Weed Population Diversity, Distribution and Relative Abundance in Soybean Experimental Field, University of Juba

*[1]Peter B. S. Gama and [2]Modi Joseph Buga
[1]Department of Agricultural Sciences,
School of Natural Resources and Environmental Studies (SNRES), University of Juba
P.O. Box 82 – Juba, South Sudan and [2]MSF-Belgium (Medicines' Sans Frontieres), Juba, South Sudan

* Corresponding author: minyolika@gmail.com

ABSTRACT

Weed management is essential for any agricultural production system as they compete with cultivated food crops for limited resources such as water, nutrients and light. Weeds can reduce soybean yield by almost 37%. To develop a sound integrated crop and weed management, it is crucial to conduct a study on distribution and abundance of weed plant species in the field, especially where legumes such as soybean, kidney beans, cowpea, and green gram are grown. The survey was carried out at the Experimental Farm aimed to identify common weed species and their respective families that prevail in the soybean field. Soybean, *Glycine max*, is an herbaceous annual plant in the family Fabaceae grown for its edible seeds. However, presence of noxious weeds hamper its production. Results of the field survey, so far, revealed that out of the 17 species identified, 14 were from various botanical families falling under three (3) classes according to their life span namely annuals, perennials and annuals/perennials. Moreover, eleven (11) species out of the overall species identified were annuals, 4 species are perennials and 2 species were annual/perennial weeds and it was found that the highest abundant weed was *Trianthema portulacastrum* with a RA of 39.3% and the least abundant species was *Sida acuta* with a relative abundance (RA) of 5.8%. Therefore, it is advisable to less resourced farmers to adopt an integrated weed management (IWM) in their weed control so that weed species with the highest RA should be given priority in weed management strategy according to their RA in the field.

Keywords: Weeds, *Glycine Max* L. (Merrill), Plant Diversity, Relative Abundance, Field Density.

INTRODUCTION

Weed management is essential for any current system of agricultural and horticultural crop production. To develop a sound integrated crop and weed management, it is crucial to carry out a survey on distribution and abundance of weed plant species in the field, especially in legumes such as French beans, cowpea, soybean and green gram.

Arable land use with mainly annual, occasionally perennial crops, is always accompanied by growth of arable weeds—spontaneously emerging, mostly annual, some perennial species adapted to arable conditions (Hanzlik and Gerowitt, 2016). However, weeds compete with cultivated food crops for limited resources (water, nutrients and light) (Cowie and Werner, 1993). Weed infestation also encourages disease problems, serves as alternate host for deleterious insects and diseases, slows down harvesting operation, increases the cost of production, reduces the market value of crops and increases the risk of fire in perennial crops, plantation and forest reserves, but some weeds (considered as neglected plant species) have nutritional values higher than other food crops (Hayashi *et al*., 2013).

Weed management is essential for any current system of agricultural production, especially for large monocultures known areas, which exert high pressure on the environment. Soybean is among the largest monoculture worldwide, with 102 million hectares (ha) harvested in 2010. The leading producing countries are Argentina, Brazil and the United States, with more than 70% of the total cultivated area. China and India produce 20%. These five countries represent 90% of world's soybean area. The

production incentive is related to growing global demand for oil and protein for food and feed, as well as the possibility of the crop for biodiesel production, is extremely important for the global economy.

However, weeds are considered the number one problem in all major soybean producing countries. Even with advanced technologies, producers note high losses due to interference by weeds. According to estimates, weeds, alone, cause an average reduction of 37% on soybean yield, while fungal diseases and pests account for 22% of losses. In the United States, weeds cause losses of several millions of US dollars annually. In Brazil, with an average production of 75 million tons, it is estimated that expenses on weed control represent between 3% and 5% of total production cost, which means more than US$ 1.2 billion used in that country, only for chemical control of weeds in soybeans.

The weed seed bank serves as history of the past cropping systems, and knowledge of its content (size and species composition) can help producers both anticipate and ameliorate potential impacts of crop weed competition on crop yield and quality. Weed seeds and other propagules like tubers, bulbs, rhizomes, and other vegetative structures on the surface of the soil disseminated from other areas or released by yielding of existing weeds in situ and those removed from the soil surface by tillage operations are reburied into the soil by either weeding or cultivation and later germinate and then emerge to the soil surface. Hence the weed frequency or density of the weed species increases affecting crop growth and yields. Some weed species are resistant to control measures so they continue to occur irrespective of any cultural, mechanical or chemical control.

The aim of this study was to investigate the weed species prevailing in the soybean field with specific objectives of identifying the different weed species, distribution and their abundance in the soybean field in the University of Juba Experimental Farm. Documenting the weed species present in any crop especially soybean fields and development of cultural practices used to control those weeds not only allows comparisons with past and future surveys, but assists in establishment of ICM (integrated crop management) and minimizes crops losses. Furthermore, documenting the relative importance of weed species also facilitates the establishment of priorities for research and extension activities.

MATERIALS AND METHODS

Study area

The survey was carried out in the Experimental Farm, Department of Agricultural Sciences University of Juba, Central Equatoria State, and South Sudan through August to December 2016. The study site is located at the latitude of 4°50'N and longitude 31°35'E, altitude of 650 m above sea level and lies in the Hills and Mountains agro-ecological zone of South Sudan (found along the Nile to the north of the Greenbelt) with wet and dry seasons and annual rainfall of 900-1200 mm (UNEP, 2007) mostly during the months of April to October. The average temperature was 29°C during the rainy season and about 35°C during the dry season (University of Juba research data, 2013). The soil was alkaline sandy clay loam with pH ranging from 7.8-8.5.

Experimental design and field layout

The survey was undertaken using commonly accepted botanical survey methods to locate, and identify the weeds present in the soybean plots. The survey methods involved searching, identifying and counting different weed species. A stratified random sampling procedures was adopted as described by Thomas (1985).

The total size of the field was 16 m x 20 m (320 m^2) and divided in two blocks with the size of 160 m^2 consisting of 3 replicates each with the distance of 40 cm between the blocks and each replicate consisted of 18 plots making a total of 54 plots per block. The size of the plot was 2.5 m^2 and the distance between the plots was 40cm as a set up by the agronomical requirement thereafter the two blocks of the surveyed area were renamed as field 1 and field two and field one was chosen at random. The three replicates were renamed as block A, block B, block C respectively. In each block six plots were selected

randomly and an area of 1 meter square (1 m^2) was marked equivalent to a standard quadrant using a tape measure. The number of individual weed species was determined in the 6 quadrants from each block (A, B, and C).

The layout of the field was as described in the experimental design and are designed to include the changes in the partition names of the soya bean field to suit the survey as described by Thomas (1985). The plant materials used in this experiment consisted of seeds of 17 soybean genotypes obtained from the International Institute for Tropical Agriculture (IITA) and one soybean genotype obtained from a local farmer in Juba, South Sudan.

Identification of the common weed species

The different weed species in each quadrant was identified and their number counted and recorded. The local names of the common weeds that occurred in the soybean were identified using knowledge from the elders in Juba from diverse tribes and recorded. Identification of the botanical families of the common weeds that occurred were performed morphologically from their growth habits, phyllotaxy, and floral parts. Furthermore, to confirm the authentic nomenclature and taxonomic characteristics, indigenous knowledge and Google™ research were used to verify the characteristics of the species in conformity with the authoritative weed science literature. The botanical families of the respective weed species that occurred in the soybean field, however, were traced according to Kranz *et al*. (1978).

Definitions

Field density (**D)** is the number of different weed species per meter square or quadrant.

Mean field density (MFD) was the mean number of plants m^2 for each and species averaged over all blocks sampled (Thomas, 1985).

Relative mean field density (**RMFD)** is the ratio of the mean field density of a given species to the sum of mean field densities of all species expressed in percentage.

Field frequency (F) for a given species was calculated as the percentage of the total number of fields (blocks) surveyed in which a species occurred in at least one quadrant (Thomas, 1985).

Relative field frequency (RF) is defined as the percentage of the frequency of a given species to the sum total of frequencies of all species in a block.

Field uniformity (U) was calculated as the percentage of the total number of quadrants sampled in which a species occurred.

Relative Uniformity (RU) is the defined as the field uniformity of a given species expressed as the percentage of the sum of field uniformity of all species.

Relative abundance (RA) of a given species was calculated as the sum of relative mean field density (RMFD), relative frequency of species (RF) and relative field uniformity of a given species.

Data collection and statistical analysis

The data collection was done three weeks after germination of the soybeans when all the weed seeds in the weed seed-bank in the soil were assumed to have germinated. The parameters for identification of the botanical, local names and families of the common weeds in the experiment were the variables identified through observations at different time intervals and they included the following:

Identification of the botanical, local names and families of the common weeds,
Field density (D) of the occurring weeds,
Mean field density (MFD) of the weed species,
Relative mean field density (RMFD),

Field frequency (F) of the weed species,
Relative field frequency (RF),
Field uniformity (U) of the weeds,
Relative field uniformity (RU) of the weeds occurring, and
Relative abundance (RA).

A stratified random sampling procedures for the identification of weed species was adopted as described by Thomas (1985). Data was processed to indicate the distribution, field density, uniformity, frequency, and abundance of the weed species using Thomas (1985) quantitative methods and experimental design was subjected to ANOVA (Gomez and Gomez, 1984) in randomly complete block design (RCBD) with three (3) replicates.

RESULTS

Weed species identified in the soybean field

The impact and importance of documenting relative abundance and distribution of weed species in a particular agro-ecosystem is very essential. Results of field survey (Table 1) of the different weed species, revealed that there were 17 weed species identified. Of the 17 species, 14 belong to the following botanical families: Aizoaceae, Cyperuceae, Solonaceae, Portulacaceae, Gramineae (Poaceae), Thirteen species out of the species identified were annual weeds (*Cleome viscosa* L., *Dactyloctenium aegyptium* L., *Sida acuta*, *Commelina benghalensis* L., *Gynandropsis gynandra*, *Phyllanthus urinaria*, *Amaranthas hybridis*, *Corchorus olitorius* L., *Digitaria sanguinalis*, *Portulaca oleracea L.* and *Physalis philadelphica* L.), and 4 species were perennials [*Achanthospermum hyspidum*., *Ipomoea* sp., *Cyanodon dactylon* (L). Pers., *Cyperus rotundus*] and 4 species were perennial weeds (*Cypeus rotundus* and *Trianthema portulacastrum*), Ipomoea ssp and *Cyanodon dactylor*.

Table 1. Scientific names, local names and families of weed species identified in soybean field

Scientific name	Common name	Local name	Family	Life span
Trianthema portulacastrum	Desert horsepurslane[1*]	Mangarapitit (K)	Aizoaceae	Perennial
Cyperus rotundus	Nutsedge	Julatat (K)	Cyperuceae	Perennial
Physalis philadelphica Lam.	Gooseberry	Lotulubek (K)	Solonaceae	Annual
Portulaca oleracea L.	Common purslane	Rigila (A)	Portulacaceae	Annual
Digitaria sanguinalis	Crabgrass	Lengbetat (B)	Gramineae	Annual
Cyanodon dactylon	Bermuda grass	Sere-sere (K)	Gramineae	Perennial
Corchorus olitorius	Jew's mallow, Jute mallow	Khudura (A)	Malvaceae	Annual
Amaranthus hybridis L.	Pigweed, Amaranthus[2*]	Gwe'degwe'de (B,K)*	Amarnthaceae	Annual
Ipomoea spp.	Morning-glory[3*]	Lorerek (K)	Ipomeae	Perennial
Phyllanthus urinaria	Gripeweed, leafflower[4*]	Lowee (B)	Phyllanthaceae	Annual
Gynandropsis gynandra	Spider plant	Tegiri (B, K)*	Capparaceae	Annual
Commelina benghalensis	Dayflower	Lubulutat (K)	Commelinaceae	Annual
Sida acuta	Prickly sida plant	Muksasa (A)	Malvaceae.	Annual
Dactyloctenium aegyptium L.	Egyptian crowfoot	NF	Gramineae	Annual
Cleome viscosa L.	Spider plant	Tegiri (B)	Capparaceae	Annual
Boerhavia erecta	Spiderling, erect boerhavia	Mangarapitit (K)	Nyctaginaceae	Annual
Achanthospermum hyspidum DC.	Bristly starbur, goat's head[5*]	Waranga (K)	Asteraceae	Annual

Synonyms: 1: 2**(Amaranthus viridis* L., *A. Blitum, = A. lividus* L.), *A. angustifolia* Lem.; 3*: *Ipomoea purpurea* (L.) Roth; 4*: *Phyllanthus niruri;* 5*: NF =equivalent of local not found; Local names: K (Kuku), A (Juba Arabic), B (Bari), K (Kuku), BK* (Common to all Bari-speakers and others (Lulu'bo and Lokoya): Bari, Mundari, Kakwa, Kuku, Nyangwara, and Pojulu)

Densities, frequency and relative frequency of common weeds

The mean field densities of common weeds found in the experimental field of University of Juba shown in Table 2 indicates that the weed, *Trianthema portulacastrum,* had highest mean density of 219

plants m^{-2} followed by *Boerhavia erecta, Cyperus rotundus* and *Commelina benghalensis*, which attained densities of 192.2, 178.9 and 138.8 plants m^{-2} respectively. Following these were two weed species: *Ipomea* spp. with density of 58.9 plants m^{-2} and *Phyllanthus urinaria* with density of 37.3 plants m^{-2}. Important weeds densities varying from 11.0 to 16 plants m^{-2}, in descending order, were *Amaranthus* spp. (11.0 plants m^{-2}), *Portulaca oleracea* (7.9 plants m^{-2}), *Corchorus olitorius* (6.1 plants m^{-2}), *Cloeme viscosa* (5.6 plants m^{-2}), *Cyanodon dactylon* (3.8 plants m^{-2}), *Dactyloctenium aegyptiaca* (2.5 plants m^{-2}), and *Gynandropsis gynandra* (1.6 plants m^{-2}). Other weeds of less significance but prevalent in the field, with mean densities of less than one, include: *Physalis philadelphica, Digitaria sanguinalis, Sida acuta and Achanthospermum hyspidum.*

Table 2. Mean field density (MFD) per m^2, Frequency (F) and (RF) of common weed species in soybean field

Weed species	Block A	Block B	Block C	Mean	F	RF
Trianthema portulacastrum	267.8	195.5	193.7	219	100	6
Cyperus rotundus L.	211	162.5	163.2	178.9	100	6
Physalis philadelphica Lam.	1	1.2	0.5	0.9	100	6
Portulaca oleracea L.	6.3	5	12.3	7.9	100	6
Digitaria sanguinalis	0.3	0.7	1.7	0.9	100	6
Cyanodon dactylon (L.) Pers.	3.7	3.5	4.3	3.8	100	6
Corchorus olitorius L.	5.1	2.7	10.5	6.1	100	6
Amaranthas hybridis L.	17.5	6.2	9.2	11.0	100	6
Ipomoea sp.	96.5	42.5	37.7	58.9	100	6
Phyllanthus urinaria	44.5	17	50.5	37.3	100	6
Gynandropsis gynandra	1.7	1.7	1.3	1.6	100	6
Commelina benghalensis L.	140	120.3	156.2	138.8	100	6
Sida acuta	0.5	0	0.8	0.4	66.7	4
Dactyloctenium aegyptium L.	0.7	1.2	5.5	2.5	100	6
Cleome viscosa L.	5	6.2	5.7	5.6	100	6
Boerhavia erecta L.	190	190.8	195.8	192.2	100	6
Achanthospermum hyspidum DC.	0.5	0.3	0.7	0.5	100	6
Total	987.1	757.3	849.6	866.3	1666.7	100
Mean	58.06	44.55	49.97	50.96	98.04	5.88

Relative mean field density (RMFD) of common weed species

The relative mean field densities (RMFD) presented in Table 3 for weed species growing in soybean field indicates that seven weed species that had, in descending order, RMFD from 25.2 to 1.2 were: *Trianthema portulacastrum* (25.2), *Boerhavia erecta* (22.5), *Cyperus rotundus* (20.6), *Commelina benghalensis* (16.1), *Ipomea* spp. (6.6), *Phyllanthus urinaria* (4.2), and *Amaranthus* spp. (1.2). Nine weed species (*Portulaca oleracea*, *Corchorus olitorius*, *Cloeme viscosa*, *Cyanodon dactylon*, *Dactyloctenium aegyptiaca*, *Gynandropsis gynandra*, *Physalis philadelphica*, *Digitaria sanguinalis* and *Achanthospermum hyspidum* had RMFD less than one and only one weed species, *Sida acuta* had RMFD of zero.

Field uniformity (U)

Field uniformity were calculated for common weed species found growing with soybean and the results were presented in Table 4 indicate that six weed species (*Trianthema portulacastrum*, *Cyperus rotundus*, *Ipomea* spp., *Phyllanthus urinaria*, *Commelina benghalensis* and *Boerhavia erecta*) had 100% field uniformity. Seven weed species (*Portulaca oleracea*, *Cyanodon dactylon, Corchorus olitorius*, *Amaranthus* spp., *Gynandropsis gynandra*, *Dactyloctenium aegyptiaca*, and *Cloeme viscosa*) had uniformity ranging from 56.6 to 83.3% while the remaining four species (*Physalis philadelphica*,

Digitaria sanguinalis, *Sida acuta* and *Achanthospermum hyspidum*) had uniformity ranging from 22.2 to 44.4% in ascending order.

Table 3. Relative mean field density (RMFD) of common weed species in soybean field

Weed species	Block A	Block B	Block C	Mean
Trianthema portulacastrum	27.0	25.8	22.8	25.2
Boerhavia erecta L.	19.2	25.2	23.0	22.5
Cyperus rotundus Linn.	21.3	21.5	19.2	20.6
Commelina benghalensis L.	14.1	15.9	18.4	16.1
Ipomoea sp.	9.7	5.6	4.4	6.6
Phyllanthus urinaria	4.5	2.2	5.9	4.2
Amaranthas hybridis L.	1.8	0.8	1.1	1.2
Portulaca oleracea L.	0.6	0.7	1.4	0.9
Corchorus olitorius L.	0.5	0.4	1.2	0.7
Cleome viscosa L.	0.5	0.8	0.7	0.7
Cyanodon dactylon (L.) Pers.	0.4	0.5	0.5	0.4
Dactyloctenium aegyptium L.	0.1	0.2	0.6	0.3
Gynandropsis gynandra	0.2	0.2	0.2	0.2
Physalis philadelphica Lam.	0.1	0.2	0.1	0.1
Digitaria sanguinalis	0.0	0.1	0.2	0.1
Achanthospermum hyspidum. DC	0.1	0.0	0.1	0.1
Sida acuta	0.1	0.0	0.1	0.0
Mean	5.89	5.88	5.87	5.87

Relative uniformity (RU)

The first six weed species shown on the Table 5 had the same relative uniformity of 8.1 while the next three species had also the same values of RU of 6.8. Two weed species, *Cloeme viscosa* and *Gynandropsis gynandra,* had RU of 5.9 and 5.4 respectively. *Gynandropsis gynandra* and *Dactyloctenium aegyptiaca* had similar RU of 4.4 and 5.4 respectively. The same applies to weed species *Digitaria sanguinalis* with RU of 3.5 and *Physalis philadelphica* with RU of 3.1. *Achanthospermum hyspidum* had RU of 2.2 and *Sida acuta* had 1.8.

Relative abundance (RA)

The 17 common weed growing with soybean in the University of Juba's Experimental Farm could straightforwardly be divided into three main groups based on their relative abundance in the field (Table 6). The first group consisting of five weed species (*Trianthema portulacastrum*, *Boerhavia erecta*, *Cyperus rotundus*, *Commelina benghalensis*, and *Ipomea* spp. had highest RA ranging from 20.7 and 30.3.

The second group, which is composed of eight weed species (*Phyllanthus urinaria*, *Amaranthus* spp., *Portulaca oleracea*, *Corchorus olitorius*, *Cloeme viscosa*, *Cyanodon dactylon*, and *Dactyloctenium aegyptiaca*) had intermediate RA values ranging from 10.7 to 18.4.

The third and the last group consisting of *Digitaria sanguinalis*, *Physalis philadelphica*, *Achanthospermum hyspidum* and *Sida acuta* had exhibited the lowest RA values of 9.7, 9.2, 8.2 and 5.8 respectively.

The top 5 species exhibited higher relative abundance while the preceding 8 species had relatively moderate RA compared to the last 4 species which had lower RA in the soybean field. Figure 1 shows graphically the relative abundance (RA) of the weeds in soybean field in the experimental field of University of Juba, and Figure 2 shows the picture of some of the noxious weeds.

Table 4. Field uniformity (U) of common weed species in soybean field

Weed species	Block A	Block B	Block C	Mean
Trianthema portulacastrum	100.0	100.0	100.0	100.0
Cyperus rotundus Linn.	100.0	100.0	100.0	100.0
Physalis philadelphica Lam.	33.3	33.3	50.0	38.9
Portulaca oleracea L.	100.0	66.7	83.3	83.3
Digitaria sanguinalis	33.3	33.3	66.7	44.4
Cyanodon dactylon (L.) Pers.	50.0	83.3	66.7	66.7
Corchorus olitorius L.	66.7	100.0	83.3	83.3
Amaranthas hybridis L.	83.3	83.3	83.3	83.3
Ipomoea sp.	100.0	100.0	100.0	100.0
Phyllanthus urinaria	100.0	100.0	100.0	100.0
Gynandropsis gynandra	50.0	50.0	66.7	55.6
Commelina benghalensis	100.0	100.0	100.0	100.0
Sida acuta	33.3	0.0	33.3	22.2
Dactylotenium aegyptium L.	33.3	50.0	83.3	55.6
Cleome viscosa L.	66.7	83.3	66.7	72.2
Boerhavia erecta L.	100.0	100.0	100.0	100.0
*Achanthospermum hyspidum.*DC	16.7	16.7	50.0	27.8
Mean	68.62	70.58	65.71	72.55

Table 5. Relative uniformity (RU) of common weed species in soybean field

Weed species	Block A	Block B	Block C	Mean
Trianthema portulacastrum	8.6	8.3	7.5	8.1
Cyperus rotundus Linn.	8.6	8.3	7.5	8.1
Ipomoea sp.	8.6	8.3	7.5	8.1
Phyllanthus urinaria	8.6	8.3	7.5	8.1
Commelina benghalensis L.	8.6	8.3	7.5	8.1
Boerhavia erecta L.	8.6	8.3	7.5	8.1
Portulaca oleracea L.	8.6	5.6	6.3	6.8
Corchorus olitorius L.	5.7	8.3	6.3	6.8
Amaranthas hybridis L.	7.1	6.9	6.3	6.8
Cleome viscosa L.	5.7	6.9	5.0	5.9
Cyanodon dactylon (L.) Pers.	4.3	6.9	5.0	5.4
Gynandropsis gynandra	4.3	4.2	5.0	4.5
Dactylotenium aegyptium L.	2.9	4.2	6.3	4.4
Digitaria sanguinalis	2.9	2.8	5.0	3.5
Physalis philadelphica. Lam	2.9	2.8	3.8	3.1
Achanthospermum hyspidum DC	1.4	1.4	3.8	2.2
Sida acuta	2.9	0.0	2.5	1.8
Mean	5.90	5.87	5.90	5.87

Table 6. Relative abundance (RA) of common weed species in soybean field

Weed species	Block A	Block B	Block C	Mean
Trianthema portulacastrum	25.2	6	8.1	39.3
Boerhavia erecta L.	22.5	6	8.1	36.6
Cyperus rotundus Linn.	20.6	6	8.1	34.8
Commelina benghalensis L.	16.1	6	8.1	30.3
Ipomoea sp.	6.6	6	8.1	20.7
Phyllanthus urinaria	4.2	6	8.1	18.4
Amaranthas hybridis L.	1.2	6	6.8	14.0
Portulaca oleracea L.	0.9	6	6.8	13.7
Corchorus olitorius L.	0.7	6	6.8	13.5
Cleome viscosa L.	0.7	6	5.9	12.6
Cyanodon dactylon (L.) Pers.	0.4	6	5.4	11.9
Gynandropsis gynandra	0.2	6	4.5	10.7
Dactylotenium aegyptium L.	0.3	6	4.4	10.7
Digitaria sanguinalis	0.1	6	3.5	9.7
Physalis philadelphica Lam.	0.1	6	3.1	9.2
*Achanthospermum hyspidum.*DC	0.1	6	2.2	8.2
Sida acuta	0.0	4	1.8	5.8
Mean	5.87	5.88	5.28	16.86

Key: RMFD: relative mean field density, RF: relative frequency, RU: relative uniformity, RA: relative abundance

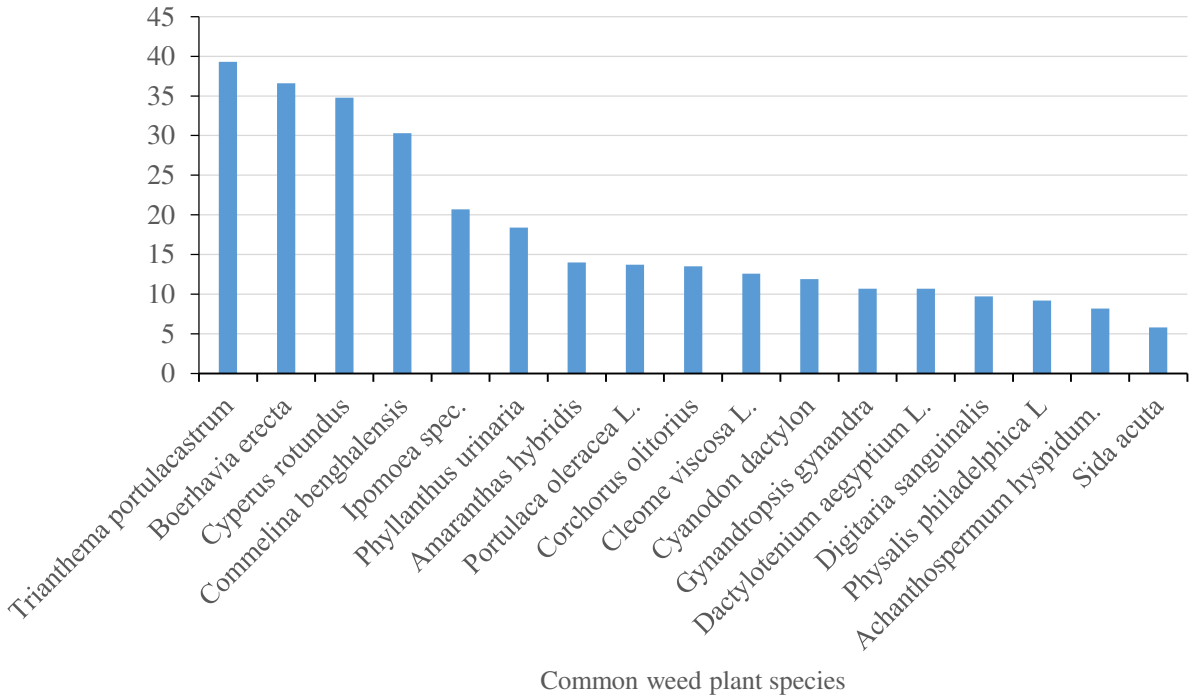

Figure 1. Relative abundance (RA) of common weed species in soybean field

Figure 2. Some of the noxious weed species in soybean field: (A) *Trianthema portulacastrum,* (B) *Boerhavia erecta* L.*,* (C) *Cyperus rotundus* (L.) Pers.*, and* (D) *Portulaca oleracea* L.

DISCUSSION

In this weed survey the data revealed that most of the prominent weeds observed in the soybean field were of 17 species of which they were characterized as annual, perennial and annual/perennial weeds and belonging to 14 botanical families (Table 1). All the weed species prevailed in all the blocks except *Sida acuta* (Hayashi *et al*., 2013) that was not found in block B and the highest weed density was recorded in block 1 with a total density of 992.1 per m^2 followed by block C having a total weed density of 849.6 per m^2 lastly block B with a total weed density of 757.3/m^2 the weed species that scored the mean highest density was *Trianthema portulacastrum* and the lowest was *Sida acuta* having densities of 219 and 0.4 per quadrate respectively and out of the 17 species of weeds 4 species shown higher densities, *T. portulacastrum, Boerhavia erecta* L.*, Cyperus rotundus* (L.) Pers. and *Commelina benghalensis* L. having densities of 219, 192, 178.9 and 138.8 per quadrant respectively. Two species shown moderate density and the remaining 11 weed species shown low and lower densities (Table 3).

The field frequency F of the weed species was 100% for all the species in the soybean field except for *Sida acuta* with an **F** value of 66.7% (Table 3). The relative frequency (F) for all the weed species was 6% except for *Sida acuta* having a low relative frequency of 4% (Table 2).

The field uniformity (U) of the weed species in the soybean field revealed that 6 species are 100% uniformly distributed in the field, 7 species had a high field uniformity between 90% and 50% and the remaining 5 species are less uniformly occurring and their field uniformity is significantly below 50% (Table 4).

The relative uniformity of the weed species was quantitatively evaluated with a highest mean value of 8.1 scored by five species and the lowest value was 2.2 scored by a single species and the remaining 11 species scored a relative uniformity that was moderately high and lower within the range of the highest and lowest values shown in descending order (Table 5).

Trianthema portulcastrum showed the highest relative mean field density (RMFD) in all the blocks followed by *Boerhavia erecta, Cyperus rotundus, Commelina benghalensis*. The above 4 species showed high RMFD of 25.2, 22.5, 20.6, 16.1 respectively the remaining 13 species showed lower RMFD (Table 3).

The most important feature of this survey is the method of ranking the weed species on their relative abundance (RA). The survey provided a quantitative comparison of the common species identified in the soybean field. *Trianthema portulacastrum, Boerhavia erecta* L.*, Cyperus rotundus* L. and *Commelina benghalensis* L. were the weed species that were ranked high in the survey having a relative abundance of 39.3%, 36.6%, 34.8% and 30.3% in descending order which are annual/perennial for the first two species, perennial and annual for the third and fourth highest species respectively. *Ipomoea spp*. and *Phyllanthus urinaria* shows moderate abundance. The remaining 11 species of the weeds were ranked lower with respect to their relative abundance (Table 6). Research on large-scale patterns of diversity [beta (β) diversity] showed that weed vegetation varies less between fields. Under rather unfavourable environmental conditions, for example, in higher altitudes, on sandy soils or under extreme soil reaction, this counts also within regions (Fried *et al*., 2008; Lososová *et al*., 2004; Šilc *et al*., 2008). *Sida acuta* was ranked the lowest with a relative abundance (RA) of 5.8%. Similar surveys that may be conducted in the same area may show variations in the results due to environmental factors, weed seed abundance in the seed bank, season of the year, seed dormancy, the number of samples considered and the agronomic practices in the past (Cowie and Werner, 1993; Hayashi *et al*., 2013). Weeds are the only spontaneous contribution of arable sites to plant diversity that makes their nature even more double sided, as they also ensure ecosystem services (Médiène *et al.,* 2011) or are themselves targets of conservation (Meyer *et al*., 2013). Sparse and diverse arable weed vegetation can provide a wide range of ecosystem services, including the conservation of soil and water resources and supplying habitats to harmless and beneficial organisms (Médiène *et al*., 2011). Thus, manipulating weed species composition into a desirable and manageable direction is a basic principle of integrated weed management. For the protection of arable biodiversity and rare plant species, management at various scales appears to be important (Gabriel *et al*., 2006). While Integrated Weed Management (IWM) is paramount to complementary Integrated Crop Management (ICM), when a field is left fallow or for grazing purposes in a mixed farming plant diversity of palatable annual and non-toxic shrubs are helpful to agro-pastoralists. Furthermore, this findings, though limited in scope (size of sampling and location), is part of an effort to establish a robust method of survey, identification and management of weeds in the different agro-ecological zones of South Sudan. Weed surveys are useful for determining the occurrence and relative importance of weed species in crop production system (Frick and Thomas, 1990 and Thomas, 1985) because documenting the weeds present, crops in fields and the herbicides applied and cultural practices adopted to control those weeds allows comparisons with past and future surveys. Furthermore, documenting the relative importance of weed species also facilitates the establishment of priorities for short and long-term research and extension activities (services) (McCloskey *et al*., 1998).

In conclusion, the survey has revealed that out of the seventeen weed species identified in the soybean field, three species exhibited higher relative abundance (RA), while 2 species showed relatively moderate RA and 11 weed species had lower RA. Similarly, out of the seventeen weed species identified, 14 botanical families were classified either as annual or perennial. Therefore, the weed species were not uniformly nor abundantly distributed in the soybean field but rather their abundance and uniformity varies from one species to the other.

Smallholder farmers ought to be sensitized on the fact that weeds are noxious plants that cause more harm than good. This approach presupposes the detailed knowledge of the potential damage attributed to an individual weed plant species in relation to their numbers in a particular agroecosystem. Ultimately, it is advisable to less resourced smallholder farmers to adopt and apply an integrated weed management (IWM) in the context of weed control, in way that weed species with the highest relative abundance (RA) should be given priority in weed management strategy according to their relative abundance in the field.

ACKNOWLEDGENTS

The authors like to express their sincere appreciation and thanks to the SNRES staff at the University of Juba Experimental Farm, they also thank Prof. James Odra (CNRES, University of Juba) for his preliminary critical review of this paper and suggestions for its improvement.

REFERENCES

Cowie, I.D. and Werner, P.A. (1993). Alien species invasive in Kakadu National Park tropical Australia. *Biological Conservation*, **63**: 127-135.

Frick, B. and Thomas, A.G. (1992). Weed surveys in different tillage systems in southwestern Ontario field crops. *Canadian Journal of Plant Science,* **72**:1337-1347.

Fried, G., Norton, L.R. and Reboud, X. (2008). Environmental and management factors determining weed species composition and diversity in France. *Agricultural Ecosystem and Environment*, **128**:68-76. doi:10.1016/j.agee.2008.05.003

Gabriel, D., Roschewitz, I., Tscharntke, T. and Thies, C. (2006). Beta diversity at different spatial scales: plant communities in organic and conventional agriculture. *Ecological Applications*, **16**:2011–2021. doi:10.1890/10510761(2006)016[2011:BDADSS]2.0.CO;2

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for agricultural research, 2nd Edition. John Wiley and Sons, Inc. pp 532-545.

Hanzlik, K. and Gerowitt, B. (2016). Methods to conduct and analyse weed surveys in arable farming: a review. *Agronomy for Sustainable Development*, **36** (11): 1-18. doi 10.1007/s13593-015-0345-7

Hayashi, K., Hayashi, E.T. and Fatondji, D. (2013). Evaluation of the indigenous use of weed *Sida cordifolia* L. in the Sahelian zone of West Africa. *JARQ*, **47** (4): 389-396.

Jürgen, G. (1977). Malvaceae. In Diseases Pests and Weeds in Tropical Crops, eds. Kranz, J. *et al*., Verlag Paul Parey Berlin and Hamburg, 599-602.

Kranz, J., Schmutterer, H. and Koch, W. (1978). Diseases, pests and weeds of tropical crops. Wiley, New York, USA.

Lososová, Z., Chytrý, M., Cimalová, Š., Kropác, Z., Otýpková, Z., Pyšek, P. and Tichý, L. (2004). Weed vegetation of arable land in Central Europe: gradients of diversity and species composition. *Journal of Vegetation Science*, **15**:415– 422.

McCloskey, W.B., Baker, P.B. and Sherman, W. (1998). Survey of cotton weeds weed control practice in Arizona Upland Cotton Fields. A College of Agriculture Report. College of Agriculture, university of Arizona, Tucson, AZ, USA. http://hdl.handle.net/10150/210369

McCloskey, M., Firbank, L.G., Watkinson, L.G., Watkinson, A.R. and Webb, D.J. (1996). The dynamics of experimental arable weed communities under different management practices. *Journal Vegetation Science*, **7**:799–808.

Médiène, S., Valantin-Morison, M., Sarthou, J-P., de Tourdonnet, S., Gosme, M., Bertrand, M., Roger-Estrade, J., Aubertot, J-N., Rusch, A., Motisi, N., Pelosi, C. and Doré, T. (2011). Agroecoystem management and biotic interactions: a review. *Agronomy for Sustainable Development*, **31**:491–514. **doi:10.1007/ s13593-011-0009-1.**

Meyer, S., Wesche, K., Krause, B. and Leuschner, C. (2013). Dramatic losses of specialist arable plants in Central Germany since the 1950s/60s—a cross-regional analysis. *Diversity and Distributions,* **19**:1175–1187. doi:10.1111/ ddi.12102

Šilc, U., Vrbnicanin, S., Bozic, D., Carni, A., Daji, C. and Stevanovic, Z. (2008). Phytosociological alliances in the vegetation of arable fields in the northwestern Balkan Peninsula. *Phytocoenologia*, **38**:241–254. doi:10.1127/0340-269X/2008/0038-0241

Thomas, A.G. (1985). Weed survey system used in Saskatchewan for cereal and oilseed crops. *Weed Science*, **33**: 34-43.