.8	0.8	2.9
23	<i>Cynodon dactylon</i> L.	Grass	Poaceae	Perennial	14.3	2.9	7.7	1.3	0.5	0.8	2.6
24	<i>Sorghum leiocladum</i>	Grass	Poaceae	Perennial	14.3	4.3	4.6	1.3	0.8	0.5	2.5
25	<i>Phyllanthus niruri</i> L.	Broadleaf	Euphorbiaceae	Annual	14.3	2.9	3.6	1.3	0.5	0.4	2.2

Biro Village

SN	Weed species	Type	Family	Lifecycle	Freq uenc y(%)	Unifor mity (%)	Density (plants/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	100.0	55.7	16.1	14.0	15.3	15.9	45.2
2	<i>Physalis</i> sp	Broadleaf	Solanaceae	Annual	85.7	51.4	10.7	12.0	14.1	9.0	35.2
3	<i>Lapochloa chinensis</i> L.	Grass	poaceae	Perennial	57.1	32.9	13.4	8.0	9.0	7.6	24.6
4	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	57.1	27.1	14.5	8.0	7.5	8.2	23.6
5	<i>Rottboellia cochinchinensis</i>	Grass	Poaceae	Annual	57.1	24.3	10.9	8.0	6.7	6.2	20.8
6	<i>Paspalum scrobiculatum</i> L.	Grass	Poaceae	Perennial	42.9	22.9	18.5	6.0	6.3	7.8	20.1
7	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	42.9	22.9	17.4	6.0	6.3	7.4	19.6
8	<i>Stenotaphrum secundatum</i>	Grass	Poaceae	Perennial	42.9	20.0	16.3	6.0	5.5	6.9	18.4
9	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	28.6	15.7	21.8	4.0	4.3	6.2	14.5
10	<i>Trichodesma zeylanicum</i>	Broadleaf	Boraginaceae	Annual	42.9	14.3	9.8	6.0	3.9	4.1	14.1
11	<i>Ischaemum rugosum</i> Salsb.	Grass	poaceae	Perennial	28.6	15.7	18.9	4.0	4.3	5.4	13.7
12	<i>Phyllanthus niruri</i> L.	Broadleaf	Euphorbiaceae	Annual	28.6	17.1	16.4	4.0	4.7	4.6	13.3
13	<i>Galinsoga parviflora</i> Cav.	Broadleaf	Asteraceae	Annual	28.6	12.9	13.4	4.0	3.5	3.8	11.3
14	<i>Alopecurus myosuroides</i> L.	Grass	Poaceae	Annual	14.3	8.6	17.3	2.0	2.4	2.4	6.8
15	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	14.3	8.6	10.4	2.0	2.4	1.5	5.8
16	<i>Commelina benghalensis</i> L.	Broadleaf	Commelinaceae	Annual	14.3	7.1	8.6	2.0	2.0	1.2	5.2
17	<i>Ipomoea aquatica</i> Forsk.	Broadleaf	Convolvulaceae	Annual	14.3	4.3	5.7	2.0	1.2	0.8	4.0
18	<i>Carex stipata</i> Muhl.	Sedge	Cyperaceae	Perennial	14.3	2.9	7.0	2.0	0.8	1.0	3.8

Mabanda Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (plant/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	85.7	48.6	27.1	12.5	13.0	19.9	45.5
2	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	85.7	52.9	22.6	12.5	14.2	16.6	43.3
3	<i>Alopecurus myosuroides</i>	Grass	Poaceae	Annual	85.7	47.1	17.5	12.5	12.6	12.9	38.0
4	<i>Paspalum scrobiculatum</i>	Grass	Poaceae	Perennial	57.1	40.0	20.9	8.3	10.7	10.2	29.3
5	<i>Paspalum dilatatum</i> Poir	Grass	Poaceae	Perennial	71.4	34.3	14.5	10.4	9.2	8.9	28.5
6	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	57.1	32.9	20.2	8.3	8.8	9.9	27.0
7	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	42.9	28.6	6.9	6.3	7.7	2.5	16.5
8	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	28.6	17.1	16.9	4.2	4.6	4.1	12.9
9	<i>Laptochloa chinensis</i> L.	Grass	poaceae	Perennial	28.6	15.7	15.6	4.2	4.2	3.8	12.2
10	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	28.6	15.7	13.7	4.2	4.2	3.4	11.7
11	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	28.6	12.9	12.3	4.2	3.4	3.0	10.6
12	<i>Eleusine indica</i> L.	Grass	Poaceae	Annual	14.3	5.7	15.3	2.1	1.5	1.9	5.5
13	<i>Brachiaria erusiformis</i>	Grass	Poaceae	Annual	14.3	5.7	10.1	2.1	1.5	1.2	4.9
14	<i>Physalis minima</i> L.	Broadleaf	Solanaceae	Annual	14.3	5.7	4.3	2.1	1.5	0.5	4.1
15	<i>Sphenoclea zeylanica</i>	Broadleaf	Sphenocleaceae	Annual	14.3	4.3	6.0	2.1	1.1	0.7	4.0
16	<i>Melochia corchirifolia</i> L.	Broadleaf	Malvaceae	Annual	14.3	4.3	3.0	2.1	1.1	0.4	3.6
17	<i>Mimosa pudica</i> L.	Broadleaf	Fabaceae	Perennial	14.3	1.4	0.0	2.1	0.4	0.0	2.5

Kilosa mpepo Village

SN	Weed species	Type	Family	Lifecycle	Frequency (%)	Uniformity (%)	Density (plants/m ²)	Relative frequency (%)	Relative uniformity (%)	Relative density (%)	Relative abundance (%)
1	<i>Fimbristylis miliacea</i> L.	Sedge	Cyperaceae	Perennial	71.4	40.0	21.3	9.8	10.9	14.8	35.5
2	<i>Stenotaphrum secundatum</i>	Grass	Poaceae	Perennial	71.4	40.0	13.8	9.8	10.9	9.6	30.3
3	<i>Ischaemum rugosum</i>	Grass	poaceae	Perennial	57.1	34.3	20.6	7.8	9.3	11.5	28.7
4	<i>Ageratum conyzoides</i> L.	Broadleaf	Asteraceae	Annual	71.4	37.1	12.4	9.8	10.1	8.6	28.6
5	<i>Paspalum scrobiculatum</i>	Grass	Poaceae	Perennial	42.9	31.4	25.3	5.9	8.6	10.6	25.0
6	<i>Echinochloa colona</i> L.	Grass	Poaceae	Perennial	57.1	30.0	15.9	7.8	8.2	8.8	24.9
7	<i>Physalis minima</i> L.	Broadleaf	Solanaceae	Annual	71.4	30.0	9.6	9.8	8.2	6.7	24.7
8	<i>Oryza longistaminata</i> L.	Grass	Poaceae	Perennial	42.9	20.0	16.3	5.9	5.4	6.8	18.1
9	<i>Lapochloa chinensis</i> L.	Grass	poaceae	Perennial	42.9	21.4	12.2	5.9	5.8	5.1	16.8
10	<i>Galinsoga parviflora</i>	Broadleaf	Asteraceae	Annual	28.6	15.7	14.4	3.9	4.3	4.0	12.2
11	<i>Leersia hexandra</i> Sw.	Grass	poaceae	Perennial	28.6	15.7	12.1	3.9	4.3	3.4	11.6
12	<i>Rottboellia cochinchinensis</i>	Grass	Poaceae	Annual	28.6	14.3	11.8	3.9	3.9	3.3	11.1
13	<i>Cyperus rotundus</i> L.	Sedge	Cyperaceae	Perennial	28.6	15.7	6.9	3.9	4.3	1.9	10.1
14	<i>Commelina benghalensis</i>	Broadleaf	Commelinaceae	Annual	14.3	7.1	10.9	2.0	1.9	1.5	5.4
15	<i>Alopecurus myosuroides</i>	Grass	Poaceae	Annual	14.3	4.3	7.4	2.0	1.2	1.0	4.2
16	<i>Phyllanthus niruri</i> L.	Broadleaf	Euphorbiaceae	Annual	14.3	4.3	3.4	2.0	1.2	0.5	3.6
17	<i>Carex stipata</i> Muhl.	Sedge	Cyperaceae	Perennial	14.3	2.9	3.4	2.0	0.8	0.5	3.2
18	<i>Corchorus aestuans</i> L.	Broadleaf	Tiliaceae	Annual	14.3	1.4	2.9	2.0	0.4	0.4	2.7
19	<i>Hibiscus trionum</i> L.	Broadleaf	Malvaceae	Perennial	14.3	1.4	2.4	2.0	0.4	0.3	2.7



KUHUSU TASNIFU HII

Magugu ni sababu kubwa ya kupunguza tija ya uzalishaji wa zao la mpunga Wilayani Malinyi Mkoa wa Morogoro. Utafiti huu ulijikita katika kutambua magugu na idadi ya palizi katika zao la mpunga. Aina 35 za magugu yametambuliwa na yanayopatikana kwa wingi ni *Paspalum scrobiculatum* na *Ischaemum rugosum*. Aina za mpunga zilizotumika ni Mbawambili, Karimata, Kisegesi na SARO 5. Karimata ilitoa mavuno makubwa zaidi (2.92 tani/hekta) na upotevu mdogo uliosababishwa na magugu (39.54%) lakini SARO 5 ilitoa mavuno madogo zaidi (1.77 tani/hekta) na upotevu mkubwa uliosababishwa na magugu (63.84%). Palizi zilizofanyika ni bila palizi, palizi 1, palizi 2, palizi 3 na palizi 4. Palizi 2, 3 na 4 zilitoa mavuno makubwa yanayokaribiana (tani 2.59, 2.65 na 2.74 tani/hekta).

Hivyo basi palizi mbili (siku ya 15 na 45 baada ya mpunga kuota) inashauriwa kutumika ili kudhibiti magugu na kuongeza mavuno. Utafiti zaidi unahitajika ili kuthibitisha matokeo haya.