DIVERSITY OF WEED AND THEIR INTEGRATED MANAGEMENT PRACTICES IN PADDY RICE (*Oryza sativa*) PRODUCTION

BY

KOSKEI KIPNGETICH VINCENT
(BSc. BIOCHEMISTRY AND MOLECULAR BIOLOGY)

THESIS SUBMITTED IN PARTIAL FULFILLMENT FOR THE DEGREE OF MASTER OF SCIENCE IN CROP PROTECTION

DEPARTMENT OF PLANT SCIENCE AND CROP PROTECTION

FACULTY OF AGRICULTURE
UNIVERSITY OF NAIROBI.

2016

DECLARATION

This thesis is my original work, and has not been presented for award of any degree or diploma in any other university.

Koskei Kipngetich Vincent

Signature……………………………. Date…………………………………

This thesis was submitted with our approval as university supervisors.

Professor Ratemo Waya Michieka

Signature……………………………… Date……………………………………
DEPARTMENT OF PLANT SCIENCE AND CROP PROTECTION
UNIVERSITY OF NAIROBI

Professor Emmanuel Safary Ariga

Signature………………………………… Date……………………………………
DEPARTMENT OF PLANT SCIENCE AND CROP PROTECTION
UNIVERSITY OF NAIROBI

Doctor Raphael Kinyanjui Wanjogu

Signature………………………………… Date……………………………………
RESEARCH AND DEVELOPMENT DEPARTMENT
NATIONAL IRRIGATION BOARD

DEDICATION

To my family for their endless prayers, support and encouragement throughout the period of this study

ACKNOWLEDGEMENT

I acknowledge the contributions of those who made the writing of this thesis a success. I am grateful to my supervisors Prof' R. Michieka, Prof' S. Ariga and Dr. R. Wanjogu for their academic support throughout this study period and writing of this thesis. My sincere appreciation goes to management and staff of National Irrigation Board (Mwea Irrigation Agricultural development center) for their technical and financial support. The University of Nairobi in guiding me and ensuring academic path that I charted was of enormous impact. My sincere thanks go to all respondents who co-operated and were willing to provide valuable information. I may not name all of you but effort put across by those who helped in data collection to build my experiment, those who traversed with me across the expansive scheme to carry out weed survey I sincerely salute you. To the leadership of farmer organization across the scheme your valuable information and guidance on the expansive scheme was timely and very indispensable. Above all I thank the almighty God for the protection and providence that ensured I was able to further my studies.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CARD	Coalition for African Rice Development
DAT	Days after Transplanting
DAP	Di-ammonium Phosphate
EG	Empty Grains
FG	Filled Grains
GDP	Gross Domestic Product
GIZ	German Technical Cooperation
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
KALRO	Kenya Agricultural Livestock Research Organization
MC	Moisture Content
MIAD	Mwea Irrigation Agricultural Development Centre
MIS	Mwea Irrigation Scheme
MoALF	Ministry of Agriculture Livestock and Fisheries
NPT	Non Productive Tillers
NIB	National Irrigation Board
NRDS	National Rice Development Strategy
PH	Plant Height
PI	Panicle Initiation
PT	Productive Tillers
RCBD	Randomized Complete Block Design
SA	Sulphate of Ammonium
SPAD	Soil Plant Analysis Development
SRI	System of Rice Intensification
TN	Tiller Number

GENERAL ABSTRACT

Weed has become a major threat in rice cultivation and its effects continue to cause enormous yield, quality and quantity loss. The above has over time been a major concern for a rice farmer since the advent of agriculture not to mention the potential danger weeds being hosts to many opportunistic rice diseases. Most practices employed by farmers to eliminate these weeds in lowland rice ecology have proved to be unsuccessful. Farmers in some instances, allow weeds to reduce huge portion of the crop through deprivation of nutrients, moisture content, resting place for insect pests and diseases and acting as a cover crop in relatively few instance among others.

This trial was conducted at Mwea Irrigation Agricultural Development Centre through a field experiment. The experiment was done for two consecutive seasons of 2013-2014 while a survey to evaluate the diversity of weeds in the expansive scheme was achieved during the off season of 2015. In this study the effect of lowland paddy field weeds on rice crop establishment and corresponding integrated weed management strategies employed were evaluated and compared with regard to major weeds within the scheme. These weeds included the grass family, broad leaf and the sedges. Barn yard grass (*E. Crus-galli* L.), Red sprangletop (*Leptochlo chinensis* L.)., Umbrella sedge *(Cyperus difformis spp* L.) and Monochoria *(Monochoria vaginalis* Burm.f) among others were found to be the most problematic in rice production.

The outcome of the trial became clear that weeds reduce up to 30% of rice crop yield per unit area. Farmer practice in weed management also became evident is enough to give significantly ($P<0.05$) optimum yield of rice produced per unit area. Common practice by these farmers of weeding twice by hand and a spot weeding at maturity stage per cropping season is costly and time consuming. Chemical weed control done for each of the three varieties suggests a quicker option and less expensive way to achieve same results. The two methods of weed management in irrigated rice cultivation need further evaluation to determine economic and environmental effect. The lower tillering variety Basmati 370 performed better with contact type of weed control chemical (herbicide) application while high tillering varieties of BW 196 and IR 2793-80-1 showed preference of systemic herbicide application to manage weeds.

Diversity of weeds in paddy fields indicated the extent at which these weeds have covered per species and an inventory of these species. Survey done across the expansive scheme indicated that there are 17 major weeds with presence from the upper part of the scheme down to the lower areas which experience perennial water shortage. The survey to determine this diversity was done during long rains of 2015 when the scheme is mixed with activities with some areas either having a main crop/ratoon/left fallow. Their frequency being the percentage of the total number of fields surveyed in which a species occurred in at least one quadrate showed *Eclipta prostrata* (False daisy) at a score of 16% being least present while *Cyperus difformis* (Small Flower umbrella nut-sedge) at 100% presence in every quadrate. Recommendation of best practices to manage weeds of paddy field should start at land preparation as shown in the diversity of these weeds that some of them are carried over during off season to the main season. The study therefore opens up more work to be done in the scheme to determine both phenotypic and genotypic variation of major lowland paddy field weeds in Mwea.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

The Agriculture sector is plays a vital role in the Kenyan economy as a result of concerted effort from all the players. The Government and relevant Stakeholders dedicates valuable time and resource to enhance crop production. With this therefore, the sector is contributing up to 24% into the gross domestic product (Ministry of Agriculture 2008). Rice (*Oryza sativa*) cultivation was introduced in Kenya in 1907 from South and Southeast Asia between northern India and northern Vietnam. While *Oryza glaberrima* is a species with an origin from the Niger River basin (Matsunaka, 1983).Over time the crop has risen to be the third most important cereal crop after maize and wheat in the country. Rice in Kenya is grown mainly by small-scale farmers as both commercial and subsistence crop (National Irrigation Board, 2008).

Mwea, Ahero, west Kano and Bunyalla public irrigation schemes are responsible for production of this key cereal crop. Private large scale rice growing is also taking place in Yala swamp in Siaya county as well as the many private farmers who are currently being promoted by the ministry of agriculture to grow upland rice. This therefore results in slightly above 95% of rice produced in the country grown under flood irrigation in these schemes. Meanwhile the remaining 5% is produced under rain-fed from private farmers and companies across the country (Ministry of Agriculture, 2008). This has therefore leaded to rise in national rice production over the last ten years from 40,000 to the current 110, 000 metric tons annually (National Irrigation Board, 2010).

Consumption of rice in Kenya is estimated to be between 10-18 kg per capita per year, this though is lower in rural settlements compared to urban areas. However, it has been established that this consumption by the rural population has been rising steadily (Africa Rice, 2013). With this annual rice consumption is increasing at the rate of 12 % compared to 4% and1% for wheat and maize respectively (Ministry of Agriculture, 2008). These changes are attributed to change in eating habits by the population. Promotion of rice production and consumption in Kenya will help reduce over-reliance on maize as a staple food hence improve households' incomes and food security.

Cultivation of this crop is faced with broad constraints including high cost of agricultural inputs, imports of cheaper finished products, shortage of irrigation water, emerging pest and diseases among others. Global Rice Details show that the crop is planted in 157,000,000 hectares in the world yielding approximately 650,000,000 metric tons (Tsuboi, 2011). Statistics show that rice is eaten by half of the world's population as staple food and can do well as a crop up to an altitude of 2400m above sea level as what has been experienced in Himalayas (Tsuboi, 2011). Paddy rice cultivation by environment falls into upland rice, rain-fed lowland rice, irrigated lowland rice, Deep water rice and Floating rice.

1.2 Statement of the Problem

Rice cultivation is limited to certain agro-ecological areas in the country despite the fact that it is one of the oldest cereal crops. Annual consumption of 300,000 metric tons is partly met by importation from Asian countries. This imported milled rice deprives the economy of up to 8 billion Kenya shillings (National Irrigation Board, 2010). Increase in local production therefore is very important if this foreign exchange is anything to go by. However production per unit area is impeded partly by among others, weeds of paddy rice. Overtime, rice farmers in the country have always believed that diversity of this weeds and their impact to influence optimum yield per unit area is secondary and requires no attention.

Mwea irrigation scheme farmers have always been forced to leave their paddy fields without any crop during off season from early January to late April. The reason for this break has always been insufficiency of irrigation water. Also scheme farmers avoid a crop at productive stage during the cold June period. This single farming system therefore encourages weed establishment during this fallow window which undergoes full cycle. During the main season beginning July, weed seeds break dormancy and start to geminate together with crop (National Irrigation Board, 2008). Ratoon (re-growth of main crop that has been harvested) farmers; also enhances performance of these weeds during the main season. Weed management practices employed is important and play a crucial role in determining good crop (Rodenburg *et al*, 2013).

Weeds are most efficiently and economically controlled by the simultaneous application of various practices which include preventive, cultural, manual, mechanical, biological and chemical. Integrated weed management practices (I.W.M) combines some of these different practices for efficient and environmentally friendly results (Sreelatha, 2013). The intention of integrated weed management practices was to create agro-ecological zone conditions which are unfavorable to weeds while maintaining suitable condition for crop. At the same time an inventory of weeds in paddy field set up was studied and documented complete with weed species.

The current practice for weed management in lowland paddy fields is a single wet rotavation, three hand puddling at pre-transplanting to burry sprouting weeds and leveling of puddled soil. There are up to three (3) hand-weeding during crop management phase as per the practice in the scheme. Rice belongs to the *Graminae* family which coincidentally resembles some of the major grass weeds in paddy field. For instance Basmati rice variety morphologically resembles barn yard grass *(Echnocloa ssp*) weeds during vegetative stage (Rao et al, 2007). Labour is not only scarce but also expensive as it costs not less than USD 45/= per acre for one set of hand weeding/pulling (Wanjogu et al 2011). Under the stated circumstances, it is prudent to study the effects of weeds in lowland rice production and consider alternative ways for management currently in place. Weed infestation primarily constrains rice production by reducing grain yield and this has been estimated to be from 44% to 96%, depending on the rice culture (Kwesi *et al*, 1991).

1.3 Overall Objective

To determine major weeds in paddy fields that compromises rice yield and recommend appropriate integrated weed management practices.

1.3.1 Specific Objectives

i. To determine weed species and their diversity in lowland rice production ecosystem
ii. To determine effective integrated weed management practice in lowland rice.

CHAPTER TWO: LITERATURE REVIEW

2.1 Effects of weeds on Rice

Rice is a weak competitor against weeds and the majority of African farmers have few options and resources available for effective weed control. Lowland weeds are well adapted to the aquatic environment, capable of rapid growth and multiplication (Rodenburg *et al*, 2013). The similarity of some weeds to rice, such as *Echinochloa* spp. at early stages of growth, makes it very difficult for farmers to distinguish. These weeds compete for rice crop nutrition, light, space and in some major instances are carriers for diseases like rice blast disease (*Pyricularia oryzae*). Quite a sizeable number of farmers use recycled seed when transplanting and therefore helping aggravate an already worse situation (Ministry of Agriculture, 2008). The distribution to farmers of rice seed contaminated with weed seeds is at least partly to blame for the widespread occurrence of many of the more serious rice weeds.

Introduction of weeds such as *Oryza* species, *Ischaemum rugosum*, *Echinochloa* species, *Rottboelliaco chinchinensis* and *Euphorbia heterophylla* into previously un-infested areas has occurred has been noted (National Irrigation Board, 2010). In lowland rice systems, weed seeds may also spread rapidly in irrigation and flood waters (David, 2009). Weed species that cause problems in rice vary with soil, temperature, latitude, altitude, rice culture, seeding method, water management, fertility level, and weed control technology (Smith, 1981). About 350 species in more than 150 genera and 60 plant families have been reported as weeds of rice in the world (Akobundu *et al*, 1977). Species of *Poaceae* are the most common, with more than 80 reported as weeds of rice. Species of *Cyperaceae* rank next in abundance with more than 50reported as rice weeds. Other families with 10 or more species reported as weeds of rice include *Alismataceae*, *Asteraceae*, *Fabaceae*, *Lythraceae*, and *Scrophulariaceae* (De Datta, 1981).

E. crus-galli L. is the most troublesome weed of rice in the world (Holm et al, 1977). *E.colona* L. is second in importance and tends to grow along the equator while *E. crus-galli* L. has a greater range from north to south. Other rice field weeds of world importance are *C. difformis* L., *C. rotundus* L., *C. iria* L., *E. leusine* L., *F. littoralis* Gaudich, *I. rugosum* Salisb.and *M.vaginalis* C. Presl (Smith, 1983). However, there are many gaps in our knowledge of the crop and weed interactions in relation to the environment and management practice. A better understanding of these interactions would support predictions of likely changes in weed communities. This will also strengthen the development of appropriate and effective knowledge-based technologies as part of an integrated weed management approach (Rao et al, 2007).

2.2 Rice varieties and soils in the Mwea Irrigation Scheme

Basmati 370 is a high quality indica rice variety (long grain, strong aroma, soft texture) was used during the experiment as this is the most popular not only in the area but also has consumer preference. Its aroma and longer grains puts it on a ready market level hence the fact that it is one of the most sought after cereal in the country. Site performance and yield analysis for Basmati 370 is 2.2 tons per acre (Wanjogu et al, 2010). The other varieties will include BW 196 and IR 2793-80-1 which are glutinous, have short grains and are high yielding rice cultivars popularly enjoyed as a subsistence rice crop by farmers in irrigation schemes. BW 196 rice variety yields up to 3.2 tons per acre while IR 2793-80-1 produces 3.0 tons per acre. The three varieties originated from Asia: India, Bangladesh and Philippines respectively (Wanjogu et al 2010).Description of their characteristics is as per the descriptor sourced from the maintainer as shown in table 2.1.

Results of previous studies showed that rice yield loss on systems using intermittent irrigation (SRI) is greater than in conventional system. This was the phenomena because weeds in rice areas were allowed to grow until the harvest (Biswal *et al*, 2013). Loss of rice yield in SRI system (which uses intermittent irrigation) was about 98.02%, while the yield loss in the conventional system was only 74.03%. Therefore, weed control becomes one of the important parts of cultivation that can affect the production of rice plants (Merry *et al*, 2014). Weeds also intensify the pest and disease problem by serving as alternate host. Weeds reduce the efficiency of harvesting, land value not to mention water contamination and yield in transplanted rice by 10-15% reduction in yield (Naipictuasdharwad *et al*, 2009).

Table 1 Irrigated lowland rice varieties descriptor

	CHARACTERISTICS	Basmati 370	BW 196	IR 2793-80-1
1	Leaf colour	Pale green	Dark green	Medium green
2	Flag leaf: Curvature of blade	Medium	Strong	Strong
3	Time of heading (50% of plants with heads)	Early 75 DAT	Late 95 DAT	Medium 95 DAT
4	Stem: Thickness	Thin	Thick	Medium
5	Stem: Length (excluding panicle)	Long	Short	Medium
6	Panicle: Length	Long	Short	Medium
7	Panicle: Curvature of main axis	Weak	Medium	Medium
8	Spikelet: Hairs on Lemma	Absent	Absent	Absent
9	Spikelet: Length of hairs on Lemma	Short	Very short	Very short
10	Spikelet: Colour of tip of lemma	Yellowish	White	Brown
11	Panicle: Length of longest awns	Long	Short	Absent
12	Panicle: Distribution of awns	Whole length	Tips only	None
13	Time of maturity	Early 120 DAT	Late 140 DAT	Medium 140 DAT
14	Grain weight of 1000 fully developed	Medium 25g	High 30g	High 30g
15	Grain: Length	Medium	High	High
16	Grain: Width	Narrow	Broad	Medium
17	Decorticated grain: Length	Long	Short	Medium
18	Decorticated grain: Width	Narrow	Medium	Medium
19	Decorticated grain: Shape (in lateral view)	Half spindle shaped	Semi- rounded	Semi- rounded
20	Decorticated grain: Colour	Light Brown	Light Brown	Light Brown
21	Polished grain: Size of white core	Very small	Large	Medium
22	Endosperms type	Non-Glutinous	Glutinous	Glutinous
23	Maximum tillers	25 (scale–1)	40 (scale–1)	35 (scale–1)
24	Plant height	115cm (5)	90cm (1)	80cm (1)
25	Panicle initial two	35-40 DAT	45-50 DAT	45-50 DAT
26	Leaf attitude	Horizontal(5)	Erect(1)	Erect(1)
27	1st flowering	60 DAT	80 DAT	80 DAT
28	Thresh ability	Moderate(3)	Intermediate	Loose(7)
29	Leaf blade colour	Pale green (1)	Dark green	Green (2)
30	Awn colour & strength	Brown (3)	Absent	Absent
31	Grain colour	Golden Yellow	Dark Brown	Brown
32	Panicle type	Open (9)	Compact (1)	Intermediate (5)
33	Potential yield (Kilograms per acre)	2240	3200	3000

Effect of weeds on crops can be determined by among other factors the yield per unit area, effect on growth parameters as well as coloration of the leaves through soil plant analysis development (SPAD). The chlorophyll meter or SPAD meter is a simple, portable diagnostic tool that measures the greenness or relative chlorophyll content of leaves (Cheryl, 2006). Meter readings are given in Minolta Company-defined SPAD (Soil Plant Analysis Development) values that indicate relative chlorophyll contents. There is a strong linear relationship between SPAD values and leaf nitrogen concentration (Maxwell, 2000).Relationship varies with crop growth stage and/or variety mostly because of leaf thickness or specific leaf weight (Virmani, 1994). The linear relationship between nitrogen and SPAD values has led to the adaptation of the SPAD meter to assess crop nitrogen status and to determine the plant's need for additional nitrogen fertilizer (Cheryl, 2006).

SPAD readings indicate that plant nitrogen status and the amount of nitrogen. The nitrogen to be applied are determined by the physiological requirement of crops at different growth stages (Cheryl,2006).This therefore shows that SPAD meter can be used to predict nitrogen index reliably, it may also be a useful tool for assessing the relative impact of weeds on crops. Recent studies have indicated a close relation between chlorophyll content and leaf nitrogen content (Maxwell, 2000). This made sense because most of the leaf nitrogen is constrained in chlorophyll molecules. Leaf chlorophyll meters (SPAD) have been used as an indirect indicator of plant N status. Use of chlorophyll meters varies with crop type and has been affected by environmental conditions (Virmani, 1994). SPAD chlorophyll meter provides a rapid, nondestructive estimate of relative leaf chlorophyll content and can be used to predict nitrogen nutrition index reliably and a useful tool for assessing the relative impact of weeds on crops (Virmani, 1994).

2.3 Weeds in lowland paddy rice fields

Some of these dreadful weeds which are adapted to lowland ecologies specific for rice growths are; the sedges such as Umbrella sedge (*Cyperus difformis*) L., Rice flat sedge (*Cyperus iria*) L., forked fringe-rush (*Fimbrixstylis spp*.) and Bulrush (*Scripus juncoides)* Roxb (Smith, 1983).The grasses such as Barnyard grass (*E. crus-galli* L.and *E. glaberescens* L.), Wrinkled grass (*Ischaemum rugosum)*Salisb. Sprangletop (*Leptochloa spp*) (Caton *et al*, 2010). Weedy rice (*O. sativa, O. longistaminata* and *O. rufipogon* Griff.*)*.The broad-leaved weeds such as Creeping water primrose (*Ludwigia adscendens* L.), Long-fruited primrose willow (*L. octovalvis* L.*)*, Monochoria (*Monochoria vaginalis*-Burm.f), false daisy (*Eclipta prostrate* L.*)*, Water clover (*M. minuta* L.) and Goose weed (*S. zeylanica* Gaertn.) (Smith, 1983).

2.3.1 Annual grasses (Graminae family)

E. crusgalli L. (Barn yard grass) belongs to *Poacea* Family found mainly during rice crop establishment. This is tufted annual grass with the height of approximately 30- 60 cm. they are thick, coarse, mostly erect smooth and branching at the base. Sessile leaf blades attached to a smooth sheath which encircles the stem in the absence of ligule. The leaf blade is 10-30 cm long and 5-20 mm wide with a prominent midrib (Smith, 1983). The stem is stout while culms branch at the base to produce tillers *E. crusgalli* L. Inflorescence is 10-20 cm long which is slender spike like which lead to a green or purplish panicle. These panicles give rise to densely crowded spikelets in 2-4 rows on each side of the stem. Seeds are light orange yellow in colour whereas root system is adventitious. This species are widely distributed throughout the warm tropics, propagating by means of seeds (Johnson, 2004).

2.3.2 Perennial grass

E. colonum L., just like *E. crusgalli* L., Belongs Poacea family. They are slender perennial grass with height of 60-90 cm. Stem is creeping below and erect above, with rooting at lower nodes making them difficult to weed by hand. Leaf blade is 7.5 to 15 cm long, often marked with purple or almost black cross bands. *E. colonum* L. Lacks ligule and their distribution is like that of barn yard grass as they also propagate using seeds (Caton *et al*, 2010).

Leptochloa chinensis L. Chinese red sprangletop is an aquatic or semi-aquatic tufted annual or perennial grass. They have stout to slender, erect or geniculate culms up to 1.5 m tall, often rooting at the lower nodes. Leaf-sheath is loose, sub-glaucous, smooth, up to 10 cm long, while ligule is a fringed, hairy membrane, 1-2 mm long. Leaf-blade is a linear, up to 50 cm x 1 cm, long-attenuate, flat or folded, scabrid above. Inflorescence 10-60 cm long, composed of numerous slender racemes scattered along an elongate central axis; racemes flexuous, 2-13 cm long, erect or laxly ascending; spikelets 3-7 flowered, narrowly elliptical-oblong, 2-3 mm, sub-sessile, often purplish, disarticulating above the glumes and between the florets; glumes unequal, scabrid on the back of the nerves; lemmas hairy on the nerves, awnless (Johnson, 2004).

Leersia hexandra Sw. Swamp rice grass is also a lowland perennial weed with creeping to ascending growth habit. They are tufted and erect up to 1.2 meters long, thrive well in flooded to wet acquatic conditions. They are seed contaminants controlled by cultural methods like rotavation, puddling in wet and/or dry period. They reproduce by means of either rhizome and/or seeds however seed dormancy is unknown (Caton *et al*, 2010).

2.3.3 Annual broad leaf weeds

Ammannia coccinea Rottb. (red-stem) is a species of flowering plant in the loosestrife family. It is generally found in moist areas, such as riverbanks and pond margins where it is weedy in some areas. This is an annual herb growing erect to heights approaching one meter or lying along the ground. Leaves are linear in shape, up to 8 centimeters long, and green to shades of deep red in color. The inflorescence is a cluster of 3 to 5 flowers growing in the leaf axils along the upper part of the stem. The rounded flower has small rose to lavender petals each a few millimeters long and protruding stamens with yellow anthers. The fruit is a rounded capsule up to half a centimeter wide containing many tiny seeds (Johnson, 2004).

2.3.4 Perennial broad leaf weeds

M. vaginalis C. Presl (Monochoria) is perennial broadleaf weed in *Pontederiaceae* Family. They have short and sub erect root stock while leaves are linear or narrowly ovate with 5 to 15 cm long base. Pedicel is long, flowers in racemes usually blue spotted with red. They propagate using seeds and root stock. Just like *Ammannia coccinea* Rottb., are distributed well in moist places (Johnson, 2004).

L. adscendens (L.) (Creeping water primrose) belongs the family *Onagraceae* which is a perennial herb with a Height - up to 60 cm. Their Leaves are linear or lanceolate; simple, alternate Flowers small, auxiliary, solitary, yellow; calyx tube narrow with 4-6 lobes; corolla 5 lobed; stamens 8-10; ovary inferior,4-5 carpels, 4-5 celled, ovules many in, vertical rows; fruit a capsule smaller, 4 sided, about 2 cm long with persistent calyx at the tip; seeds small, pink. Propagation is through seeds and plant fragments (Caton *et al.* 2010).

2.3.5 Annual sedges

Cyperus difformis L. belong to the *Cyperaceae* family with slender weak plant, and tufted Stem which is 12.5 to37.5 cm long. Their leaves are flaccid, long as the stem; bracts 2-3, 5 to 20 cm long. They also have many spikelet grouped into congested globose heads. Their glumes are obviate, apex rounded, nut being sub-equally trigonous, yellow or pale brown (Caton *et al*, 2010).

Cyperus iria L. (Umbrella sedge) also belong to *Cyperaceae* Family and is widely distributed species in paddy fields. They have 15 to 50 cm high stems, trigonous leaves up to 42.5 cm long; bracts are 3-5 to 25 cm long; spike consists of 5-15 spikelets which are linear, oblong, yellow or pale brown (Caton *et al*, 2010).

2.3.6 Perennial sedges

Bolboschoenus maritimus L. (Bullrush) *Cyperaceae* Family and is rhizomatous plant with rigid Stems, tubers, erect 30-120 cm high. Leaves often are as long as the stem and are up to 10 cm long. Spikelets of this species are 2 to many in umbels; clustered, glumes broadly ovate, brown or golden brown; nut acute, smooth, dark, olive-brown, shining. They propagate using rhizomes (Goldblatt, 2000). The sedge is occasional in brackish water or on the shore. The plant grows up to 120 cm tall. Spikelets are 10-20mm long and can be identified by egg shaped spikelets. Stems are sharply

3 sided while in some instances are winged, much leafier than common club-rush, with long leaves grooved above and keeled below. Inflorescence is often staked dusters of spikelets. They have an upright leaf like bract which appear like a continuation of stem beyond the inflorescence, as well as 2 or 3 smaller bracts at an angle to the stem (Manning, 2000).

C*yperus rotundus* L. (Purple nut sedge) is also in the *Cyperaceae* Family and is one of the world's worst weed. It is swollen and thickened at the base with a triangular smooth scape, 10 to 60 cm in height. The stature is from the center of a basal cluster of narrow grass like leaves of 30-50 cm long and 8 mm wide. Their leaves are smooth shiny, dark green and grooved on the upper surface (Manning, 2000). The slender underground runners grow out from the base of the stem and form series of black, irregular shaped or nearly round tubers which are 2 cm in length. Tubers sprout to produce new plants while still attached to parent plant (Goldblatt, 2000).

The inflorescence arises from stem apex. It consists of a number of slender branches which carries a cluster of spikelets at the end which are brown to dark brown in color. Each spikelet consists of 10-30 small crowded florets which ripen to form black triangular nuts (Goldblatt, 2000). The rhizomes give rise to underground tubers which proliferates intensively. Tubers are concentrated in the surface 10 cm soil and store food and are effective means of propagation (Manning, 2000). New tubers are produced within 3 weeks after sprouting of individual tuber. Tubers have nodes, internodes and scale leaves.

2.4 Crop-weed competition

Crop-weed competition depends on several factors which include but not limited to several factors. Among them is type of rice culture with up-land having severe competition while Low-land irrigated and deep water culture having less competition. Method of crop establishment also plays a role in weed establishment with transplanted rice showing less to moderate effect. Meanwhile direct seeded rice has severe competition comparatively. The Variety of rice planted indicates that tall structured varieties have less competition unlike Semi dwarf. Rice with low tillering ability will have more weed competition as opposed to high tillering varieties (Wanjogu *et al*, 2010).Cultural practices play a role in weed competition for lowland rice in that during land preparation puddled soil will have less competition while non-puddled experience more competition (Naipictuasdharwad, 2009).

Transplanted rice should be weed free at 30-45 days after transplanting while direct seeded rice is 15-45 days after seeding is the critical period of crop weed competition. This is the period from sowing up to which the crop has to be maintained in a weed free environment for remunerative crop production (Caton, 2012)

2.5 Methods of weed control

There exists several weed control methods employed with a sole purpose of managing effects of weeds in a paddy field. Among this include;

2.5.1 Preventive methods

They check weed introduction and spread of weed seeds in paddy fields. This method is easy and economical. Preventive measures include use of weed free seeds; weed free seed bed, clean tools and machinery, clean irrigation canals.

2.5.2 Complementary practices

Land preparation by puddling of paddy fields before transplanting incorporates weeds and gives rice seedlings a head start over weeds. This will ensures transplanted rice seedlings are managed ahead of young weeds which are yet to sprout. Use of weed free crop seed and seedlings also plays a big role in good agricultural practices. This ensures that invasive weeds are carried into weed free paddy field. Straight-row planting will allow easy to weed by hand or by mechanical tool during weeding period. Meanwhile, random transplanting impedes weeding as well as limit use of mechanical tool. Similarly transplanting ideal seedlings in a paddy field will allow less weed competition as opposed to direct seeded which tolerates severe weed competition.

2.5.3 Direct methods of weed control

Hand weeding is a method that entails pulling by hand or using tools like hoe, spade or sickle. Transplanted rice requires one or two hand weeding between 20-42 days after transplanting. And its advantage over other is that is most common, easy and effective. Can be taken up even where random planting is done. This method has its fair share of disadvantages in that it is costly and laborious. Mechanical weeding on its own requires use of a rotary weeder which is pushed by hand or motorized/powered between straight rows. The advantage of this method is that it saves labor while its disadvantage is that it require row transplanting or seeding.

Chemical weeding (Herbicides application) is a method that involves application of various forms of chemicals to control unwanted plants in a cropping area. Herbicides are chemicals that are capable of killing some plants (weeds) without significantly affecting the other plants (crops). Herbicide activity is said to be active or to possess activity if it hinders, inhibits or prevents the germination and growth processes of the plant. It is active on sensitive plants and inactive on tolerant plants. Herbicide activity is determined by degree of tolerance of the plant to herbicides.

In this case herbicide selectivity refers to phenomenon where chemical kills the target plant species in a mixed plant population without harming or only slightly affecting the other plants. Herbicide selectivity is the single most factors that lead to success of chemical weed control in crops. Propanil is atypical herbicide that has high inhibitory activity on the hill reaction of photosynthesis. It is especially valuable in rice culture because of its high selectivity. Rice plants are 40 times more tolerant of propanil than *E. crus-galli* L. Therefore can be used for weeding in direct seeded or broadcasted rice where rice and weeds are growing at the same stage (Matsunaka, 1983).

In transplanted paddy, the young paddy plants have an advantage over germinating weeds and immediate flooding after transplanting limits the establishment of many weeds, hence yield losses due to weed competition tend to be less than those in direct seeded paddy. In Asia, yield losses due to uncontrolled weed growth in direct seeded lowland paddy was 45-75%, and for transplanted lowland paddy approximately 50% (Johnson 1996). All weeds on crop field may not be harmful. At low density, weeds do not affect yield and certain weeds can even stimulate the crop growth (Yu *et al* (1996). The best way of weed management is to make use of it, to promote it to a level of wanted plants.

CHAPTER THREE: WEED SPECIES AND THEIR PRESENCEIN MWEA IRRIGATION SCHEME

3. Abstract

Mwea irrigation scheme has seen a lot of rice cultivation improvement assessments for the last several years with significant impacts in rice farming. Some of these are geared towards managing lowland weeds in paddy fields as this is one of the major impedance to good yield. Farmers have varied feelings when it comes to weeds and their effect on crop performances as well as those weeds they consider most problematic. During crop cultivation stage, farmers practice up to three sets of hand weeding operations. It is thought that each weeding practice has both negative and/or positive implication especially on crop performance. Survey was done between the month of March and April of the year 2015 to determine weed species and their diversity in the 20,000 acre public irrigation scheme.

A pre-test was done on the first day to determine the speed of the work as well as work out the number of paddy fields to be sampled. The real work of sampling began by throwing a 1m square quadrant at three different positions. A total of 31 sampling points were sampled across the irrigation scheme by collecting the samples at the feeder, middle and drain areas. Besides, Soil p^H levels of the soils and Global positioning system (GPS) points were recorded in all the points. The status of the crop and/or paddy field was also noted. During this period, 13% was fallow, 64% having a second crop while the remaining 13% ratoon rice crop.

Weed species data collected was used to calculate species frequency, field uniformity, field density and relative abundance. Generally the P^H in the areas that were sampled gave moderately acidic (M_3 = 5.35 soil P^H) to near neutral results (K_2 = 7.99 P^H). Results of the number of weed species were; perennial weeds (ten) and annual weeds (seven) respectively. Out of the perennial weeds six were broad leaf, three were grass family and sedge(one). Annual weeds sampled indicated, Broadleaves (four), Grass (one) and Sedges (two) respectively. Species with highest frequencies, field uniformity, mean field densities and relative abundance included broadleaf such as *L. adscendens* (L.), *M. minuta* (L.), and *S. Cyakuloides* while *L. Chinensis* (L.) and *C. Difformis* (L.) represented grasses and sedges respectively .According to the findings, weeds sampled during survey work are thought to be the most noxious in this expansive irrigation scheme.

3.1 Introduction

Mwea Irrigation Scheme is the largest public irrigation settlement in Kenya. It is credited in producing 65,000 MT of rice annually (Wanjugu *et al* 2013). This is through main rice crop production, ratoon management and a second crop in some of the out grower areas. Weeds have either competitiveness with a target crop for space, light, water and nutrients or have a rapid growth and/or ease of germination (Sign *et al,* 2008). Weed management methods for lowland paddy fields weeds determine not only average yield of rice crop per unit area but also cost implication on the management of the crop. For a farmer to practice Agri-business, some of the challenges that are encountered along rice cultivation have to be identified and managed.

Farmer understanding on weeds of significance and their effect on crop is just one of the main aspects in getting expected yield per unit area. Effective weed management therefore is important in enhancing not only crop yields but also avoid being alternate host for opportunistic pests. The current practice for weed management in rice fields is hand weeding except a few selected areas where herbicides are being used. The practice recommended for lowland irrigated rice culture is three hands weeding per season. One set of hand weeding per acre requires 15 man days which in most occasions is more depending with intensity of this weeds (Wanjugu *et al* 2013).

Under normal circumstance, farmers practice up to three sets of manual weeding per season. Survey was done across the scheme to characterize weed populations in lowland paddy field situated in Mwea. Findings from this surveys guide in determining cost aspect and environmentally friendly management measure (Uddin *et al*, 2010). Weeds of significance found in paddy fields located in Mwea are not limited to certain category. However, expectation is that different sections of the scheme have different weeds of significance which requires varied methods of management to reduce its effect on the crop. Seeds of the annual weeds survive in unfavorable conditions and they are able to complete their life cycle from seed in one season (Sign *et al*, 2008).

3.2 Materials and methods

3.2.1 Site description

The study was carried out in Mwea Irrigation Scheme, which is situated in Kirinyaga County. It is approximately 113Kilometers North East of Nairobi at 1159m above sea level and located in $39^0$26S and $37^0$17E.$037^0$20.6’E. It is the largest rice-growing scheme in Kenya that produces 80% of irrigated rice that is consumed domestically (National Irrigation Board, 2010). This public irrigation scheme is divided into five sections Mwea, Tebere, Thiba, Wamumu and Karaba with additional out grower sections (Nderwa and Curukia) all comprising of 19,800acres (Wanjogu *et al*, 2011).

Table 2 Meteorological information of the Mwea Irrigation scheme during study period

Month		**Rainfall (mm)**	**Maximum temperature (ºC)**	**Minimum temperature (ºC)**	**Relative Humidity (%)**	**Evaporation rate (mm)**	**Dew point (ºC)**
2015 March	Total (2 Months)	24.5	997	498.7	1920	200.5	458
	Average	0.79	32.16	16.09	61.94	6.47	14.77
2015 April	Total (2 Months)	286.9	892.6	537.6	2331	150.9	581.8
	Average	9.56	29.75	17.92	77.7	5.03	19.39

Mwea belongs to sub-tropical climate and is suitable for rice growing throughout the year. It has a mean and maximum temperature of 14^0C and 33^0C respectively and receives mean annual rainfall of 940mm. Humidity in the region is low thus discourages rice pests and disease most times of the year. The low humidity, ideal temperature, solar radiation including sunshine hour and annual rainfall favors one cropping season. This however fluctuates during the year as the pattern of precipitation is bi-modal, long rains occurring from March to June while short rains October–December. For this reason, irrigation by flooding is a crucial for improved rice growing in the expansive scheme (Wanjogu *et al*, 1997).

3.2.2 Survey strategy and design

The study was based on extensive and intensive fields surveys conducted in selected areas of the main scheme excluding out-grower during the long rains season of 2015 (Mid-March and April). The timing was to coincide with the season when there is a mixture of a main rice crop, a ratoon and those areas which have been left fallow awaiting land preparation for main season (Dangwal, 2012). A total of 31 sampling points were randomly done in five scheme sections and each sampling point was replicated three times at the feeder canal, middle and one last at the drain area. Soil p^H levels of the soils were measured in all the sampling points to determine status of the soils. Global positioning system (GPS) points were taken in all the areas that were sampled using Garmin GPSMAP®78 Series model. Summary of the soil status and GPS coordinates are represented in the table below.

To achieve the data in table 3.1, one meter square quadrant was used with three samples in each field as indicated in figure 1. While meteorological data during the time of survey was as represented table 3.1.

Table 3, Scheme sections surveyed and status of paddy field

Scheme Section	unit area	soil p^{H}	GPS coordinates	Status of rice crop
Thiba (H)	H19	5.68	037^{0}20.6'E and 0^{0}42.8S	Fallow
Thiba (H)	H19	5.76	037^{0}19.5'E and 0^{0}42.5'S	Fallow
Thiba (H)	H2	6.53	037^{0}20.6'E and 0^{0}42.1'S	Reproductive stage of off season crop
Thiba (H)	H5	5.88	037^{0}20.1'E and 0^{0}42'S	Fallow
Thiba (H)	H6	5.99	037^{0}20.6'E and 0^{0}42.8'S	Fallow
Karaba (K)	K2	6.51	037^{0}21.8'E and 0^{0}44.7S	Mid tillering off season crop
Karaba (K)	K2	7.99	037^{0}22.7'E and 0^{0}44.8'S	Mid tillering off season crop
Karaba (K)	K4	6.98	037^{0}23.2'E and 0^{0}448'S	Mid tillering off season crop
Karaba (K)	K5	6.11	037^{0}24.1E and 0^{0}44.4'S	Transplanting of second main crop
Karaba (K)	K7	6.24	037^{0}24.7'E and 0^{0}44.4'S	Transplanting of second main crop
Karaba (K)	K7	6.27	037^{0}25'E and 0^{0}44.1'S	Second ratoon crop
Karaba (K)	K9	6.34	037^{0}23.8'e and 0^{0}44.7'S	Mid tillering off season crop
Mwea (M)	M1	6.58	037^{0}18.8'E and 0^{0}38.7'S	Reproductive stage of off season crop
Mwea (M)	M12	5.58	037^{0}18.7'E and 0^{0}40.5'S	Reproductive stage of off season crop
Mwea (M)	M17	5.53	037^{0}19.7'E and 0^{0}40.5'S	Reproductive stage of off season crop
Mwea (M)	M17	5.57	037^{0}19.7'E and 0^{0}40.1'S	Reproductive stage of off season crop
Mwea (M)	M3	5.35	037^{0}19.9'E and 0^{0}39.1'S	Early tillering of off season crop
Mwea (M)	M4	5.85	037^{0}20.5'E and 0^{0}39.4'S	Reproductive stage of off season crop
Mwea (M)	M8	5.86	037^{0}19.2'E and 0^{0}39.5'S	Reproductive stage of off season crop
Mwea (M)	M9	5.68	037^{0}179'E and 0^{0}39.2'S	Mid tillering off season crop
Tebere (T)	T11	6.89	037^{0}23.7'E and 0^{0}39.4'S	Reproductive stage of off season crop
Tebere (T)	T16	6.22	037^{0}23.3'E and 0^{0}40.6'S	Mid tillering off season crop
Tebere (T)	T17	6.21	037^{0}22.4'E and 0^{0}40.7'S	Mid tillering off season crop
Tebere (T)	T18	6.02	037^{0}24'E and 0^{0}40.7'S	Reproductive stage of off season crop
Tebere (T)	T22	6.48	037^{0}24.8'E and 0^{0}40.3'S	Second ratoon crop
Tebere (T)	T22	6.02	037^{0}24.7'E and 0^{0}41'S	Mid tillering off season crop
Tebere (T)	T5	6.27	037022'E and 0038.3'S	Mid tillering off season crop
Tebere (T)	T6	6.88	037^{0}23.2'E and 0^{0}38.6'S	Mid tillering off season crop
Wamumu (W)	W1	6.21	037°20.8' E and 0^{0}43.8'	Second ratoon crop
Wamumu (W)	W3	7.04	037021.6E and 0044.2'S	Mid tillering off season crop
Wamumu (W)	W5	5.99	037^{0}21.1'E and 0^{0}44.4'S	Second ratoon crop

Criteria to choose sampling points was random however great care was taken to ensure at least five meters from the paddy field bunding was factored to avoid none paddy field weeds. The sampled paddy fields comprised of; 13% being fallow, 64% second season rice crop at reproductive stage, 10% second season rice crop being transplanted and 13% being ratoon crop.

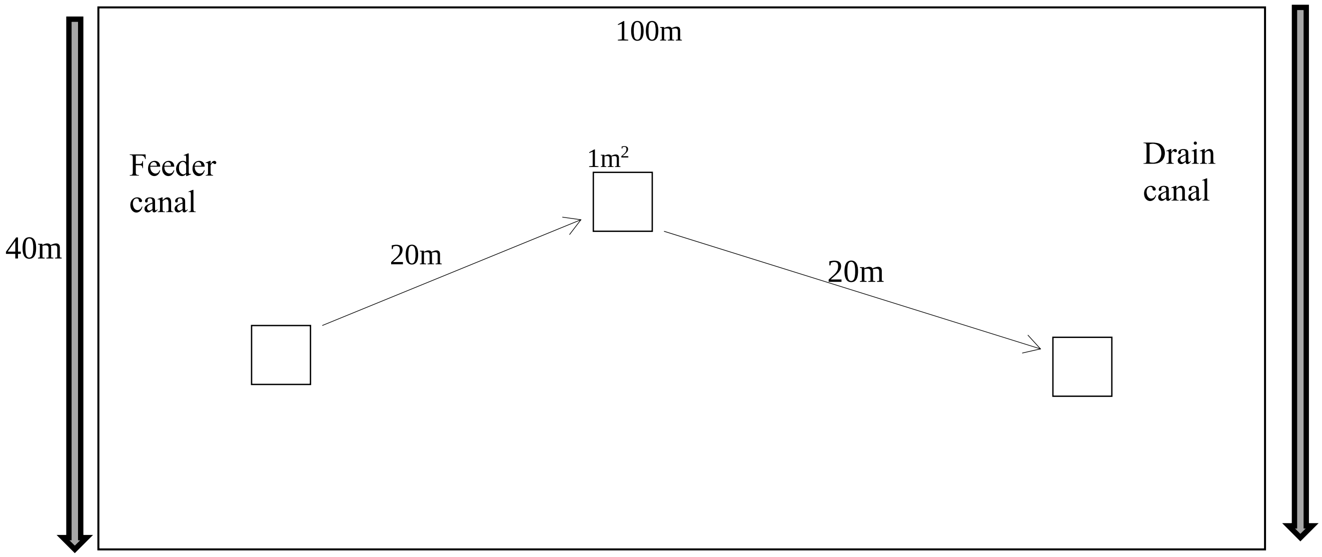

Figure 1 Schematic representation of sampling points

3.3 Data collected

Immediately after survey, specimen samples of all weeds were collected and identified per species, counted and recorded.

3.3.1 Identification of weeds (Weed frequency)

Weed frequency (f) was determined as the percentage of the total number of fields surveyed in which a species occurred in at least one quadrant in the following formulae;

$$\mathrm{Fk} = \frac{\Sigma \mathrm{n1Yi}}{\mathrm{n}} \mathrm{X}\ 100$$

Where F_k= Frequency Value for species k

Yi= Presence (1) or absence (0) of species k in field i

n= Number of fields surveyed

3.3.2 Determination of weed frequency and density of occurrence (Field uniformity)

Field uniformity (FU) is the percentage of total number of quadrates sampled in which a species occurred

$$FUk = \Sigma n1\Sigma 31 \left(\frac{\mathrm{Xij}}{3\mathrm{n}}\right) X\ 100$$

Where FU_k=field uniformity value for species k

X_{ij}=Presence (1) or absence (0) of species k in quadrate j

n= Number of fields surveyed

3.3.3 Determination of weed field occurrence (Density occurrence)

Density occurrence (D) of each species in a field was calculated by summing the number of plants in all quadrates and dividing by the area of 3 quadrates

$$Dki = \frac{\Sigma 3iZi}{Ai}$$

Where D_{ki}= Density (in numbers m^{-2}) value of species k in field i

Z_i= Number of plants of a species in quadrates j (quadrate is $1m^2$)

A_i= area in m^2 of 3 quadrates in field i

3.3.4 Mean field density (MFD)

The number of plants m^{-2} for each species averaged over all fields sampled

$$MFDk = \frac{\Sigma n1Dki}{n}$$

Where MFD_k= mean field density of species k

D_{ki}= Density (in numbers m-2) of species k in field $_I$

n=Number of fields surveyed

3.3.5 Relative abundance (RA)

Ranks weed species in the survey and it was assumed that the frequency, field uniformity and mean field density measures were of equal importance in describing the relative importance of a weed species. The value (RA) has no units but the value for one species in comparison to another indicates the relative abundance of the species (Thomas and Wise, 1987).

Relative frequency for species k (RF_k) = (Frequency values of species/ Sum of frequency values for all species) X 100.

Relative field uniformity for species k (RFU_k) = (Field uniformity value of species k / Sum of field uniformity values for all species) X 100Relative mean field density for species k ($RMFD_k$).

Mean field density value of species k/sum of mean field density values for all species) X 100

The relative abundance therefore for species k (RA_k) was calculated as the sum of relative frequency, relative field uniformity, and relative mean field density for that species;

$$RAk = RFk + RFUk + RMFDk$$

Relative abundance value is an index that was calculated using a combination of frequency, field uniformity and field density for each species as described (Hakim *et al*, 2013) this relative abundance allows for comparison of the overall abundance of one species versus another.

3.4 Results

3.4.1 Weed species

From the data collected there were a total of 17 weed species of weeds in total across the scheme during the long rains season. Out of the weed species scored, 7 were annual weeds while majority 10 was perennial weeds of lowland paddy field condition. Amongst the 7 annual weeds, four (4) were broadleaf weed species while, one (1) was grass and the remaining three (3) being sedges. Meanwhile in the perennial weeds group, there were six (6) broadleaf, three (3) grasses and one (1) species of sedge weed. Generally there were more broadleaf weeds types than both grasses and sedges that are associated with lowland paddy condition. Graph below shows the number of weed species in Mwea irrigation scheme.

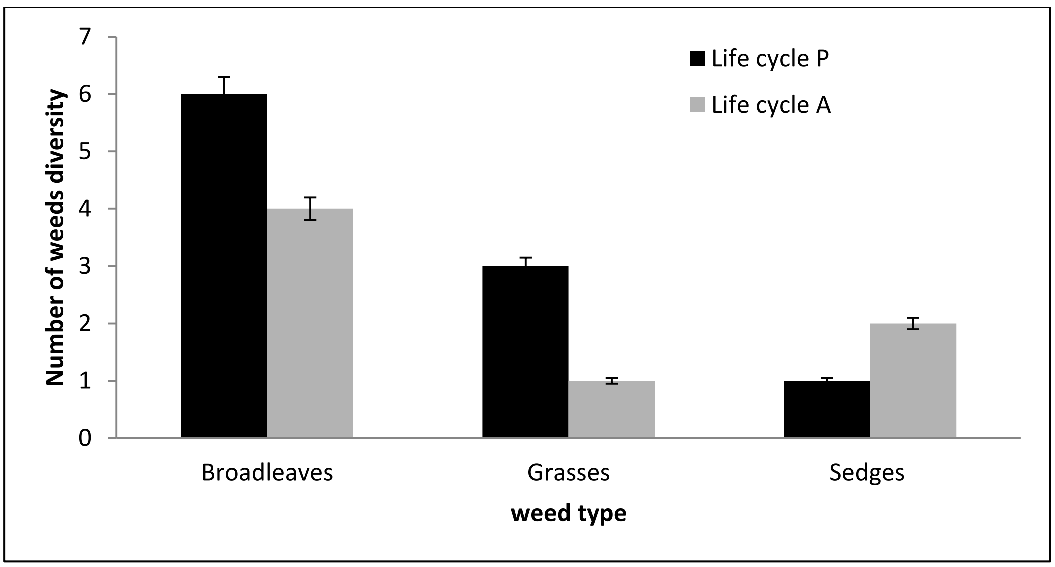

Figure 3.2, Weeds diversity in Mwea irrigation Scheme

Generally the soil P^H in the areas that were sampled gave moderately acidic to near neutral results with M3 unit recording the most acidic at 5.35 soils P^H while the lower end of the scheme; K2 unit recording 7.99 P^H.

3.4.2 Weed species frequency

Amid the broadleaf weed species that were sampled in Mwea Irrigation Scheme showed that *Ludwigia adscendens* L., *Marsilea minuta* L. And *Spharanthus cyakuloides* (Table) were the most abundant with 97%, 94% and 84% respectively. The least abundant species in this category of weed species were *Eclipta prostrate* L. with 16% presence in the Scheme. It is worthy to note that only four species scored below 50% presence in the scheme, this included *Monochoria vaginalis* Burm.f (23%), *Ammania coccinea* Rottb. (39%),*Sphaeranthusafricanus*(32%)and *Eclipta prostrata* L.(16%).

The results from the grass species indicated that *Leptochloa chinensis* L. With 97% presence in the scheme were the most abundant while *Echinocloa crusgalli* L. (77%) were the least. Striking aspect in the grass species was that all the four species were relatively abundant at more than 71% compared with those of grasses and sedges respectively. Species frequency for the sedge type were relatively lower than those of broadleaf and grass species with all the three giving less than 33%. *Cyperus difformis* L. species was the most abundant in this group with 33% abundance while *Cyperus rutundus* L scores the least in abundance.

3.4.3 Field uniformity

On this parameter which showed the spread of a weed species within a given field, among the broad leaf species, *Ludwigia adscendens* L., *Marsilea minuta* L, and *Spharanthus cyakuloides* at 32%, 31% and 28% had the highest species spread. *Monochoria vaginalis* Burm.f is the least present at 8% among the broad leaf weeds explaining the reason why they were the most abundant weed after land preparation through rotavation and flooding. Meanwhile grass species of lowland weeds showed that the most present across the paddy fields of Mwea Irrigation Scheme was *Leptochloa chinensis* L. 31%presence in the sampled sections of the scheme. The results also indicated that among this category of paddy field weeds spread there was minimal divergence with other grass species as *Echnochloa colona* L.*(27%), Leersia hexandra* L.*(24%), and Echinocloa crusgalli* (26%) hence a fact that the spread among grass family was uniform.

Sedges species were associated with the fallow window by the farmers especially during off-season were shown to be uniformly spread in the field that were sampled. *Cyperus difformis* with 33% were the highest in terms of spread followed by *S. juncoides* at (31%). The least spread species were *Cyperus rotundus* (26%) and the pattern indicates that this species was so close and majority were found in the paddy fields without a crop which represented 12.9% of all the fields that were sampled (Table).

3.4.4 Field density

The most dense broadleaf weed species per meter square from the data was *L. adscendens* L at 1plant m^{-2}. The survey results showed that there was no any other broadleaf species in the area surveyed per meter square. However, for the grass family *L. chinensis* weed was the most abundant with a density of 2 plants m^{-2}. Overall the most abundant weed in the scheme was sedge species *Cyperus difformis* with density of 3 plants m^{-2}(Table). Weeds that appeared highest frequencies, field uniformity and mean field densities indicated the difficulty in management. Most suggestive way of managing weeds species which fall in this category is timely weeding. This is true as all weed types that have field frequency <50%, field uniformity <35% and mean field densities <2% plants m^{-2} may either be less competitive with rice plants or may be effectively be controlled by current weed management practice in place (Hakim *et al*, 2013). This means that for weeds to be managed in lowland ecology effective monitoring of density is very important aspect.

3.4.5 Relative abundance

Relative abundance parameter was quantification of predominance of a particular weed species in a given ecological environment in relation to other weeds present therein. This value compared that of frequency, field uniformity and density of a particular weed species relative to all other weed species (Hakim *et al*, 2013). It is vital when an indicating overall weed problem posed by specifics species is to be managed accordingly. The survey data from Mwea Irrigation Scheme shows that among the broadleaf weed species *Ludwigia adscendens* (49) was relatively the most abundant among the species, while *Leptochloa chinensis* (56) is relatively the most abundant grass weed species. *Cyperus difformis* (79) on the other hand was the most abundant weed species in sedge family as well as all other weed types.

Ranking relative abundance in descending order indicates that *C. Difformis (79), L. chinensis (56), L. adscendens (42), M. minuta (39), S. juncoides (35), C. rotundus (34), E. colona (34), L. octavalis (31), E. crusgalli (28), A. sessilis (28), L. hexandra (27), C. diffusa (26), A. coccinea (22), S. africanus (14), M. vaginalis (12) and E. prostrate (6)*follow each other in relative abundance.

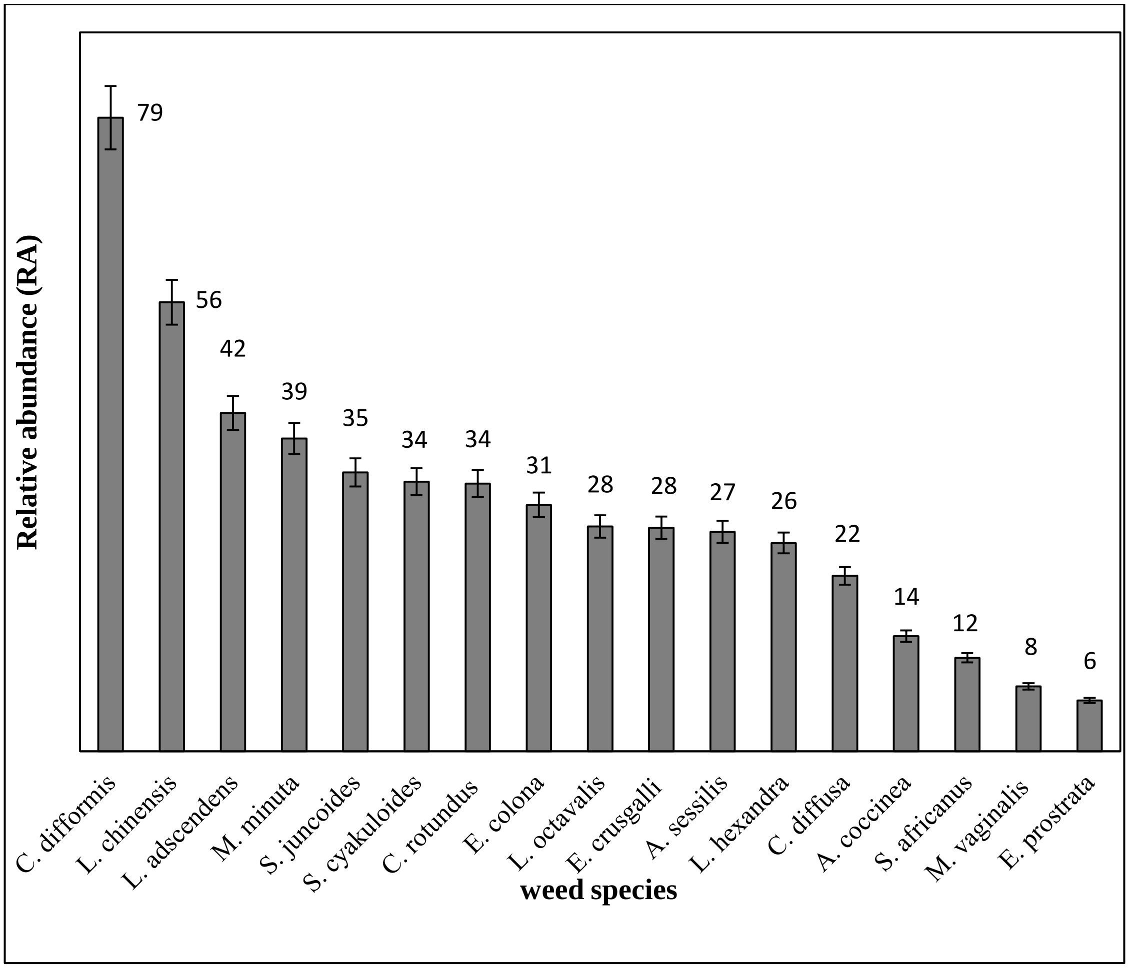

Figure 3.3, Relative abundance of weeds species observed in Mwea Irrigation Scheme

Table 4 Species of weeds in Mwea Irrigation Scheme

Species name	Common name	Life cycle	Frequency (F)	Field Uniformity (FU)	Relative Field Uniformity (RFU)	Relative Frequency (RF)	Number of plants of a species in quadrates (Z_i)	Field Density (D)	Mean Field Density (MFD)	Relative Mean Field Density (RMFD)	Relative Abundance (RA)
i. Broadleaf											
L. adscendens	Creeping water primrose	Perenial	97	32	8	26	93	18	1	8	42
M. vaginalis	Oval leafed-pond weed	Perenial	23	8	2	6	93	0	0	0	8
L. octavalis	Water primrose	Perenial	77	26	7	21	93	1	0	1	28
A. coccinea	Redstem	Annual	39	13	3	11	93	1	0	1	14
C. diffusa	spreading dayflower	Perenial	61	20	5	17	93	0	0	0	22
M. minuta	Water clover	Perenial	94	31	8	25	93	14	0	6	39
S. cyakuloides	Pig weeds	Annual	84	28	7	23	93	9	0	4	34
A. sessilis	sessile joy weed	Perenial	71	24	6	19	93	5	0	2	27
S. africanus	East Indian Globe Thistle	Annual	32	11	3	9	93	1	0	0	12
E. prostrata	False daisy	Annual	16	5	1	4	93	1	0	1	6
ii. Grasses											
L. chinensis	Chinese sprangletop	Perenial	94	31	8	25	93	53	2	23	56
E. colona	Jungle rice	Perenial	81	27	7	22	93	5	0	2	31
L. hexandra	swamp rice grass	Perenial	71	24	6	19	93	2	0	1	26
E. crusgalli	Barnyard grass	Annual	77	26	7	21	93	1	0	0	28
iii. Sedges											
C. difformis	Small Flower umbrella nutsedge	Annual	100	33	8	27	93	101	3	44	79
B. maritimus	Bull rush	Annual	94	31	8	25	93	4	0	2	35
C. rotundus	Purple nutsedge	Perenial	77	26	7	21	93	14	0	6	34

3.5 Discussion

Results from the survey suggest that soils in this expansive lowland public irrigation scheme are slowly becoming acidic based on the data from various locations in the scheme (Table above) This however is not so serious to warrant decline in rice production as rice plant will thrive in near neutral soil P^H conditions (Wanjogu, 1995). The scheme which is progressively expanding coupled with over use of natural resource as seen increased use of fertilizer especially acidic formulated. This scenario has not only reduced soil P^H but also seen invasion of new weeds that have proved to be difficult to manage (Ferrero, 2003).

The most frequent weed species among the broadleaf is *L. adscendens* L., while grass type has *L. chinensis* L., which has been cited as the most difficult to rid of during crop stage. This concurs to the fact that *Poaceae* (grass type of weeds) have a wide range of presence from north to south and are the most common, with more than 80 species reported as weeds of rice (Ferrero ,2003). Sedge species has *C. difformis* L. weed type being the most frequent during the off season when there is no crop of rice in the paddy field. This a true representative of the fact that *C. difformis* L. was the least abundant weed type of the three; Broadleaf, grass and sedge weed categories with less than 50% abundance in the scheme. This could be attributed to realization that the sampled area comprised of 13% being fallow a condition which is associated much with *Cyperaceae* (Nguu, 2006)

Uniformity of these paddy field weeds in the scheme indicates that broad leaf weed species have a significant difference between those that are more frequent and those that are least. The most uniformly present weed species *L. Adscendens* L. at 32% are more visible in the scheme than those which are least present *M. vaginalis* Burm.fat 8%. However the grass family weeds do not display any significant difference in terms of field uniformity explaining the reason why currently they are the most troublesome weeds in lowland rice cultivation ecology. The same trend was also displayed by the sedge family category of lowland paddy field weeds (Johnson, 2006).

The most crowded weed species per unit area under lowland paddy condition is C. *difformis* a sedge type of weed mainly found during off season. This suggests the fact that since there is no weed management during off season allows this weed species to thrive and regenerate within a short period of time (Jonne, 2013). However, it is worthy to note that *Leptochloa Chinensis* L. grass species is relatively dense per unit square. An indication that weed management targeting this weed in lowland paddy condition should be taken keenly to ensure it is contained especially due to the fact that they are morphologically similar to rice plant during vegetative phase (Ferrero, 2003).

The study confirms that the scheme famed for producing high aromatic rice is face with the problem of 17 major weed species. This therefore suggests that for good management a raft of weed management practices need be employed. Presence of all the three families of weeds namely, broadleaf, sedge and grass demands timely weed management as well. This is due to the fact that each weed species have different competitive aspect from the other (Dangwal, 2012). The scheme which is 100% transplanted means rice will have a competitive edge and therefore weeds of rice that emerge afterwards can be well managed.

CHAPTER FOUR: EFFECT OF INTERGRATED WEED MANEGEMENT PRACTICES ON LOWLAND RICE (*Oryza sativa*) PRODUCTION

4 Abstract

Management of weeds come third after bird scaring and inputs in operational cost of paddy rice production respectively in Mwea irrigation scheme according to a baseline survey that was conducted by the ministry in May of 2012. This is attributed to among others, resistance to herbicides and importation of rice varieties from neighboring countries which are infested with weed seed. Field experiment was conducted in the main cropping seasons in the short rainy season of the year 2012 and long rainy season (2013) at Mwea Irrigation Agricultural Development Centre research fields. The objective of this study was to determine effect of integrated weed management practices on lowland rice cultivation.

Recommended rice crop management practices were kept constant in test plots. Weed management practices that combined five most common aspects in the expansive scheme was then tested in a view to check on their performance. The five management aspects were total weed free condition, un-weeded condition, contact herbicide, systemic herbicide and common weed management practice. Three main rice varieties were used namely Basmati 370, BW 196 and IR 2793-80-1.Data on agronomic parameters were collected which included tiller number, plant length, SPAD meter reading, weed count by species and yield. There was significance in variety, weed management strategy applied and their interaction in yield in tons per hectare in short rains of 2013 at P=0.0006, P<0.0001and P=0.0022 respectively.

This shows that weed and variety interaction had an effect on the yield that was realized. However, of the three major weeds that were sampled in the plots showed *C. difformis* and *L. Adscendens* L. Were highly significant in respect to the management practice employed (Both P<0.0001 respectively). Meanwhile results show that 2, 4-Dichlorophenoxyacetic acid and common weed management practicehad significantly more *(<45) C. difformis* L. (181 and 197 respectively) than other management practices in short rains. Mean while *L. octavalis* L. Type of weed was highly significant for weed strategy employed (P=0.0001) and significant for Basmati 370 variety (P=0.0199). Results indicated that for farmers to realize good rice yield, weed management strategy is key as it saves up to 30% of the loss of rice loss due to uncontrolled weeds.

4.1 Introduction

The demand for rice has continuously increased in the country due to change in eating habit, in line with this therefore, a lot need to be put in place to ensure there is optimum yield realization per unit area. The current average yield of 5-10 tons per hectare for common rice varieties can be increased by simply improving on crop management practices. Key among this practice is weeding which has been a challenge for the rice farmers as cost of manual labor continue to escalate not to mention the fact that labor is scarce during peak crop season. A baseline survey conducted in Mwea irrigation scheme in the year 2012 indicated that labour is third highest cost of operation after those of Fertilizer input and bird scaring (Wanjogu *et al* 2012). It is worth noting that the government through subsidized fertilizer programme has brought down the cost of inputs therefore living bird scaring activity to be the main constraint in rice production followed by weed management.

Basmati 370 rice variety also known as "pishori" is the most viable commercial variety grown in the scheme (Wanjogu *et al* 2012). It's cultivated in approximately 94% of the area covering this largest public irrigation scheme owing to its high commercial value that it attracts in the local market. BW 196 and IR 2793-80-1 varieties turns out to be the most preferred to be grown because of its subsistence aspect covers the remaining portion of the scheme. Other local varieties are also being grown in the scheme however their popularity is not worth noticeable as they are preferred by very few amongst the older generation of farmers.

Mwea irrigation scheme has always been the centre of interest for many international development partners for instance Japan International Co-operation Agency (JICA) and German Technical Cooperation GIZ as they try to improve production zone for Rice. With this expansion process through technology and infrastructure development, the scheme will witness growing area increasing to about 12,000 hectares by the year 2030 (Saprof 2007). The same international partners have also desired to develop high yielding lowland rice cultivars which are highly susceptible to Biotic and a biotic stress. The need to focus on weed management strategy is key to the success of all this effort and hence creates a food secure country.

4.2 Materials and methods

4.2.1 Description of experimental materials

Rice varieties tested included Basmati 370, BW 196, and IR 2793-80-1. Two weed management practices were used as the control. The first was total weed free which involved weekly manual weed management while Un-weeded treatments involved no weed management done throughout the season. Recommended rate of contact selective herbicide was applied once by first draining irrigation water at 5-6DAT and spraying at 7-10DAT. Soil was then left moist for 3 days before reintroducing irrigation water before one hand weeding at 35DAT. Treatment three was systemic herbicide chemical application at recommended rate of selective herbicide applied once by first draining irrigation water at 5-6DAT. Spraying was then achieved at 7-10DAT leaving the soil moist for 3 days before reintroducing irrigation water thereafter one hand weeding at 35DAT. The last treatment was Mwea famer practice of Manual hand weeding done three times at 14-21DAT, 35DAT and 60DAT respectively.

Table 5, Materials used in the experiment and their major characteristics

Material	Source	Characteristics
Basmati 370 rice variety	India	Long grain aromatic rice variety yielding 5.6tons per hectare. Takes approximately 120 days to mature. Basmati 370 plants are tall and slender and are prone to lodging in high winds
BW 196 rice variety	Bangladesh	Short grain non aromatic variety. High yielding (8 tons per hectare), take approximately 140 days to mature.
IR 2793-80-1 rice variety	International Rice Research institute (IRRI) rice line	Short grain non aromatic variety. High yielding (7.5 tons per hectare), takes approximately 140 days to mature.
Propanil	Formulated by Twiga chemical industries limited	Contact selective herbicide used in rice field
Dicopur D (Dimethylamine salt of 2,4- Dichlorophenyl Acetic Acid (2,4-D)- 720g/L salt; equivalent to 600gL acid/L)	Distributed by Farmchem Kenya limited	Systemic selective herbicide used in rice field

4.2.2 Experimental treatments design and layout

The experiments was laid out in a split plot design with three rice cultivars as the main plots and five lowland paddy field weed management strategies as the sub plots. Rice seedlings were transplanted at the age of 21 days after sawing. Transplanting Spacing for the seedlings was achieved at 20cm x 20cm, with 2 seedlings per hill. Irrigation water management was done as per Mwea scheme practice (*Wanjogu et al., 1996*) while insecticide application was achieved using Cypermethrin 10% +Chlorpyriphos 35%at 14 days after transplanting. Nutrient management of Nitrogen (N), Phosphorous (P) and potassium (K) fertilizers were applied at the rate of 80kgsha^{-1}, 60Kgsha^{-1} and 50Kgsha^{-1} respectively as per Mwea soils requirement.

4.3 Data Collection

The following data parameters were taken to determine the effect of treatments on weeds of paddy rice. Plant height for five 5 tagged hills per plot at 14 days interval up to 70 days after transplanting (DAT).Tiller number for five 5 tagged hills per plot at 14 days interval up to 70 DAT. Weed count in 1 meter square quadrant per plot done at three different spots. Leaf chlorophyll content at 14 DAT. Yield components to determine production per unit area which included (Number of hills per meter square, productive tillers per meter square, Number of spikelets per panicle, Percentage ripened grains per panicle, Field moisture content and 1000 grains weight in grams)Data collected was the subjected to analysis of variance (ANOVA) using SAS software.

4.4 Results

4.4.1 Effect of weed management practice on rice tillering and plant height (in centimeters).

There was significance difference ($P<0.05$) in tiller number for Total weed free treatment and total weed treatment for weed management of Basmati 370 rice variety at 56 Days after transplanting (DAT). However, there was no significance difference between weed free treatment and farmers practice ($P>0.05$) as shown table 5 below at the same DAT. There was however significance between total weed free condition and systemic herbicide at 84 DAT for Basmati ($p<0.05$) while insignificance for both contact and farmers practice.

Table 6 Number of tillers for three rice varieties under various weed management practices during short rains of 2014 in Mwea Irrigation Scheme

	DAYS AFTER TRANSPLANTING					
WEED MANAGEMNT PRACTICE	**14**	**28**	**42**	**56**	**70**	**84**
Basmati 370 rice variety						
Total weed free (No weed)	2_a	5_b	20_c	23_c	23_b	26_b
Un-weeded	2_a	5_b	17_b	16_a	13_a	12_a
Propanil (5lts ha^{-1})	2_a	6_c	20_c	23_c	21_b	21_b
2, 4-D (1.25lts ha^{-1})	2_a	4_a	15_a	19_{ab}	21_b	19_b
Manual hand weeding (Farmer practice)	2_a	6_c	20_c	21_b	21_b	20_b
LSD (P≤0.05)	0.2	0.9	2.8	3.9	5.4	6.2
C.V (%)	0.20	0.86	2.79	3.88	5.42	6.24
BW 196 rice variety						
Total weed free (No weed)	2_a	7_b	27_b	33_b	35_b	33_c
Un-weeded	2_a	6_a	22_b	26_a	20_a	17_a
Propanil (5lts ha^{-1})	2_a	5_a	25_b	34_b	33_b	25_b
2, 4-D (1.25lts ha^{-1})	2_a	5_a	14_a	24_a	26_a	$27_{b\,c}$
Manual hand weeding (Farmer practice)	2_a	6_a	23_b	33_b	35_b	$31_{b\,c}$
LSD (P≤0.05)	0.2	1.1	5.8	5.9	8	7.5
C.V (%)	0.20	0.94	5.95	6.75	3.64	5.97
IR 2793-80-1 rice variety						
Total weed free	2_a	6_a	28_b	36_b	30_a	27_b
Un-weeded condition	2_a	7_b	25_b	24_a	24_a	18_a
Propanil (5lts ha^{-1})	2_a	6_a	21_b	31_b	28_a	27_b
2, 4-D(1.25lts ha^{-1})	2_a	6_a	17_a	26_a	27_a	25_b
Farmers practice	2_a	7_b	28_b	35_b	31_b	26_b
LSD (P≤0.05)	0.2	0.9	6	6.7	3.6	6
C.V (%)	0.17	1.13	5.83	5.94	8.03	7.53

BW 196 variety at 70 DAT (Maximum tillering) showed significance difference for weed free treatment and total weed treatment as that of Basmati 370. At the same 70 DAT, this variety indicated that there was no significance between contact herbicide treatment and farmer practice (P<0.05). At 84 DAT the trend was similar to that of 70 DAT, however there was no significant difference between systemic treatment and farmer practice (P<0.05) indicated in table 6 below. There existed no significance difference between both contact and systemic herbicide application and farmer practice (P<0.05) at maturity period of BW 196 rice variety.

IR2793-80-1 variety at 70 DAT indicated that there was significance difference between weed free treatment and total weed treatment (P<0.05). Similarly there existed significance (P<0.05) between farmer practice and total weed treatment the same variety at maturity stage (84 DAT) showed that tiller number is not affected by weed management practice employed between total weed free, contact herbicide application, systemic herbicide application and farmers practice as there was no significance (P<0.05).

Weed management regime on plant height in centimeters for Basmati 370 variety showed that there existed significance difference at 56 days after transplanting (DAT) for weed free treatment and un-weeded treatment (P<0.05). Similarly there was also significant difference for plant height in centimeters for total weed treatment with that of contact herbicide, systemic herbicide and farmer practice at 56 DAT (P<0.05). At 84 DAT Basmati 370 variety indicated that farmer practice treatment was the highest in plant height in centimeters though not significantly different from weed free, contact and systemic treatments respectively (P<0.05)

Table 7 Plant height (cm) for three rice varieties under various weed management practices during short rains of 2014 in Mwea Irrigation Scheme

	DAYS AFTER TRANSPLANTING					
WEED MANAGEMNT PRACTICE	**14**	**28**	**42**	**56**	**70**	**84**
Basmati 370 rice variety						
Total weed free (No weed)	20.9_{a}	35.8_{a}	51.8_{a}	78.1_{b}	102.1_{b}	119.8_{b}
Un-weeded	21_{a}	36.2_{a}	52.5_{a}	65.6_{a}	88.2_{a}	107_{a}
Propanil (5lts ha^{-1})	20.6_{a}	34.3_{a}	52.2_{a}	74_{b}	98.4_{b}	115.7_{b}
2, 4-D (1.25lts ha^{-1})	20.1_{a}	35_{a}	54.5_{b}	79.1_{b}	98.8_{b}	117.7_{b}
Manual hand weeding (Farmer practice)	22.8_{b}	36.5_{a}	56.8_{b}	76.5_{b}	103.5_{b}	121.1_{b}
LSD (P≤0.05)	1.3	1.1	2.6	6.7	7.4	6.9
C.V (%)	1.25	1.12	2.59	6.73	7.44	6.92
BW 196 rice variety						
Total weed free (No weed)	20.6_{b}	35.4_{b}	47.5_{b}	52.1_{a}	$56.8_{b\,c}$	66_{b}
Un-weeded	20.5_{b}	34.4_{b}	46.5_{b}	51.8_{a}	50_{a}	50.5_{a}
Propanil (5lts ha^{-1})	19.8_{a}	33.6_{a}	47.3_{b}	53.3_{b}	58.8_{c}	65.3_{b}
2, 4-D (1.25lts ha^{-1})	19.9_{a}	35.4_{b}	45.7_{a}	53.5_{b}	$56.4_{b\,c}$	64.6_{b}
Manual hand weeding (Farmer practice)	20_{a}	32.6_{a}	45.1_{a}	51.3_{a}	54.4_{b}	62.8_{b}
LSD (P≤0.05)	0.4	1.5	1.3	1.2	2.7	3.6
C.V (%)	0.44	1.51	1.27	1.19	2.71	3.56
IR 2793-80-1 rice variety						
Total weed free (No weed)	19.4_{b}	30.1_{b}	41.9_{b}	53.1_{b}	61.9_{b}	70.9_{b}
Un-weeded	18.7_{b}	31.3_{b}	37.5_{a}	50.2_{a}	58.5_{a}	66.1_{a}
Propanil (5lts ha^{-1})	17.7_{a}	28.3_{a}	38.1_{a}	51.7_{b}	60.3_{b}	68.4_{b}
2, 4-D (1.25lts ha^{-1})	17.8_{a}	28.9_{a}	39.1_{a}	49.9_{a}	59.5_{b}	66.9_{b}
Manual hand weeding (Farmer practice)	17.4_{a}	28.7_{a}	37.5_{a}	48.8_{a}	56_{a}	62.7_{a}
LSD (P≤0.05)	1	1.5	2.3	2.1	2.7	3.7
C.V (%)	1.05	1.51	2.29	2.08	2.73	3.75

BW 196 rice variety plant height (cm) showed that weed free treatment and un-weeded treatment showed significance difference (P<0.05) at 70 and 84 DAT. Meanwhile, Un-weeded condition treatment and farmers practice were also significantly different for plant height (cm) at 70DAT and 84DAT (P<0.05). Results on plant height (cm) at 84 DAT also shows that total weed free treatment was insignificantly different (P<0.05) compared to contact herbicide, systemic herbicide and farmer practice treatments as shown in.

Weed management method employed on IR 2793-80-1 rice variety also showed that total weed free treatment was significantly different (P<0.05) to un-weed condition at 84 DAT. However there was no significance difference (P<0.05) between un-weed condition and farmer practice for plant height (cm) at same DAT as sown in the table of results. Results also indicate that at 84 DAT farmer practice was significantly the shortest (P<0.05) to that of both contact herbicide treatment and systemic herbicide application.

4.4.2 Effect of weed management practice on chlorophyll content

Results of (SPAD) meter reading values to determine chlorophyll content of Basmati 370 for total weed free treatment and Un-weeded condition treatment at 42, 56 and 70 DAT respectively showed significance difference (P<0.05). Same SPAD reading indicated that at 42 DAT there was significance (P<0.05) between farmer practice and both contact and systemic herbicide treatment.BW 196 variety displayed same trend to that of Basmati 370 on SPAD meter reading at 42, 56 and 70 DAT for weed free treatment and Un-weeded condition treatments respectively (P<0.05). Farmers practice treatment as well displayed higher significance values (P<0.05) to contact herbicide treatment at 70 DAT for the SPAD meter reading.

SPAD meter reading for short rains season for IR 2793-80-1 were no different from the previous two varieties. It indicates that there was significance difference (P<0.05) at 42, 56 and 70 DAT between weed free treatment and Un-weeded condition treatment. Besides, there were lower significance in the critical period of panicle initiation stage of this variety at 70DAT between contact herbicide treatment with that of both systemic herbicide and famer practice (P<0.05).

Table 8 Chlorophyll content for three rice varieties under various weed management practices during short rains of 2014 in Mwea Irrigation Scheme

	DAYS AFTER TRANSPLANTING			
WEED MANAGEMNT PRACTICE	**14**	**28**	**42**	**56**
Basmati 370 rice variety				
Total weed free (No weed)	35.7 b	32.8 a	32.2 b	29.4 a
Un-weeded	31.0 a	29.1 a	28.6 a	28.2 a
Propanil (5lts ha^{-1})	34.7 b	32.1 a	31.4 b	29.2 a
2, 4-D (1.25lts ha^{-1})	34.7 b	32.3 a	31.1 b	25.7 a
Manual hand weeding (Farmer practice)	32.2 a	32.2 a	31.0 b	29.5 a
LSD (P≤0.05)	2.4	1.8	1.7	4.5
C.V (%)	2.45	1.84	1.67	4.47
BW 196 rice variety				
Total weed free (No weed)	45.9b	46.4 b	43.8 b	29.5 a
Un-weeded	43.3a	43.9 a	41.9 a	33.2 a
Propanil (5lts ha^{-1})	44.5a	45.1 a	42.2 a	39.2 c
2, 4-D (1.25lts ha^{-1})	46.1b	46.8 b	43.6 b	35.5 b
Manual hand weeding (Farmer practice)	45.4b	46.1 b	43 b	34 b
LSD (P≤0.05)	1.4	1.4	1	4.4
C.V (%)	1.43	1.45	1.04	4.38
IR 2793-80-1 rice variety				
Total weed free (No weed)	40.9 b	42.7 b	38 b	29.2 a
Un-weeded	38.1 a	40.1 a	36.4 a	33.7 a
Propanil (5lts ha^{-1})	40.3 b	41.2 a	37.1 a	39.2 b
2, 4-D (1.25lts ha^{-1})	41.1 b	42.2 b	37.3 b	35.7 b
Manual hand weeding (Farmer practice)	39.4 a	41.1 a	37.3 b	33.2 a
LSD (P≤0.05)	1.5	1.3	0.7	4.5
C.V (%)	1.53	1.26	0.71	4.54

4.4.3 Effect of weed management practice on type and density of weeds

Weed count per plot for Basmati 370 rice variety indicated that weed management practices differed significantly in controlling *C. difformis (0.0002)* and *L. chinensis* L.(0.003) during short rain season. Meanwhile results show that 2, 4-Dichlorophenoxyacetic acid (1.25lts ha^{-1}) and Farmers practice had significantly more (<45) *C. difformis* (181 and 197 respectively) than other management practices. Also 2 4-D(1.25lts ha^{-1}) and Farmers practice had significantly higher *L. chinensis* population of 43and 15 respectively than other management practices. However there was no significance difference between 2, 4-Dichlorophenoxyacetic acid (1.25lts ha^{-1}) and Farmers practice.

Table 9 Weed count for three rice varieties under various weed management practices during short rains of 2014 in Mwea Irrigation Scheme

WEED MANAGEMNT PRACTICE	*Cyperus difformis*	*Leptochloa chinensis*	*Ludwigia adscendens*	*Ludwigia octavalis*	*Marselea minuta*
Basmati 370 rice variety					
Total weed free (No weed)	36_a	0_a	0_a	5_a	0_a
Un-weeded	43_a	0_a	0_a	7_a	0_a
Propanil (5lts ha^{-1})	28_a	7_a	0_a	6_a	0_a
2, 4-D (1.25lts ha^{-1})	181_b	43_b	3_a	12_b	8_a
Manual hand weeding (Farmer practice)	197_b	15_a	4_a	7a	12_a
LSD ($P \leq 0.05$)	75.2	19.9	5.4	10.5	14.9
BW 196 rice variety					
Total weed free	57_a	18_a	0_a	2_b	8_a
Un-weeded condition	222_b	53_a	0_a	8_a	14_b
Propanil (5lts ha^{-1})	73_a	20_a	2_b	11_b	30_c
2, 4-D(1.25lts ha^{-1})	87_a	27_a	0_a	7a	17_b
Farmers practice	91_a	23_a	0_a	7a	32_c
$LSD_{0.05}$	105	64	2.4	7.6	6.7
IR 2793-80-1 rice variety					
Total weed free	43_a	12_a	0_a	1_a	0_a
Un-weeded condition	103_b	69_b	0_a	9_a	8_a
Propanil (5lts ha^{-1})	43_a	17_a	2_a	7_a	3_a
2, 4-D(1.25lts ha^{-1})	52_a	14_a	0_a	1_a	2_a
Farmers practice	56_a	18_a	3_a	7_a	8_a
$LSD_{0.05}$	70.5	35.9	5.7	10	8.8

In BW 196 during short long rain, Weed managements were only significantly different in weed count for *C. difformis (p=0.0317).* Un-weeded condition plot had significantly more weed (222) than other management ($\leq$ 91). Other significance difference was realised in *M. minuta* weed(0.0453) where Propanil selective herbicide at the rate of 5lts ha^{-1}(30) and Farmers practice (32) had significantly more weed than other management (<18) (table).There were no significance differences in weed count among management for all weed species in IR2796 – 80-1 variety for short rain season (Table 16). However for *M. minuta* (Water clover) weed species, Un-weeded condition and Farmers practice management had the most weeds (both 8).

4.4.4 Effect of weed management practice on rice tillering and plant height (in centimeters).

During long rains season of 2014 weed management strategy employed on Basmati370 rice variety showed that there was a significant difference in tiller number at 56DAT between weed free treatment and total weed treatment ($P<0.05$). Results also show that weed management on Basmati 370 rice variety shows that weed free treatment is insignificant ($P<0.05$) with farmer practice treatment but significant ($P<0.05$) for other treatments at 56 DAT.

BW 196 rice variety at 70DAT indicated that weed free treatment is significantly different ($P<0.05$) with total weed and systemic herbicide treatments respectively for tiller number. This however was not the case for the results of weed free treatment and farmer practice which showed insignificance ($P>0.05$) for tiller count as indicated. Results for IR 2793-80-1 rice variety on tiller number indicated that at 56, 70 and 84 Days After Transplanting (DAT), plots that were weedy throughout had significantly lower tiller numbers compared to the rest of the treatments which similar and superior.

Table 10 Number of tillers for three rice varieties under various weed management practices during long rains of 2014 in Mwea Irrigation Scheme

	DAYS AFTER TRANSPLANTING			
WEED MANAGEMNT PRACTICE	28	56	70	84
Basmati 370 rice variety				
Total weed free (No weed)	7_a	22_c	29_c	29_b
Un-weeded	7_a	15_a	20_a	20_a
Propanil (5lts ha^{-1})	6_a	18_a	26_b	26_b
2, 4-D (1.25lts ha^{-1})	6_a	15_a	25_b	26_b
Manual hand weeding (Farmer practice)	7_a	19_b	27_b	27_b
$LSD_{0.05}$	0.7	3.8	4.1	4.3
C.V (%)	0.74	3.77	4.11	4.29
BW 196 rice variety				
Total weed free (No weed)	16_b	28_b	34_b	35_b
Un-weeded	16_b	23_a	24_a	23_a
Propanil (5lts ha^{-1})	15_a	24_b	30_b	31_b
2, 4-D (1.25lts ha^{-1})	15_a	19_a	27_a	24_a
Manual hand weeding (Farmer practice)	15_a	26_b	32_b	32_b
$LSD_{0.05}$	0.6	4	4.7	6.5
C.V (%)	0.65	4.00	4.71	6.48
IR 2793-80-1 rice variety				
Total weed free (No weed)	23_b	30_b	35_b	33_b
Un-weeded	20_a	22_a	22_a	20_a
Propanil (5lts ha^{-1})	24_b	31_b	31_b	31_b
2, 4-D (1.25lts ha^{-1})	21_a	31_b	31_b	28_b
Manual hand weeding (Farmer practice)	23_b	32_b	31_b	32_b
$LSD_{0.05}$	1.9	5	6	6.3
C.V (%)	1.93	5.00	5.96	6.34

Effect of weed management strategy for Basmati 370 variety showed that farmer practice treatment was significantly different P<0.05) to the rest of the treatments on plant height (cm) at 70 DAT. Similarly there was no significant difference (P>0.05) between weed free treatment and total weed for plant height (cm) at the same date. However, contact, systemic and farmer practice treatments respectively were significantly different (P<0.05) for plant height at 56 DAT as represented in table below.

Results for BW 196 rice variety show that there was a notable significance difference (P<0.05) between effect of weed free treatment and the rest of the treatments for plant height (cm) at 84 DAT. It indicates also that total weed treatment is the tallest in plant height (cm) though insignificantly (P<0.05) compared with those of contact, systemic and farmer practice treatments respectively. Weed management for IR 2793-80-1 rice variety shows that there was no significance difference (P<0.05) in plant height for all the five treatments at 84 Days after Transplanting (DAT) as shown in plant height table.

Table 11Plant height (cm) for three rice varieties under various weed management practices during long rains of 2014 in Mwea Irrigation Scheme

	DAYS AFTER TRANSPLANTING			
WEED MANAGEMNT PRACTICE	28	56	70	84
Basmati 370 rice variety				
Total weed free (No weed)	31.3 b	38.7 b	57.3 a	66.3 a
Un-weeded	32 b	35.7 a	56 a	66.3 a
Propanil (5lts ha^{-1})	30.3 a	38.7 b	54 a	65.3 a
2, 4-D (1.25lts ha^{-1})	29.7 a	41 b	57.7 b	68 b
Manual hand weeding (Farmer practice)	31.3 b	38 b	61.3 c	65 a
$LSD_{0.05}$	1.1	2.4	3.3	1.5
C.V (%)	1.13	2.35	27.79	1.46
BW 196 rice variety				
Total weed free (No weed)	31 b	33.3 a	41 a	45 a
Un-weeded	30.7 b	32.7 a	41.7 a	50.3 b
Propanil (5lts ha^{-1})	31 b	37 b	41 a	47.7 b
2, 4-D (1.25lts ha^{-1})	29 a	36 b	42 a	49.7 b
Manual hand weeding (Farmer practice)	31.3 b	34.3 a	45.3 b	48.3 b
$LSD_{0.05}$	1.1	2.2	2.2	2.6
C.V (%)	1.14	2.25	2.22	2.57
IR 2793-80-1 rice variety				
Total weed free (No weed)	33.7 b	40.3a	49.7 b	56 a
Un-weeded	31 a	51 b	51 b	56.7 b
Propanil (5lts ha^{-1})	33 a	48 b	48 b	55.3 a
2, 4-D (1.25lts ha^{-1})	35.3b	47 b	47 b	55.3 a
Manual hand weeding (Farmer practice)	34 b	41.7 a	41.7a	56 a
$LSD_{0.05}$	2	5.6	4.4	0.7
C.V (%)	1.96	5.56	4.44	0.73

4.4.5 Effect of weed management practice on chlorophyll content.

SPAD meter reading gave a rapid, non-destructive estimate of relative leaf chlorophyll content and therefore predicted nitrogen nutrition index. Results from the data therefore gave a relative impact of weeds on crops (Zaefarian, 2012).Results suggests effect of weed management practice on Basmati 370 rice variety shows that Propanil selective herbicide treatment was significantly different (P<0.05) from the rest of the treatments at 56 DAT. The trend changed at 70 DAT for plant chlorophyll content and subsequently Nitrogen in both plant and soil of Basmati 370 variety as weed free and Un-weeded condition treatment remained insignificant (P>0.05) but significantly different (P<0.05) with the other three treatments of contact, systemic and farmer practice.

Table 12 SPAD reading for three rice varieties under various weed management practices during long rains of 2014 in Mwea Irrigation Scheme

	DAYS AFTER TRANSPLANTING		
WEED MANAGEMNT PRACTICE	28	56	70
Basmati 370 rice variety			
Total weed free (No weed)	37.0 $_a$	40 $_a$	35.3 $_a$
Un-weeded	38.3 $_b$	39.3 $_a$	33.6 $_a$
Propanil (5lts ha^{-1})	37.3 $_a$	41.7 $_b$	35.7 $_a$
2, 4-D (1.25lts ha^{-1})	38.7 $_b$	40.3 $_a$	39.3 $_b$
Manual hand weeding (Farmer practice)	39.3 $_b$	40 $_a$	37.7 $_b$
$LSD_{0.05}$	1.2	1.1	2.7
C.V (%)	1.19	1.10	2.75
BW 196 rice variety			
Total weed free (No weed)	44 $_a$	46.3 $_b$	44.3 $_b$
Un-weeded	44.3 $_b$	42.3 $_a$	39.7 $_a$
Propanil (5lts ha^{-1})	42.3 $_a$	46.3 $_b$	45.7 $_b$
2, 4-D (1.25lts ha^{-1})	46 $_b$	47 $_b$	45 $_b$
Manual hand weeding (Farmer practice)	45.7 $_b$	46.7 $_b$	44.3 $_b$
$LSD_{0.05}$	1.8	2.4	2.9
C.V (%)	1.84	2.40	2.94
IR 2793-80-1 rice variety			
Total weed free (No weed)	43 $_a$	47 $_b$	42 $_b$
Un-weeded	45 $_b$	44.3 $_a$	38.3 $_a$
Propanil (5lts ha^{-1})	44 $_a$	46.3 $_b$	41.3 $_a$
2, 4-D (1.25lts ha^{-1})	43.3 $_a$	46.7 $_b$	45.7 $_c$
Manual hand weeding (Farmer practice)	43 $_a$	45.7 $_b$	42.3 $_b$
$LSD_{0.05}$	1.1	1.3	3.3
C.V (%)	1.06	1.33	3.28

BW 196 rice variety indicated that there was significant difference (P<0.05) between Un-weeded condition treatment and the rest of the treatments for SPAD meter reading at 56 DAT and 70 DAT respectively.

There was significance difference (P<0.05) for Un-weeded condition treatment and the rest of the treatments for SPAD meter reading of IR 2793-80-1 at 56 DAT. This changed at 70DAT as there was insignificance (P>0.05) on SPAD meter reading values for total weed free and farmer practice treatment as shown in the table. Systemic herbicide treatment however had significant higher values (P<0.05) to those of contact herbicide treatment for IR 2793-80-1rice variety at 56 DAT.

4.4.6 Effect of weed management practice on type and density of weeds

Basmati 370 long rain, Weed managements were only significantly different in weed count for *C. difformis (p=0.034).* Un-weeded plot had significantly more weed (310) than other management (≤ 73) while other weed species did not differ significantly among the five weed management.

Plots that had BW 196 rice variety during long rain showed that weed management strategies were only significantly different in weed count for *C. difformis spp* (p=0.0065).Un-weeded plot had significantly more weed (207) than other weed management practices employed (≤ 61). Results also indicated that in other species, weed count did not differ significantly among the five weed management practices used. Weed Management types differed significantly in weed count for species weed of *C. difformis (0.0414), L. chinensis (0.0011)* during long rain season in those plots planted with IR 2796-80-1 rice variety. For *C. difformis* un-weeded had significantly more while for *L. chinensis*, farmer practice had significantly more than other management.

Table 13Weed count for three rice varieties under various weed management practices during short rains of 2014 in Mwea Irrigation Scheme

WEED MANAGEMNT PRACTICE	*C. difformis*	*L. chinensis*	*L. adscendens*	*M. vaginalis*	*L. octavalis*	*L. hexandra*	*M. minuta*	*S. cyakuloides*
Basmati 370 rice variety								
Total weed free (No weed)	25_{a}	1_{a}	3a	2_{a}	0_{a}	0_{a}	1_{a}	-
Un-weeded	310_{b}	5_{a}	7_{b}	14_{a}	7_{b}	1_{a}	3_{b}	-
Propanil (5lts ha^{-1})	27_{a}	0_{a}	1_{a}	6a	15_{a}	1_{a}	1_{a}	-
2, 4-D (1.25lts ha^{-1})	52_{a}	1_{a}	2_{a}	1_{a}	3a	0_{a}	0_{a}	-
Manual hand weeding (Farmer practice)	73_{a}	2_{a}	5_{a}	3a	8_{a}	0_{a}	0_{a}	-
$LSD_{0.05}$	166	5.6	4.6	15.6	24.9	1.2	1.5	-
BW 196 rice variety								
Total weed free (No weed)	61_{a}	1_{a}	2_{a}	2_{a}	0_{a}	0_{a}	0_{a}	0_{a}
Un-weeded	207_{c}	2_{b}	10_{a}	5_{a}	8_{a}	1_{a}	2_{a}	1_{a}
Propanil (5lts ha^{-1})	29_{a}	0_{a}	1_{a}	4_{a}	0_{a}	0_{a}	0_{a}	1_{a}
2, 4-D (1.25lts ha^{-1})	23_{a}	0_{a}	1_{a}	0_{a}	2_{a}	0_{a}	0_{a}	1_{a}
Manual hand weeding (Farmer practice)	95_{b}	1_{a}	7_{a}	5_{a}	5_{a}	0_{a}	0_{a}	1_{a}
$LSD_{0.05}$	61.8	1.8	9.8	7.5	9.5	1	2.6	2.8
IR 2793-80-1 rice variety								
Total weed free (No weed)	43_{a}	1_{a}	4_{a}	1_{a}	2_{a}	0_{a}	1_{a}	0
Un-weeded	331_{b}	2_{a}	6_{a}	3_{a}	9_{b}	0_{a}	0_{a}	1_{a}
Propanil (5lts ha^{-1})	47_{a}	0_{a}	2_{a}	2_{a}	4_{a}	1_{a}	0_{a}	0
2, 4-D (1.25lts ha^{-1})	29_{a}	1_{a}	0_{a}	4_{a}	2_{a}	0_{a}	1_{a}	0
Manual hand weeding (Farmer practice)	112_{a}	5_{b}	9_{b}	2_{a}	4_{a}	0_{a}	1_{a}	0
$LSD_{0.05}$	180	2.3	7.8	2.5	5.2	1	1.5	-

4.4.7 Effects of weed management practice on Yield of rice

Yield parameters for Basmati 370 rice variety indicates that productive tillers (PT) for plots treated with farmer practice had higher significant number ($P<0.05$) to that of systemic herbicide, contact herbicide and Total weed free treatments. Similarly the same trend was shown for filled grains (FG) parameter for Basmati 370 rice variety which showed that there was significance difference

($P<0.05$) for Un-weeded condition treatment with the rest. 1000 Grain weight parameter for the same variety was significantly different ($P<0.05$) for farmer practice and the rest of the treatments. Yield (tons/hectare) for short rains resulted in significance difference between Un-weeded condition and contact treatment respectively with that of the rest. In short rains, also indicated that plots with significantly ($P<0.05$) highest yield (tons/hectare) was from weed free and systemic herbicide treatments. It also shows results for yield (tons/hectare) for long rains and that total weed treatment were significantly different ($P<0.05$) with the rest of the treatments.

Results on productive tillers (PT) for BW 196 rice variety shows that there was no significance difference ($P>0.05$) between farmer practice treatments and those of both systemic and contact chemical treatments despite higher values. While filled grains indicated that there was significantly lower grains ($P<0.05$) between weed free treatment and the rest of treatments. Total weed free was significantly different ($P<0.05$) with the rest of treatments for 1000 grain weight (g) as indicated in table. Meanwhile yield (tons/hectare) for both short rains and long rains indicated that there was significance ($P<0.05$) between Un-weeded condition and the rest of the treatments for BW 196 rice variety under lowland condition. Results for yield (tons/hectare) during the two seasons shows that weed free treatment was the highest though not significantly ($P<0.05$) compared with other treatments except Un-weeded condition.

Table 14 Yield for three rice varieties under various weed management practices during short rains of 2014 in Mwea Irrigation Scheme

TREATMENT	Productive Tiller	Non Productive Tiller	Filled Grains	Empty Grains	Grain Weight (g)	LONG RAINS Yield (tha^{-1})	SHORT RAINS Yield (tha^{-1})
Basmati 370 rice variety							
Total weed free (No weed)	17.3b	2_a	75_b	7_a	20.7_a	6.5b	7b
Un-weeded	10.7a	3.3_b	40_a	8_a	20.7_a	2a	3.2a
Propanil (5lts ha^{-1})	14.7b	2.3_a	48_a	9_a	20.7_a	3.1a	6.6b
2, 4-D (1.25lts ha^{-1})	17b	2.7_b	77_b	12_b	20.7_a	6.1b	6.5b
Manual hand weeding (Farmer practice)	18.7c	3_b	61_b	11_b	21_b	5.5b	5.7b
$LSD_{0.05}$	3.9	0.6	20.3	2.4	0.2	2.5	1.9
C.V (%)	3.89	0.65	20.29	2.38	0.17	2.46	1.89
BW 196 rice variety							
Total weed free (No weed)	35.7_b	1_a	50_a	11_b	26.7_b	11.3_b	9.8_b
Un-weeded	16_a	1.3_b	57_b	6_a	24_a	4.9_a	3.7_a
Propanil (5lts ha^{-1})	28.3_b	1.3_b	60_b	10_b	26.7_b	10.3_b	9.3_b
2, 4-D (1.25lts ha^{-1})	20.3_a	1_a	56_b	11_b	26.3_b	6.9_a	8.5_b
Manual hand weeding (Farmer practice)	29.7_b	1_a	54_a	8_a	27_b	10.3_b	8.4_b
$LSD_{0.05}$	9.7	0.2	4.7	2.6	1.5	3.4	3
C.V (%)	9.73	0.20	4.72	2.61	1.52	3.37	3.04
IR 2793-80-1 rice variety							
Total weed free (No weed)	31_b	0.6_a	73_a	14_b	24.7_a	13.9_b	9.4_b
Un-weeded	12.7_a	1.6_b	68_a	15_b	24.7_a	5.1_a	4.9_a
Propanil (5lts ha^{-1})	27_b	1_a	88_b	14_b	24.7_a	14.6_b	8.4_b
2, 4-D (1.25lts ha^{-1})	26.7_b	1.3_b	76_a	9_a	25_a	12.6_b	8.5_b
Manual hand weeding (Farmer practice)	27.3_b	1.3_b	74_a	9_a	25.3_b	13.1_b	8.3_b
$LSD_{0.05}$	8.8	0.5	9.1	3.4	0.3	4.8	2.2
C.V (%)	8.77	0.47	9.08	3.44	0.33	4.79	2.16

Weed management on IR 2793-80-1 rice variety showed that results for productive tillers (PT) indicated a lower number of PT though not significantly difference ($P>0.05$) for systemic herbicide and the rest of the treatments except Un-weeded condition. Contact herbicide treatment showed significantly ($P<0.05$) higher number of filled grains compared to the rest of the treatments. Results for 1000 grain weight showed that farmers practice were significantly ($P<0.05$) the heaviest (g) relatively to the rest.

Yield (tons/hectare) for the variety, indicated that during long and short rains respectively, total weed treatment significantly differed ($P<0.05$) with the rest of the treatments as shown in the table below.

4.5 Discussion

Weed management trials that were carried out for two seasons indicated that weeding is very important during tillering stage. During both long rain and short rain seasons, effect of weed on the number of tillers was evident at ($P<0.05$). Weed effect on the number of tillers could not be distinguished as all the three varieties showed that tillering was compromised by weeding management practice employed. This therefore clearly suggests that lack of proper weeding will essentially compromise good tillering for all the three popular rice varieties. Results after Statistical data analysis indicate that farmer practice on weed management is ideal for good tiller count on all the lowland irrigated rice varieties used (Jamshid, 2012). Tiller number at maturity period of Basmati 370 rice variety was positively affected by contact herbicide and shows that farmers practice is similar to what contact herbicide does albeit the less cost involved. Meanwhile, use of chemical application to manage weeds has no importance in terms of better results as far as tiller number effect on BW 196.

For cost reduction in weed management, use of chemical application is recommended especially systemic herbicide application which has insignificant higher tiller count but lower than that of farmer practice during short rains. The case with IR 2793-80-1 show that the three weed management practice being tested will give similar results with that of total weed free condition and therefore will recommend the lesser costly method of practice (Jamshid, 2012). Transplanted rice should be weed free at 30-45 days after transplanting while direct seeded rice is 15-45 days after seeding is the critical period of crop weed competition. This is the period from sowing up to which the crop has to be maintained in a weed free environment for remunerative crop production (Caton, 2012)

Effect of weed management of lowland rice crop on plant height in centimeters during both short rains and long rains season respectively was also very evident. Results during the two seasons at maturity stage when the crop no longer grows suggests that weed management on rice will either elongate further or cause some varieties to stagnate (Merry, 2015). Basmati 370 rice varieties unlike the other two varieties of BW 196 and IR 2793-80-1 seemed to have been caused to stagnate by the effect of weed. At maturity stage however, Basmati 370 had taller plants in those plots treated with farmer practice as weed management practice. This probably because of hand weeding which disturbs the soil and ultimately the roots of the crop therefore catalyzing extended elongation of Basmati 370 (Jamshid, 2012).

On the other hand BW 196 and IR 2793-80-1 displayed mixed effect during both short and long rain season respectively. Efforts to do perfect weeding for BW 196 rice variety will not translate to any change in plant length as shown by the results at 70 and 84 DAT respectively. IR 2793-80-1 during long rains indicated that plant height for those plots treated with total weed condition was taller than the rest of the treatments suggesting that weed infestation could play a role in elongation possibly due to competition. However, farmers' practice of weed management is enough to ensure that all the three varieties of rice attain maximum plant height as described by breeders manual (National irrigation Board, 2011).

Different weed management practices employed on the three different rice varieties suggest an effect on SPAD meter reading on chlorophyll content. Basmati 370, BW196 and IR 2793-80-1 rice varieties showed consistence significance difference ($P<0.05$) across the two seasons in weed management practice for SPAD meter reading. Treatments with chemical application in short rains season, (contact and systemic herbicide respectively) show better results for chlorophyll coloration in Basmati 370 rice variety. This in addition to the fact that it is less costly to manage weeds by use of chemical herbicide and achieve similar results as that of manual hand weeding which is the practice with farmers(Maxwell, 2000). The results show significance ($P<0.05$) between un-weeded condition and the rest of the treatments for SPAD meter reading at 70 DAT for two seasons. This suggests that any weeding management practice employed will have a positive response on the chlorophyll content of lowland rice cultivation. contact herbicide application seem to have a negative effect on the coloration of BW 196 variety as the trend was also confirmed in the second season and translated to lower yields in the short rains. This therefore suggests use of contact herbicide for this variety will not translate to cost saving as it eventually lower the yield achieved (Merry, 2015). All weeds on crop field may not be harmful (Cheryl, 2006). At low density, weeds do not affect yield and certain weeds can even stimulate the crop growth (Yu *et al*, 1996). The best way of weed management is to make use of it, to promote it to a level of wanted plants.

The same phenomena was repeated as contact herbicide application seem to suggest negative results for SPAD meter reading at crucial panicle initiation stage of IR 2793-80-1 rice variety.

During short rains, lower yields were harvested while contrary a good yield per hectare in long rains was due to high number of filled grains. It is noteworthy though that significant lower value of SPAD meter reading of contact herbicide treated plants during long rains could be as a result of mode of action of this herbicide on the variety (Maxwell, 2000).

Yield (tons per hectare) of lowland rice is influenced by weeding method employed regardless of the season. A farmer will save average of up to 38.2%, 40.6% and 44.4% for Basmati 370, BW 196 and IR 2793-80-1 respectively if total weed free management practice is in used. This is the case as those rice components that determine yield are thought to be enhanced by weeding method. Nonproductive tillers (NPT) were relatively reduced by weeding method employed for all the three varieties which means the number of tillers which will give rice to rice grains are improved (Merry, 2015). Farmer practice on weed management under low land condition is ideal in achieving optimum rice yield. The three varieties that were used in the experiment gave impressive results in the two seasons for suggesting that whatever the method a farmer will practice will give good yield. Work involved and accompanying cost in doing weeding will inform the difference in cost implication.

CHAPTER FIVE: GENERAL DISCUSSION, CONCLUSIONS AND RECOMENDATIONS

5.1 General Discussion

The experimental study revealed that farmers practice on weed management in the scheme has a significant effect on the crop performance. Through the two seasons under study it is obvious farmers need to practice good agricultural practices especially if weed menace is to be checked to enable them achieve optimum yield per unit area. Farmers practice on weed management was shown to be adequate in getting a good rice crop with optimum yield produce. However in some aspects chemical weed control will score better than farmers' practice especially when cost factor is considered. During short rains season Propanil selective herbicide (5lts ha^{-1}) suggested to be a better option to control weeds in Basmati 370 rice variety plots. Not only did it (Propanil selective herbicide at 5lts ha^{-1}) control other weeds but also it managed *Cyperus difformis* (Small Flower umbrella nut sedge and *Leptochloa chinensis* L, (Red spranletop) weeds which were a problem during the season as well as globally (Goldblatt *et al*, 2000).

Timing of weeding in rice production is essential more so when using herbicides as it will save on time and cost. Transplanted rice should be weed free at 30-45 days after transplanting while direct seeded rice is 15-45 days after seeding is the critical period of crop weed competition. This is the period from sowing up to which the crop has to be maintained in a weed free environment for remunerative crop production (Caton, 2012). There is also a strong linear relationship between SPAD values and leaf nitrogen concentration, but this relationship varies with crop growth stage and/or variety mostly because of leaf thickness or specific leaf weight (Virmani, 1994). The linear relationship between nitrogen and SPAD values has led to the adaptation of the SPAD meter to assess crop nitrogen status and to determine the plant's need for additional nitrogen fertilizer. SPAD readings indicate that plant nitrogen status and the amount of nitrogen to be applied are determined by the physiological nitrogen requirement of crops at different growth stages (Cheryl, 2006). Nutrient deficiency is also associated much with weed infestation thereby giving target crop nutritional competition. Therefore to maintain optimum levels of required plant nitrogen, management of paddy field weeds is one of the most important Agricultural practices among others.

Mwea irrigation scheme farming community are willing to practice what they feel is ideal to manage weeds in their paddy fields. This is a fact due to the fact that farmers' in the scheme are quick to embrace a technology which has been tested and brought to them through various dissemination measures (Ministry of Agriculture, 2012). Weeds in paddy field is slowly becoming a major worry and which farmers have unanimously felt requires more time from all the concerned stakeholders to address.

5.2 Conclusion

Weed management in rice farming is very important for a good crop and ultimately enhanced yield per unit area. Rice production in lowland paddy condition will adequately require one hand weeding and herbicide chemical application for good results. More than three hand weddings and application of a chemical in between suggests ideal only when situation is in dire need. This will push the cost of weed management slightly higher and in some cases double the cost of doing it on time. Weeds require proper timing to be said it has been managed and therefore good land preparation is essential to achieve it.

Farmer level of under is very encouraging especially on integrated weed management strategy because of their educational levels and more so through their extended experience in rice farming. The gap that exists currently in terms of young generation and those with extended experience, compliments new strategies based on current situation and convectional way of weed management. Therefore, suppose a well-planned knowledge management strategy is employed to lowland rice ecological setup farmer will reduce loss of significant yields per unit area (Merry, 2015).

5.3 Recommendation

Study will recommend further study on effect of herbicide chemical spray is capable of causing in the long term as well as on grain yield of lowland rice cultivation in tropics. This information will inform further on different formulation of chemical herbicides and negative effects on the agronomy of a rice crop. Mapping of the scheme is also very important to enable identification of areas which are affected by each category of weeds for informed choice of mitigation measures. Areas which experience water shortage are thought to have different weed family compared to those areas which relatively receive good volumes of irrigation water. Life cycle and dormancy of some of the most significant weeds is very critical in better management of these weeds. Study on their behavior under lowland paddy conditions is also very critical as this information will enable farmers to do proper integrated weed management for enhanced rice crop.

REFERENCES

Anima M.V.R. *et al*, 2013. Site Suitability Analysis of SRI (System of Rice Intensification) Cultivation in Potential Rice Cropped Areas of Andhra Pradesh: A Geospatial Approach. Page 15-23.

Akobundu I.O., 1994, Weeds and their control In: Introduction to Tropical Agriculture. Food and Agricultural organization. 3:160-179

Auld B.A, Kim K.U (ed), 1996. Weed management in rice. Food and Agricultural Organization. Page 178-188.

Awotundun J. S. (2004). Evaluation of Time and Frequency of Weeding on the Grain Yield of an Upland Rice. Karnataka J. Agri. Science, 2: 229-233

Bhagirath S. C (2013). Management strategies for weedy rice in Asia. Australian university press.1:1-4

Caton B. P., Mortimer M, Hill J. E, Johnson D. E., (2nd Ed), 2012. A practical field guide to weeds of rice in Asia. International Rice Research Institute. 2: 12-85

Cheryl L. Baisden (2006), Images of America South west farming. Arcadia publishing. 1:86-112

Dangwal L.R., *et al* (2012), Major weeds of paddy fields in district rajouri (j&k) India. ournal of The Bombay Natural History Society. Volume: 93:527-531.

Dario H., Božena M., Dubravka S., Antun A. 2015. Echinochloa colona (L.) Link (Poaceae), a new species in the flora of Croatia. 74 (1):159–164

David E. Johnson, (2009). Weed management in small holder rice production in the tropics, International Rice research Institute, page 2-6.

De Datta S. K and Herdt R. W. (1981) Weed control technology in irrigated rice, International Rice research Institute, page 115-160

Ferrero A (2003). Weedy rice, biological features and control in: Labrada R (ed) Weed management for developing countries. Addendum 1. FAO Plant Production and Protection Paper, Rome, Italy, pp 89–109.

Goldblatt and Manning, 2000 http://link.springer.com/journal/606

Holm L.G., Pluckenett D.L, Pancho J.V., Herberger J.P. (1977): The World's Worst Weeds Distribution and Biology. The University Press of Hawaii, Honolulu, Page 56-112.

Jonne Rodenburg and David E. Johnson, (2013) Realizing Africa's Rice Promise-CAB International. Africa Rice Center page 204.

Kate M. and Giles Johnson N. (2000) Chlorophyll florescence-A practical guide. Journal of experimental Botany. 49:1563-1573.

KwesiAmpong-Nyarko and S.K De Datta (1991). A hand book for weed control in rice, International Rice research Institute. 2: 1-5

Matsunaka S. (1970). Evolution of rice weed control practices and research: World perspective publication. 2:5-6.

Merry A., Ida N., YuyunY, Tualar S., (2014). Effect of Difference Weed Control Methods to Yield of Lowland Rice in The SOBARI: http://dx.doi.org/10.1016%2Fj.profoo.2015.01.035

Ministry of Agriculture (2008). National Rice development strategy-Government Policy paper page 4-10

Ministry of Agriculture Livestock and fisheries, (2012). RICEMAPP Baseline survey for Mwea Irrigation Scheme. Page 1-17.

Moussa S. *et al,* (202). Towards a rational use of Africa rice for breeding in sub-saharan Africa. Global science books. Journal 1: 3-4.

Naipictuasdharwad, (2009). Weed Management in rice, Agropedia edition. http://agropedia.iitk.ac.in/

Nguu V. N, Aldo F. (2006).Meeting the challenges of global rice production page 1-8

Noda K. and Chisaka (1977). Farmers' weed control technology in mechanized rice systems in East Asia 1977 page 153-160

Peter G. and John C. Manning (2000). Plant diversity of the cape region of southern Africa page 282-288.

Johnson, D.E., Wopereis, (2004) Timing of weed management and yield losses due to weeds in irrigated rice in the Sahel. *Field Crops Research* 85, 31–42

Jonne R., and David E. (2008) Managing weeds of rice in Africa. Page 1-3

Rao, A.N., Johnson, D.E., Sivaprasad, B., Ladha, J.K. and Mortimer, A.M. (2007) Weed management in direct-seeded rice. Advances in Agronomy 93, 153–255.

Rodenburg, J. and Demont, M. (2009) Potential of herbicide resistant rice technologies for sub-Saharan Africa. AgBioForum 12, 313–325.

Rodenburg, J., Zossou, N., Gbehounou, G., Ahanchede, A., Touré, A., Kyalo, G. and Kiepe, P. (2011b) Rhamphicarpa fistulosa, a parasitic weed threatening rain-fed lowland rice production in sub-Saharan Africa – a case study from Benin. Crop Protection 30, 1306–1314.

Shamiul M. Islam (2008), Ratoon rice response to different fertilizer doses in irrigated rice, page 197-202.

Virmani S.S. (1994). Hybrid rice technology- New developments and future prospects International Rice research Institute, page 93-95.

Tatsushi T. (2011). Rice cultivation hand book, March 2011 page 1-2

Wanjogu R.K, (2012) Report on evaluation of Clomazone herbicide for weed control in paddy fields at Mwea irrigation scheme. Page 1-2

Yabuno, T., 1983: Biology of Echinochloa species in Weed control in Rice. International Rice Research Institute and International Weed Science Society, Manila. 1:307–318

Yu Weiand Benli Gu, (1996) Acoustical imaging Volume 20, South East University China, page 497-499.

Zaefarian I .F. *et al* (2012), Leaf Chlorophyll of Corn, Sweet basil and Borage under Intercropping System in Weed Interference. Vol: 6 Page 260-262.