Assessment of Weed Species Traits, Germination to Flowering duration and Crops Affected on Farms in Kisii Central Sub County, Kisii County, Kenya

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Abstract

Weed invasion is one of the greatest challenges affecting smallholder farming in Kenya. Timely and effective weed management needs knowledge on weed species traits and their nature of growth. This study aimed at assessment and documentation of weed species traits and time taken from germination to flowering for effective weed management. Ten plots were selected 1km equidistantly along a transect set across each of the eight randomly sampled sub-locations in the study area. In each plot, a $2m^2$ portion was demarcated for monitoring weed species germination to flowering time. Botanical classification of weed species was carried out through examination of the foliage and reproductive regions with the aid of guide books. Weed species G. parviflora and E. brachycephala had the shortest duration to flowering of 4 weeks while T. minuta and D. stramonium, each had the longest flowering duration of 7 weeks. Majority (14) of the weed species were broadleaved while eight were narrow leaved weed species. Thirteen annual weed species were recorded while only nine species were perennial. Three weed species were grass, 2 sedges, 1 shrub and 16 herbs. Fourteen weed species were eudicot while only 8 were monocots. Four weed species were dispersed by insects while wind dispersal and animal dispersal had 9 weed species in each case. Most farms were infested by a variety of weed species which included Pennisetum clandestinum, Oxalis latifolia, Cyperus rotundus, Amaranthus hybridus and Datura stramonium. Weed species traits and interval from germination to flowering will aid forecast on successive weed invasions and thus guide farmers on the effective time of weed management measures such as adoption of integrated weed management practises to optimize crop production.

Keywords: Weed, Shrub, Sedge, Eudicot, Smallholder Farmers, Kisii

INTRODUCTION

According to Mahmoodi & Rahimi (2009) and Oudhia (2004), weeds are plants which compete with arable crops for resources such as moisture, light, space and nutrients. Weeds are unfriendly as a consequence of their allelopathic, competitive, persistent and pernicious attributes (Zaman et al., 2011). KARLO (2013) established that weeds are one of the major constraints to rice production in sub-Saharan Africa. According to Iyagba (2010), weeds that sprout three months after sowing pose great danger in crop production more than those that emerge later.

On most farms, weeding usually competes with other farm activities and is postponed to a later date (Oudhia, 2004). Farmers will not weed crops that are sown first until they complete the seedbed preparation and sowing of all other fields (KARLO, 2013). Farmers prefer to go on planting to take advantage of moisture in the soil (Farooq et al., 2013). As in most plants, weed seeds are very vital in the growth cycle of annual or perennial weed species that reproduces through seed alone (Swanto et al., 2008). The competitiveness of

weeds is often measured in terms of crop yield reduction per unit of weed population or biomass, and the yield reduction can vary greatly as a result of the weed species (Hassan et al., 2010).

Biological and ecological information, specifically, germination ecology of a specific weed, is necessary to optimize weed control and maximize the efficiency of management tactics (Bhowmik, 1997). Allelochemicals are exhibited in all plant varieties besides tissues and are released into the soil rhizosphere through various mechanisms, such as degradation of residues, volatilization, and root exudation (Farooq et al., 2013). According to Macías et al., (2007), allelochemical structures and modes of action are varied and can provide room for the formulation of herbicides. Recent research suggests that allelopathic properties can render one species more invasive to native species and thus potentially detrimental to both agricultural and naturalized settings (Nichols et al., 2015; Farooq et al., 2013; KARLO, 2013). In contrast, allelopathic crops further provide a leeway for the development of propagules which are greatly weed suppressive (Bajwa, 2014).

The ability to produce a huge number of minute seeds serves as a crucial weed survival mechanism towards weed eradication methods. According to Irri (2010), one plant of *Ludwigia octovalvis* (Onagraceae) is capable of producing 250,000 seeds and among the species within the family Cyperaceae, *Schoenoplectus juncoides* produces 82,098 seeds m^{-2} (Leck and Schutz, 2003). After successful weed seed dispersal, the seeds may land onto the soil surface or be buried by different biotic and abiotic agents, thus forming a soil seed bank that forms a significant source of weeds in agro-ecosystems (KARLO, 2013). Weed seed location in the soil seed bank influences germination, emergence and vertical seed distribution in the soil (Norsworthy and Oliveira, 2006). Kisii Central Sub County is one of the regions that food crops are produced for both subsistence and commercial purposes (KNBS, 2019). The region is endowed with arable fertile soils and sufficient rains that favour weeds flourishing in terms of weed species traits (Nyamwamu et al., 2019).

MATERIALS AND METHODS

Description of the Study Area

Kisii Central Sub County forms one of the nine Sub Counties of Kisii County in Southwest Kenya (Kisii County Development Plan, 2013). It lies on coordinates, 0.8067° S, 34.7741° E and temperatures of the area ranges from 10ºC to 30ºC. According to the (KNBS, 2019), Kisii Central Sub County had a population of 588,000; however, with a growth rate of 3.6%, the population is ballooning over 700,000 (19% of whom inhabit urban regions). Kisii Central Sub County is one of the most densely populated Sub Counties in Kenya. The sub county has area coverage of 317.4 Km^2. Notably, as a result of the high population density; a large percentage of the land is utilized for intensive agricultural production.

The Land has been sub-divided among families, with the farms growing progressively smaller with an average farm being 15,000 m^2 in area; with an average of an eighth of an acre allocated for arable farming (MoA, 2017). Majority of farmers engage largely in subsistence and minimal commercial production. The land allocated for cash crop production in the study area is approximately 3,800ha while that for food crop production is about 12,500ha. Livestock production is characterized by dairy farming and local poultry rearing (MoA, 2017) Agriculture employs an estimated 80% of the population either directly or indirectly and the estimated rural poverty is 30% with some areas having as high as 61% (MoA, 2016).

Data Collection

Eight administrative sub-locations were randomly selected in the sub-county. Ten plots were selected at an interval of a kilometre along a transect laid across each of eight randomly selected sub-locations in the study area. In each plot, a $2m^2$ portion was demarcated for

monitoring weed species growth and time to flowering. After ploughing, weed emergence was monitored after a week and later on weekly basis for three months. Botanical identification of weed species was done through the analysis of both the vegetative and reproductive parts in reference to guide books besides making a comparison of the weeds with voucher specimens deposited at National Museums of Kenya. Plant taxonomists were also consulted to aid in the identification of weed species that were not identified in the farms.

Data Analysis

Data on duration of weed species germination to flowering and weed species traits on the farms was subjected to one sample t-test analysis to compare the effect on mean number of durations of weed species germination to flowering and weed species traits respectively.

RESULTS

Weed Species Duration of Germination to Flowering

The duration taken from weed germination to flowering of some weed species was monitored and recorded (Table 1). Weed species *G. parviflora* and *E. brachycephala* exhibited the relatively shortest duration to flowering of 4 weeks while *T. minuta* and *D. stramonium* each had the longest flowering duration of 7 weeks. Weed species germination to flowering duration was statistically significant ($p < 0.05$) among weed species on the farms.

Table 1: Weed species duration of germination to flowering

Weed species	Germination to flowering duration (weeks)
Black jack (*Bidens pilosa*)	6
Pigweed (*Amaranthus hybridus*)	5
Mexican marigold (*Tagetes minuta*)	7
Couch grass (*Digitaria scalarum*)	5
Macdonald's eye (*Galinsoga parviflora*)	4
Kikuyu grass (*Pennisetum clandestinum*)	6
Spider flower (*Gynandropsis gynandra*)	5
Black night shade (*Solanum nigrum*)	6
Chinese lantern (*Nicandra physalodes*)	6
Star grass (*Cynodon dactylon*)	5
Thorn apple (*Datura stramonium*)	7
Flat sedge (*Cyperus esculentus*)	5
Emilia brachycephala	4
Cyperus rotundus	5

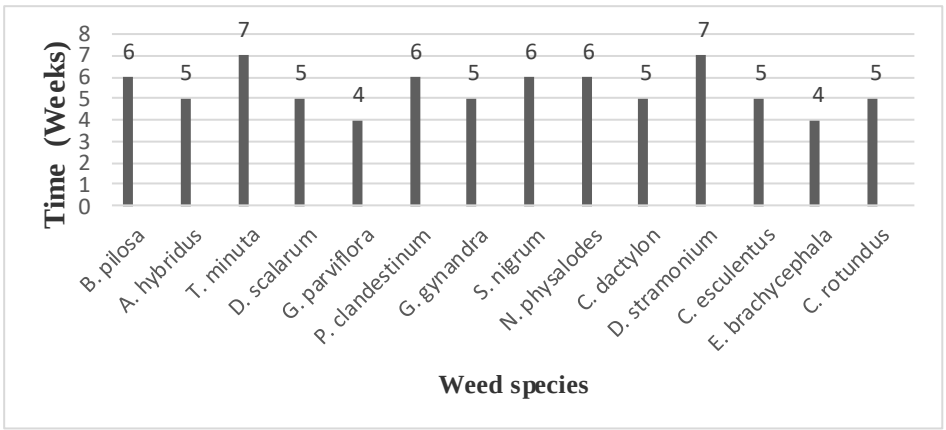

Figure 1: Weed species duration of germination to flowering

The duration taken from weed germination to flowering of some weed species was monitored and recorded as shown in Figure 1.

Weed Species Traits

Weed species like *Pennisetum clandestinum* is a perennial narrow leaved grass with one cotyledon and its seeds are dispersed by wind while *Bidens pilosa* is an annual broad leave weed, a eudicot herb which is dispersed by animals. *Digitaria scalarum* is a perennial grass with two cotyledons which is dispersed by wind while *Commelina benghalensis* is a perennial narrow leaved herb with one cotyledon and it is insect dispersed. The *Galinsoga parviflora* is an annual broadleaved herb which is eudicot and wind dispersed as illustrated in Table 2. Weed species traits were statistically significant ($p < 0.05$) among weed species on the farms.

Table 2: Traits of weed species on farms

Botanical name	Leaf type	Life Span	Habit	No. of Cotyledons	Mode of seed dispersal
Pennisetum clandestinum	Narrow	Perennial	Grass	Monocot	Wind
Bidens pilosa	Broad	Annual	Herb	Eudicot	Animal
Digitaria scalarum	Grass	Perennial	Grass	Monocot	Wind
Commelina benghalensis	Narrow	Perennial	Herb	Monocot	Insects
Tagetes minuta	Narrow	Annual	Herb	Eudicot	Animal/wind
Galinsoga parviflora	Broad	Annual	Herb	Eudicot	Wind
Nicandra physalodes	Broad	Annual	Shrub	Eudicot	Insects/wind
Amaranthus hybridus	Broad	Annual	Herb	Eudicot	Wind/animal
Cynodon dactylon	Narrow	Perennial	Grass	Monocot	Wind
Solanum incanum	Broad	Annual	Herb	Eudicot	Animal
Gynandropsis gynandra	Broad	Annual	Herb	Eudicot	Animal/wind
Oxalis latifolia	Broad	Annual	Herb	Eudicot	Wind
Conyza banariensis	Narrow	Annual	Herb	Monocot	Wind
Datura stramonium	Broad	Annual	Herb	Eudicot	Animal/wind
Solanum nigrum	Broad	Annual	Herb	Eudicot	Wind/insects
Cyperus esculentus	Grass	Perennial	Sedge	Monocot	Wind
Emilia brachycephala	Broad	Annual	Herb	Eudicot	Wind
Pteridium aquilinum	Narrow	Perennial	Herb	Monocot	Wind
Crassocephalum vitellinum	Broad	Perennial	Herb	Eudicot	Wind
Leonotis mollissima	Broad	Annual	Herb	Eudicot	Wind/animal
Leucas martinicensis	Broad	Annual	Herb	Eudicot	Wind/animal
Physalis ixocarpa	Broad	Annual	Herb	Eudicot	Animal
Cyperus rotundus	Narrow	Perennial	Sedge	Monocot	Wind
Achyranthes aspera	Broad	Perennial	Herb	Eudicot	Animal

Based on leaf type, majority (14) of the weed species were broadleaved, seven were narrow leaved while only one was grass. Classification on lifecycle, thirteen annual weed species were recorded while only nine were perennial. In terms of growth habit, 3 were grass, 2 sedges, 1 shrub and 16 herbs. On number of cotyledons, fourteen weed species were eudicot while only 8 were monocots. Based on mode of dispersal, only four weed species were dispersed by insects while wind dispersal and animal dispersal had 9 weed species in each case as illustrated in Table 3.

Table 3: Summary of weed species traits

Leaf type			Life span		Growth habit				No. of cotyledons		Mode of dispersal		
Narrow	Broad	Grass	Annual	Perennial	Herb	Shrub	Grass	Sedge	Monocot	Eudicot	Animal	Insect	Wind
7	14	1	13	9	16	1	3	2	8	14	9	14	9

Crops affected on the farms

Weed species such as *Pennisetum clandestinum, Oxalis latifolia, cyperus rotundus*, *Amaranthus hybridus* and *Datura stramonium* occur in most cultivated crops such as cereals, legumes, brassicas, tea and pastures as illustrated in Table 4.

Table 4: Crops affected on farms

Common Name	Botanical Name	Local Name	Crops affected
Kikuyu grass	*Pennisetum clandestinum*	Esereeti	Maize, tea, beans, coffee.
Mexican marigold	*Tagetes minuta*	Omotioki	Legumes, most cultivated crops.
Black jack	*Bidens pilosa*	Ekemogamogi	Most arable crops; cereals
Pigweed	*Amaranthus hybridus*	Emboga	Most arable crop; cereals.
Macdonald's eye	*Galinsoga parviflora*	Omondeere	Most arable crops.
Couch grass	*Digitaria scalarum*	Ekenyambi	Most arable crops; *Brassicas*.
Nut grass/sedge	*Cyperus rotundus*	Chindwani	Most arable crops pastures
Star grass	*Cynodon dactylon*	Emuurwa	Most arable crops like legumes.
Wandering jew	*Commelina benghalensis*	Rikongiro	Most arable crops.
Sodom apple	*Solanum incanum*	Omoratora	Most arable crops like kales
Bracken fern	*Pteridium aquilinum*	Eengwe	Most arable crops; legumes
Oxalis (Sorrel)	*Oxalis latifolia*	Enyonyo	Most arable crops; *Solanaceae*
Lion's ear/tail	*Leonotis mollissima*	Risiibi rinetu	Most cultivated crops; Legumes
Black night shade	*Solanum nigrum*	Rinagu	Most cultivated crops.
Seaport goosefoot	*Chenopodium opulifolium*	Rinyabogundo	Most arable; *Brassicas*
Devil's Horse Whip	*Achyranthes aspera*	Esaraara	Most cultivated crops; Pyrethrum
	Emilia brachycephala	Omonyaboba	Most arable crops; Cereals
Thorn apple	*Datura stramonium*	Omotabararia	Most cultivated crops; Bananas

DISCUSSION

Weed Species Duration of Germination to Flowering

Most of the weeds were annuals which propagate by seeds only. Similar studies conducted by Qureshi and Arian (2003) reported that weeds like *G. parviflora, E. brachycephala, A. hybridus* and *B. pilosa* have a short life span and thus grow and mature within one season. Due to smaller seed size, most of these seeds get easily dispersed within farms, *B. pilosa* seeds are able to attach to animal fur and human clothes aiding dispersal. On the basis of their growth cycle/lifespan, the annual weeds whether broadleaved or narrow leaved are able to germinate, grow and mature in the field within a period of one season/year or less and most of them are easily controlled especially if it is done before flowering. The perennial weeds also narrow leaved or broad-leaved take more than one year/season to complete their lifecycles and are most difficult to control. Weed seed germination is an important event in the weed life-cycle since it determines when the weed species will emerge and begin to grow and become evident in fields and other habitats (Gardarin et al., 2011). Germination is a physiological process usually initiated by water imbibition followed by embryo growth resulting in the emergence of the radical through its coating tissues (Eslami, 2011). It is

influenced by dormancy and a variety of edaphic, climatic and environmental factors (Doststny et al., 2015).

Weed Species Traits

Weed species portray variations in potentiality to compete with arable crops at analogous density magnitudes and this is attributed to their differences in growth habits and allelopathic effect they may pose on sprouting and development of adjacent crops. This study found that weeds have a variety of attributes that aid them to survive and compete favourably with desired crops (Table 2). Such competitive characteristics enable them to consume large amount of habitat resources and deprive the crops. Broad-leaved weeds are not as detrimental as the grasses and sedge in crop production. However, they cause some damage and should not be over looked. Some produce many seeds making them difficult to control such as the Pig weed (*A. hybridus*) though adequate weed management practises such as through repeated shallow cultivation can check on the annual weed species (Hassan et al., 2010).

Notably, the annual species were higher in abundance than perennial species and annual broadleaved species were dominant than perennial broadleaved species and grasses. In this study, most of the abundant weed species were annual and broadleaved in nature. In related studies done by Kimemia and Nyabundi (1998) on different weed control methods in coffee in Kenya, it was also noted that the broadleaved weeds were more in number of species as compared to the rest of the weed species. They also indicated that *C. dactylon* was the most common grass species while *B. pilosa* and *G. parviflora* were the most abundant broad leaved weed species where *T. minuta* recorded zero dominance since they relatively grew faster with highly competitive abilities. Since weeds compete with arable crops for resources such as water and nutrients besides light, and it has been a matter of great concern for farmers (Rajput et al., 2008; Sultan & Nasir, 2007).

The losses caused to agricultural crops by weeds such as *C. rotundus* are quite significant (Marwat & Khan, 2006). Weeds have specific characteristics that help their survival like having elaborate root systems which is useful in anchorage, nutrient absorption and also water uptake from the soil (*A. hybridus, G. parviflora*), different modes of propagation like suckers, bulbs, stolons, rhizomes and corms (*P. clandestinum, C. dactylon* and *C. rotundus*) and succulent stems to withstand dessication (*C. benghalensis*). Such competitive characteristics aid these weeds to deprive and consume large amount of habitat resources meant for the desired crops.

Crops Affected on the Farms

Most weed species are found in cultivated crops and have been discovered to exert a significant effect on the potential yield of major crops such as the cereals, legumes and pastures (Tanveer et al., 2015). Weed species such as *Pennisetum clandestinum, Oxalis latifolia, cyperus rotundus, Amaranthus hybridus* and *Datura stramonium* prevail uniquely in particular crop like maize, tea or bean fields where they cause significant crop damage (Bajwa, 2014). Related studies carried out by Gesimba and Langat (2005) in Kisii highlands noted that perennial grasses and sedges are the most common and problematic weeds of arable crops. They cause significant damages and are also difficult to control. Such grasses weeds include Couch grass (*Cynodon dactylon*). According to Shah and Khan (2006), it has been established that *Cyperus rotundus* is one of the most invasive weed species, having successively dispersed out to a global distribution in both tropics and temperate regions. Thus, it has been referred to as "the world's worst weed" as it is known as a weed in over 90 countries, and infesting over 50 crops worldwide. According to Alshallash (2016), most weed species are common in arable lands whereby the weeds' competitiveness is also dependent on weed species density and abundance, causing considerable yield losses to a variety of crops such as maize. Consequently, the weed

species are reportedly capable of reducing corn grain yield by 35-70% if not managed in time and uncontrolled weed growth brings about 83% decline in average grain yield of maize (Michieka et al., 2017).

CONCLUSION

Most weed species exhibited a relatively short life span and this enabled them to germinate, grow and reach maturity before harsh environmental conditions set in. Weeds have traits that enhance successful weed species survival on farms regardless of management practises which include having a short growth cycle, effective mode of dispersion, extensive root network, exhibiting long dormancy periods besides survival on limited resources.

RECOMMENDATIONS

Through the Ministry of Agriculture, farmers should be exposed to agricultural experts who will train them on weed management practises in order to reduce rates of weed invasion to maximise crop yields.

For the Kisii county government, Ministry of Agriculture, through extension officers there is need to increase dissemination of knowledge on weeds to farmers in terms of weed diversity, their damage and control in order to adopt appropriate weed management practises so as to maximise crop yields.

In addition, farmers should adopt the integrated weed management (IWM) technique which is a holistic approach to weed management that integrates different methods of weed control to provide the crop with an advantage over weeds.

Since farmers are among the contributors to the national grid, the government should find means of subsidizing farming materials and tools. This will enable them afford complimentary expenditures like buying herbicides, fertilizer, labour and professional services from trained personnel.

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Conflict of interest
"The author(s) declare(s) that there is no conflict of interest."
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