Allelopathic Effect of Niger Plant (*Guizotia abyssinica* L.) on Abundance of Selected Weeds

Oimbo, L. M., Ngode, L., Auma, E.

Department of Seed, Crop and Horticultural Sciences
University of Eldoret, Kenya

DOI: 10.29322/IJSRP.8.11.2018.p8341
http://dx.doi.org/10.29322/IJSRP.8.11.2018.p8341

Abstract

Plants release many secondary metabolites to the environment that can be harnessed for important uses. These secondary metabolites are known as allelochemicals. The current worldwide demand for cheaper, more environmentally-friendly weed management technologies has motivated a number of studies on the allelopathic interaction between crops and weeds. Niger plant has been observed to have allelopathic effects on certain weeds. In order to evaluate the influence of Niger plant on selected weeds, an experiment was laid out in Randomized Complete Block Design (RCBD) with three replicates. Treatments included weedy check (no weed control measure, having all weeds including Niger plant), weed free, Niger plant intercrop and all weeds except Niger plant. Three cultivars of beans (Rosecoco, Mwitemania and Mwezi Mbili) were used. Data collection included the total number of four prominent weeds over a span of four weeks. A 50 x 50 quadrat was laid on the same spot in all the treatments and the weeds enclosed within it were counted separately. Data analysis was done by ANOVA in Genstat and results presented using graphs. Results showed that Niger plant enhanced bean growth and development whereas it inhibited the germination and growth of some weeds i.e. field mustard, broom weed, double thorn and couch grass. It was concluded that Niger plant exhibited negative allelopathy on the weeds that were studied and positive allelopathy on all the bean cultivars. From the results it is recommended that further research be carried out on more crops and more weeds so as to have an in-depth understanding of this subject.

Key words: Allelopathy, Metabolites, Niger plant, Weeds.

Introduction

Niger plant (*Guizotia abyssinica*), is a herbaceous green plant with bright yellow flowers in the Family Asteraceae. In Kenya, Niger plant is considered a weed especially in the highlands of the North Rift Valley where cereals are extensively grown. However, in Ethiopia and India, Niger plant is cultivated for production of edible oil at 51% and 20% respectively of all edible oil used (Patil *et al,* 2013).

Weed infestation is a major concern to crop production especially in the tropics where much time and labour are devoted to weed control. It is estimated that about 50-70% of the labor in crop production is spent weeding (Chikoye, *et al.*, 2007). In Africa, yield losses due to weeds range from 25% to total crop failure. Weeds cause yield loss in crops through both competition for water, light and nutrients and by allelopathy (Zohaib *et al,* 2016). Coexistence with weeds can modify plant morphology biomass accumulation, plant growth and, successively, the yield of crops of interest by interfering with different metabolic processes (Wandscheer *et al.,* 2013).

In light of the losses caused by weeds, and given the fact that human population is ever increasing and thus stretching the demand for food, weed control is a major concern thus weed- mediated decline in crop production needs urgent intervention so as to attain high yields and achieve food security. For economic purposes, weed control techniques attempt to achieve a balance between cost of control and crop yield lost. Herbicide discovery in the 1950s was a major boost to crop production. However, the indiscriminate use of herbicides worsens the quality of soil, water, other life support systems, human health and food coupled with herbicide resistance. As a result of the increasing awareness of the adverse toxicological effects of synthetic herbicides, one of the recent trends in weed management is to reduce heavy reliance on synthetic herbicides and to move towards low input sustainable agriculture (LISA) (Nikneshan *et al.,* 2014). One of the promising alternatives to herbicide use is allelopathy.

Allelopathy is a phenomenon of growth interference of one plant on another through the release of chemicals from another plant into the environment (Inderjit & Callaway 2003). The chemicals released are known as allelochemicals. Plants with allelopathic potential help to reduce weed intensity, and hence improve crop productivity when intercropped with other plants (Saudy, 2015). The allelochemicals, also known as secondary metabolites, are liberated from plants and affect the germination and growth of recipient plants (Asaduzzaman *et al.,* 2013). According to Gallandt *et al.,* (1999), allelochemicals affect weed dynamics by reducing and delaying seed germination and establishment, in addition to suppressing individual plant growth resulting in an overall decline in the density and vigor of the weed community. Allelopathy can be exploited for weed suppression, and can thus be helpful in reducing reliance on herbicides (Weston *et al.,* 2013).

Allelochemicals released by plants include phenolics, flavonoids or terpenoids (Macías *et al.,* 2007). Wise exploitation of allelopathy in cropping systems may be an effective, economical and natural method of weed management, and a substitute for heavy use of herbicides. Allelochemicals usually have a mode of action different from synthetic herbicides, being more easily and rapidly degradable owing to a shorter half-life with comparatively fewer halogen substituents and no unnatural ring structures (Roth *et al.,* 2000). Because of this, allelochemicals have low or no toxicity to animals, have different sites of action and degrade faster in the environment (Cloyd, 2004). To exert effect on the recipient plants, allelochemicals may influence vital physiological processes such as respiration, photosynthesis, cell division and elongation, membrane fluidity, protein biosynthesis and activity of many enzymes, and may also affect tissue water regime (Field *et al.,* 2006).

Plants in the family Asteracea have been noted to be highly allelopathic. It has been observed that, Niger plant, a plant in this family, is a good precursor for cereals, pulses and oil seeds, because crops following Niger plant in a rotation have less weed infestation (Adarsh *et al.,* 2014) implying that the previous crop of Niger plant exudes some chemicals into the rhizosphere that affect growth of other plants. Niger plant also contributes to conservation of soil health and land rehabilitation because of its mycorrhizal relationship and its potential as a bio-fertilizer.

Even with the ongoing advances in research on allelopathy, the knowledge gap is still vast. The effect of Niger plant secondary metabolites on crops has not been studied to combine its effects on both crops and weeds. This study was therefore carried out to determine the weed suppressive ability of Niger plant in the field. There is a need to expand on the knowledge of interference mechanisms of Niger plant in order to better understand its success as a weed, and to seek ways to harness its success in improving crop production.

Materials and methods

Study site

Field experiments were conducted at the University of Eldoret Research farm for two seasons from September – December 2017 and December – February, 2018. The area lies at an altitude of 2100 m above sea level and a longitude of 35^o 18’ E and 0^o 30’ N latitude. Rainfall is relatively high at 730 mm with an annual temperature range between 9.5^0 C and 23.5^0 C respectively.

Experimental treatment, design and plot lay out

The experiment involved growing three cultivars of beans (Rose coco, Mwitemenia and Mwezi Mbili) under four different weed regimes. The weed regimes included a weedy treatment (W) where there were all weeds including Niger plant, a treatment with only Niger plant growing amongst the beans (NP), weed free treatment, (WF) and a treatment that had all weeds growing except Niger plant (All – N.P). A weedy treatment was achieved by letting all the weeds, including Niger plant, that could germinate to grow together with the beans for the entire period. In a Niger plant intercrop treatment, all weeds were removed except Niger plant which was allowed to grow with the beans. Since the Niger plant germinated on its own, its distribution did not follow any pattern. Weed free treatments had all the weeds removed as soon as they were spotted. In treatments with all weeds except Niger plant, only Niger plant was weeded out leaving all the other weeds to grow with beans. Hand weeding was done by uprooting by. The experiment was a 3x4 factorial arranged in Randomized Complete Block Design (RCBD) and replicated three times.

Establishment of field experiment and management

The field was dug to a fine tilth targeting 15 cm of the top soil. Animal manure was broadcast on the soil surface until planting time when it was incorporated into the soil. Following the pre-planned design the field was marked ready for planting. Three cultivars of beans were planted at a uniform spacing of 15 cm by 10 cm. Pest control begun two weeks after planting and was done by use of synthetic insecticides sprayed every week. Foliar feed was sprayed once just before flowering. Weed control was done according to the specific treatments required per plot.

Parameters measured

Data were collected on the abundance of selected weeds which were the most dominant and evenly distributed in the field. A 50 x 50 cm quadrat was laid at the center of each plot the specific weeds within the quadrat counted. This was done for four consecutive weeks. The quadrat was laid on the same spot each time. The weeds on which data were collected include Field mustard (*Brassica rapa*), Broom weed (*Gutierrezia sarothrae*), Double thorn (*Oxygonum sinuatum*) and Couch grass (*Cynodon dactylon*). The data collected were subjected to analysis of variance (ANOVA) using Genstat version 14 and means separated by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Results and discussion

Effect of Niger plant on abundance of Wild mustard

Results of the study showed that in season 1, there were significant differences between the two weed regimes from which data was collected on the abundance of wild mustard (Fig. 1). In the course of the four-week period through which data was collected, amongst the specific weed regimes, there were variations in weed abundance though the variations were not statistically significant. In all weeds except Niger plant regime, weed abundance started at 84 in week 1, rose to 88 in week 2 before falling back to 84 in week 3. In week 4, the weed abundance was 80. In weedy regime, week 1 had 76 weeds which rose to 80 in week 2 before settling at 76 in both week 3 and 4.

The significant differences shown between the two weed regimes can be attributed to the effect of Niger plant. From the results, it is clear that all weeds except Niger plant regime had higher abundance of Wild mustard than the abundance in weedy regime. This can be because in weedy regime, the presence of Niger plant suppresses the germination and growth of wild mustard. In all weeds except Niger plant regime, there was no Niger plant effect thus higher abundance of Wild mustard. El- Rokiek *et al*., (2010) in their study illustrated that mango leaves induced significant reduction in the growth of mother tubers in purple nut sedge. Growth inhibition in weeds recorded by many allelopathic plants is in response to accumulation of phenolic compounds indicating allelopathic stress (El-Rokiek, 2007).

In season 2, there were no significant differences in the first three weeks. Significant differences were noted in week four where all weeds except Niger plant regime was significantly higher than in weedy regime. This can be attributed to the accumulating effect of the Niger plant allelopathy in the soil to levels that were injurious to other weeds. Sisodia and Siddiqui (2010) conducted a study on the allelopathic effects of *Croton bonplandianum* on germination and seedling growth and concluded that effect was found to increase with increasing concentrations of different aqueous extracts.

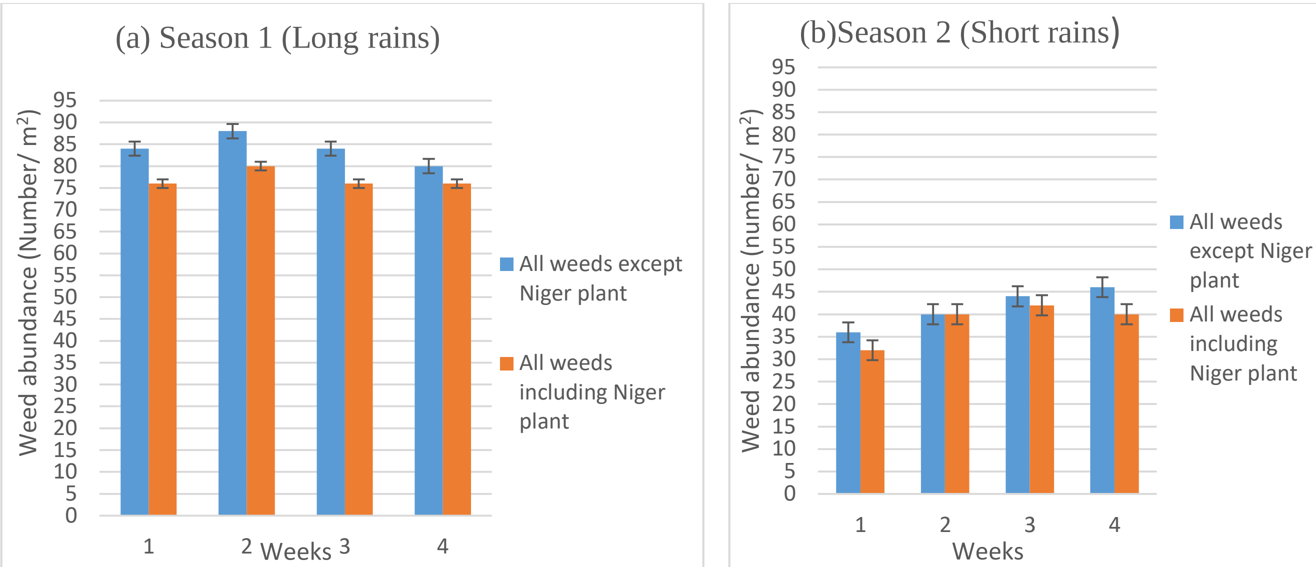

Figure 1: Effect of Niger plant on abundance of Wild mustard

Effect of Niger plant on abundance of Broom weed

The results of the study shown in Figure 5 below revealed that there were significant differences between the two weed regimes in all the four weeks of season 1 and the first week of season 2. Season 1 had high weed abundance in all weeds except Niger plant regime and this can also be due to the absence of Niger plant in the immediate vicinity to exert allelopathic effects. Presence of Niger plant in the weedy regime may have led to the introduction of allelochemicals to the soil that suppressed weed germination and growth. These results are in agreement with Ejaz *et al.*, (2015), who found out that allelopathic chemicals in Tobacco and Eucalyptus significantly suppressed weeds by reducing weed density.

In season 2, there was lower abundance of Broom weed in week 1 than in week 2. This observation may have been due to delayed germination occasioned by Niger plant allelochemicals in the soil. A study by Herro & Callaway (2003) showed in some plant species, allelochemicals cause delayed germination and reduction in in seedling growth. Since the Broom weed delayed to germinate, the seedlings may have faced stiff competition for resources from the already established ones. This may have led to the reduction in the number of Broom weed observed in week 3 and 4.

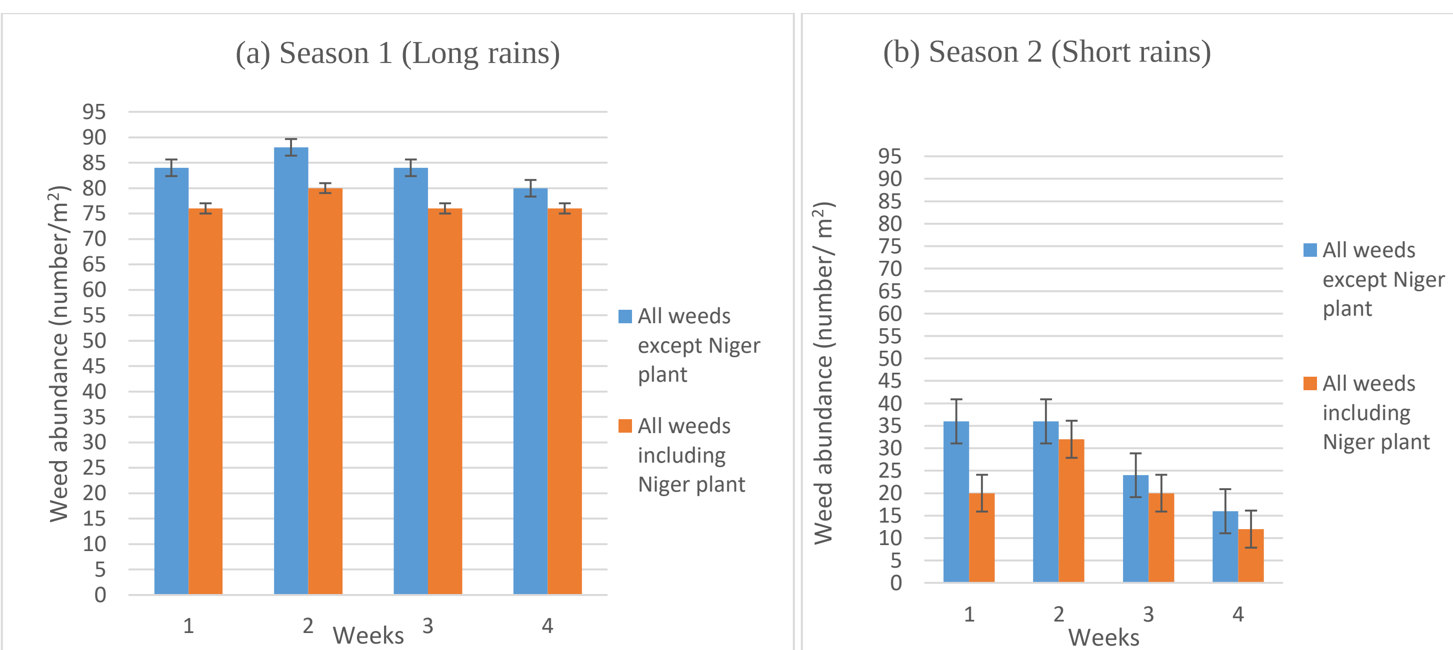

Figure 2: Effect of Niger plant on abundance of Broom weed

Effect of Niger plant on abundance of Double thorn

In double thorn, there were significant differences in season 1. In season 2, significant differences were in week one. There was low germination percentage in weedy regime in season 1. High abundance was recorded in season 2 but the newly emerged seedlings could not survive. This led to numbers decreasing sharply from week 2 to week 4. In all weeds except Niger plant regime, germination was high and the number was maintained to the second week when sharp increases were noticed. Low germination percentage could be as a result of enzyme and hormone interference in the receiver plants. Turk and Tawaha (2003), studying the allelopathic effect of black mustard (*Brassica nigra*) on germination and seedling growth of wild oat (*Avena fatua*) observed that protease enzyme activity was suppressed causing reduced water uptake which led to poor seed germination thus low stand count.

The sharp decrease in double thorn abundance can be attributed to a low threshold to allelochemicals. A study by Hussein (2014), revealed that different plants differ in their allelochemical threshold thus some are affected more by the same concentration of allelochemicals than others.

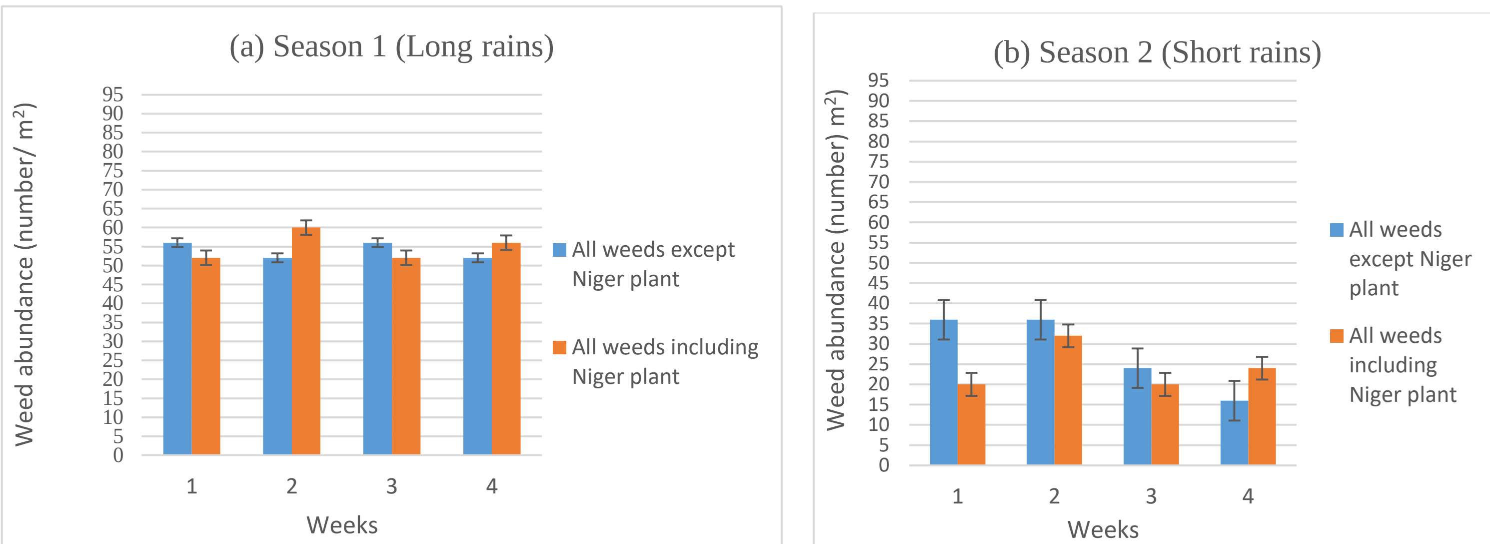

Figure 3: Effect of Niger plant on abundance of Double thorn

Effect of Niger plant on abundance of Couch grass

Couch grass abundance in season 1 showed significant differences in week 1 and 2 (Fig. 4). In week 1, there was a higher number of emerged weeds in all weeds except Niger plant regime. The number of sprouted weeds reduced in week 2 through withering and death. A few more weeds sprouted in week 3 but the number reduced in week 4. The dynamics observed can be partly attributed to allelopathy and competition. Chon *et al.*, (2006) attributed the highly allelopathic herbicidal potential of some plant extracts to the presence of allelopathic substances for example coumarin, benzoic acid and cinnamic acid. This is in agreement with a study by Kumbhar *et al.*, (2016) which concluded that Niger plant, just like other members of the Asteraceae family, has many different kinds of allelochemicals, chief among them being phenolics. It was also seen that weeds that emerged later that the second week do not survive but rather wither and die off. This can be attributed to the direct effect of competition for space to take foot on and also competition for nutrients and water given that the newly germinated seedlings are not competitive enough in acquiring these resources.

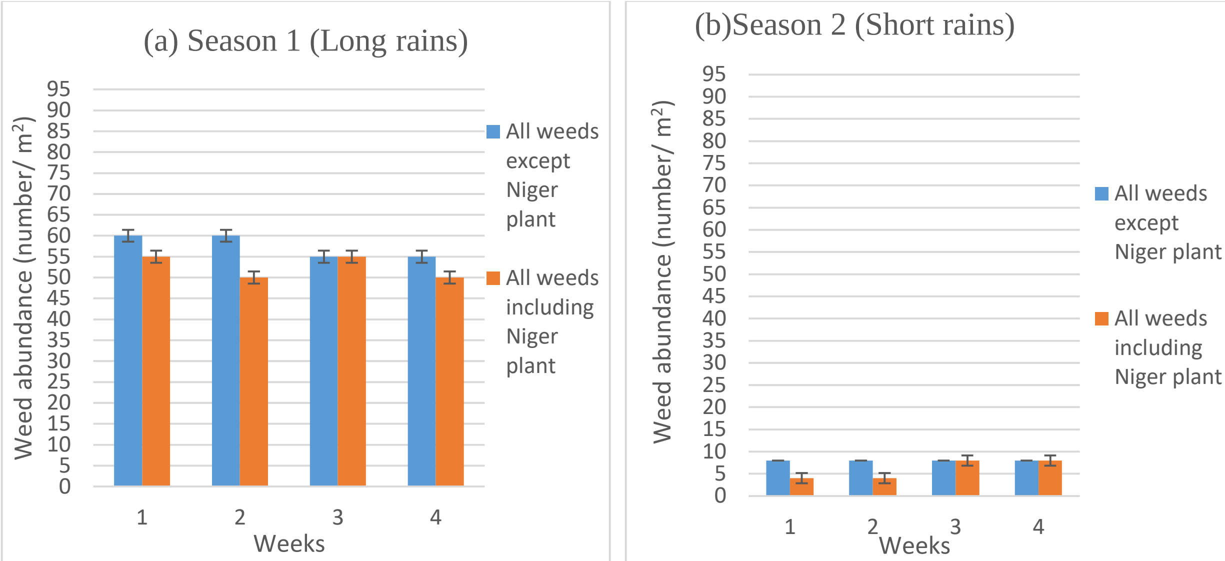

Figure 4: Effect of Niger plant on abundance of Couch grass

Conclusions and recommendations

Conclusion

Niger plant exhibited negative allelopathy on the weeds that were studied i.e. field mustard, broom weed, double thorn and couch grass.

Recommendations

- Further research should be carried out for means on how Niger plant secondary metabolites can be extracted.
- A wide study should be done on more weeds so as to widen the understanding on the effectiveness of Niger plant in suppressing weeds.

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Authors

Oimbo, Lynnete Moraa*. (PhD student) moraalynna@gmail.com. +254723141506

University of Eldoret

Ngode, Lucas. (PhD). lucasngode@yahoo.com

University of Eldoret

Auma, Elmada. (PhD). elmadaauma@yahoo.com

University of Eldoret

***- : corresponding author.**