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Research Article

Allelopathic effect of Niger Plant (*Guizotia abyssinica* L.) on abundance of selected weeds

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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 have 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. 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 were counted separately. Data analysis was done by ANOVA in Genstat and results were presented using graphs. Results showed that Niger plant enhanced the 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 needs to be carried out on more crops and more weeds to have an in-depth understanding of this subject.

Keywords allelopathy, metabolites, Niger plant, weeds

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Introduction

Niger plant (*Guizotia abyssinica*), is an herbaceous green plant with bright yellow flowers in the Family Asteraceae. In Kenya, Niger plant is considered as 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 the edible oils used [1].

Weed infestation is a major concern to crop production especially in the tropics where much time and labor is devoted to weed control. It is estimated that about 50-70% of the labor in crop production is spent on weeding [2]. In Africa, yield losses due to weeds is about25% of the total crop production. Weeds cause yield loss in crops through competition for water, light and nutrients and by allelopathy [3]. Coexistence with weeds can modify plant morphology, biomass accumulation, plant growth and, successively, the yield of crops by interfering with the different metabolic processes [4]. In the 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. Hence, weed- mediated decline in crop production needs urgent intervention in order to attain high yields and achieve food security. For economic purposes, attempt on weed control techniques is required to achieve a balance between the cost of control and the lost crop yield. Discovery of herbicides in 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. 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) [5]. One of the promising alternatives to use of herbicides is allelopathy.

Allelopathy is a phenomenon of interference of growth of one plant on another through the release of chemicals from one plant into the environment [6]. 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 [7]. The allelochemicals, also known as secondary metabolites, are liberated from plants and affect the germination and growth of recipient plants [8]. According to Gallandt et al., [9], allelochemicals affect weed dynamics by reducing and delaying seed germination and establishment, in addition to suppressing the 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 [10].

Allelochemicals released by plants include phenolics, flavonoids or terpenoids [11]. 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 [12]. Due of this, allelochemicals have low or no toxicity to animals, have different sites of action and degrade faster in the environment [13]. 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 [14].

Plants in the family Asteraceae 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 [15] 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 secondary metabolites of Niger plant 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 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.

Methodology

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° 18’ E and 0° 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 the three cultivars of beans (Rose coco, Mwitemenia and Mwezi Mbili) under four different weed regimes. The weed regimes included (a) a weedy treatment (W) where all were weeds including the Niger plant, (b) a treatment with only Niger plant growing amongst the beans (NP), (c) a weed free treatment (WF) and (d) a treatment that had all weeds growing except Niger plant (All – N.P). A weedy treatment was achieved by allowing all the weeds, including Niger plant, 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. 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 so that 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 only once just before the flowering time. Weed control was done according to the specific treatments required per plot.

Parameters measured

Data were collected on the abundance of selected weeds that were the most dominant and evenly distributed in the field. A 50 x 50 cm quadrat was laid at the center of each plot and 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 included 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 (Figure 1). In the four-weeks course during which data was collected, amongst the specific weed regimes, there were variations in weed abundance. However, 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 obtained 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 suppressed the germination and growth of wild mustard. In all weeds except Niger plant regime, there was no Niger plant effect showing higher abundance of Wild mustard. El- Rokiek et al., [16] 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 was in response to accumulation of phenolic compounds indicating allelopathic stress [17].

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 which were injurious to other weeds. Sisodia and Siddiqui [18] conducted a study on the allelopathic effects of *Croton bonplandianum* on germination and seedling growth and concluded that effect increased with the increasing concentrations of different aqueous extracts.

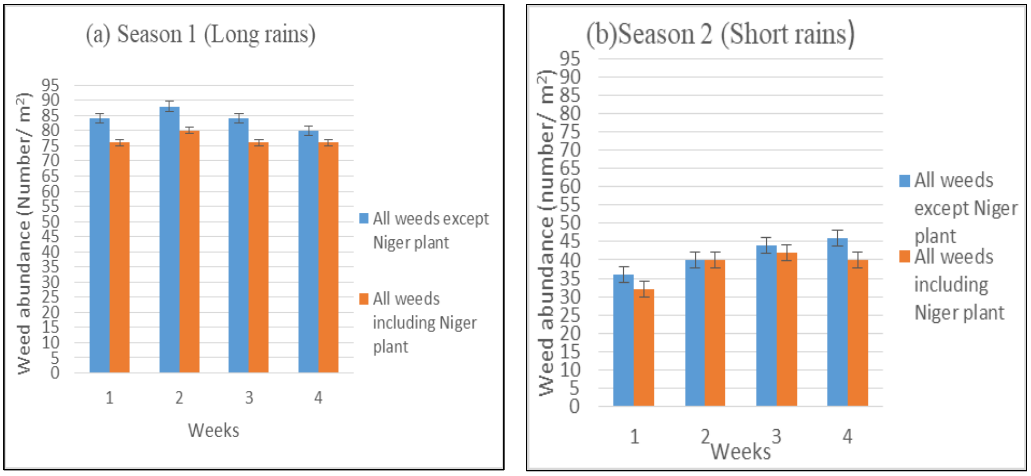

Figure 1. Effect of Niger plant on abundance of Wild mustard

Effect of Niger plant on abundance of broom weed

The results of the study shown in Figure 5 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 were in agreement with Khan et al., [19], who found out that allelopathic chemicals in Tobacco and Eucalyptus significantly suppressed the weeds by reducing weed density.

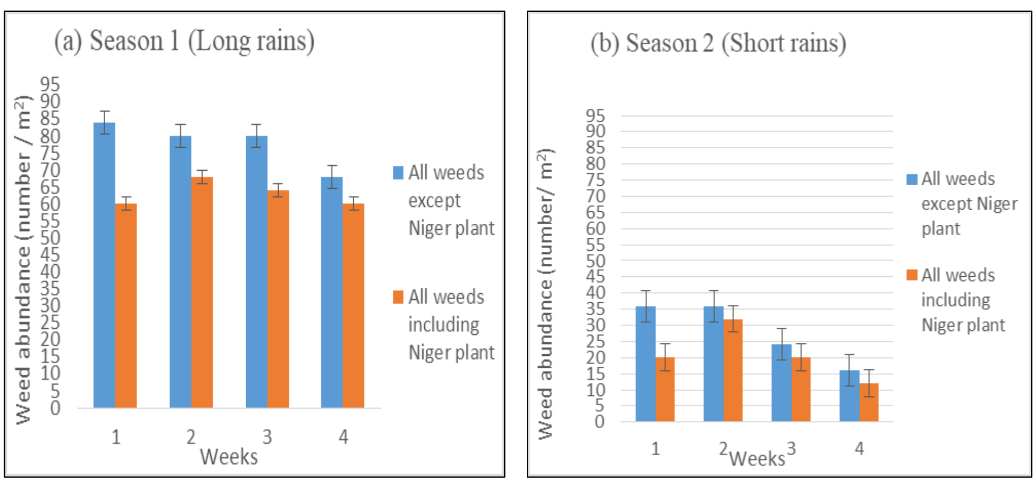

Figure 2. Effect of Niger plant on abundance of Broom weed

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 and Callaway [20] showed in some plant species, allelochemicals cause delayed germination and reduction in the 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.

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 observed 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 the sharp decrease in numbers 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 increments were noticed. Low germination percentage could be as a result of enzyme and hormone interference in the receiver plants. Turk and Tawaha [21], studied the allelopathic effect of black mustard (*Brassica nigra*) on germination and seedling growth of wild oat (*Avena fatua*) and observed that protease enzyme activity was suppressed causing reduced water uptake which led to the poor seed germination and thus low stand count.

The sharp decrease in double thorn abundance can be attributed to a low threshold to allelochemicals. A study by Hussein [22] revealed that different plants differ in their allelochemical threshold and hence, some are affected more by the same concentration of allelochemicals than others.

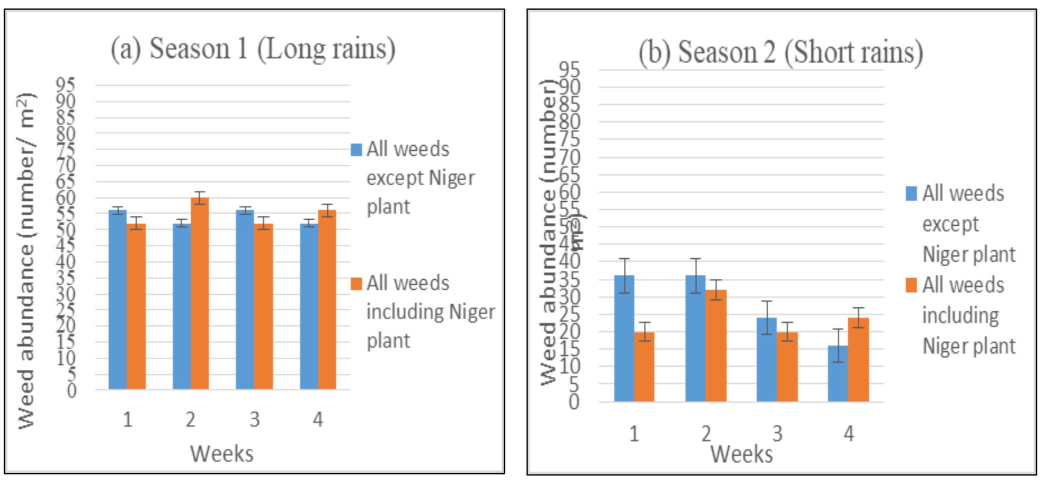

Figure 3. Effect of Niger plant on abundance of Double thorn

Effect of Niger plant on abundance of Couch grass

Couch grass abundance in season 1 showed significant differences in week 1 and 2 (Figure 4). In week 1, there was 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., [23] 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., [24] which concluded that Niger plant, just like other members of the Asteraceae family, has many different kinds of allelochemicals and phenolics is crucial among them. It was also seen that weeds that emerged later at the second week do not survive but rather wither and die off. This can be attributed to the direct effect of competition for space, nutrients and water, given that the newly germinated seedlings are not competitive enough in acquiring these resources.

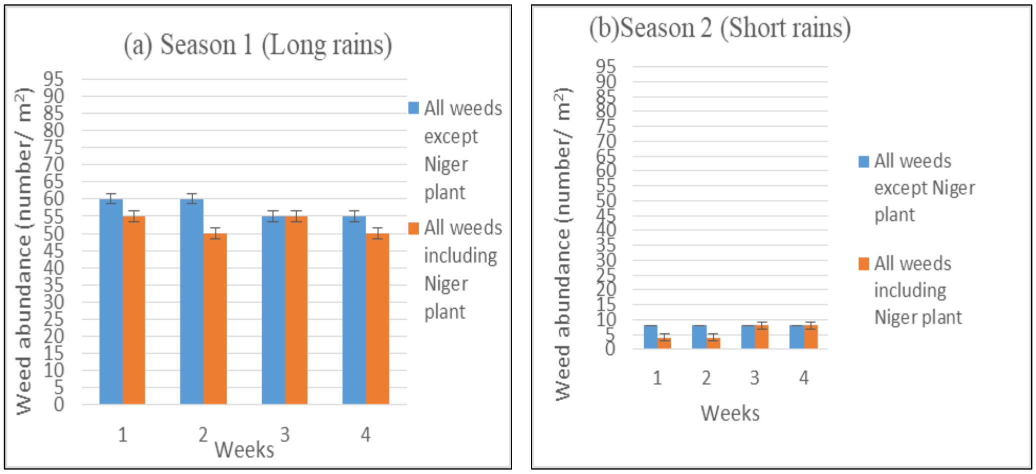

Figure 4. Effect of Niger plant on abundance of Couch grass

Conclusion and recommendations

Niger plant exhibited negative allelopathy on the studied weeds i.e. field mustard, broom weed, double thorn and couch grass. Further research should be carried out to understand the extraction of secondary metabolites from Niger plant. A wide study should be done on more weeds in order to widen the understanding on the effectiveness of Niger plant in suppressing weeds.

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